Passive Solar Construction Handbook

featuring use of concrete, brick, and masonry with fenestration materials

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The information presented in the Passive Solar Construction Handbook is intended to help provide the building industry with a starting point for developing standard and accepted construction practices for passive residences. Experimental construction procedures have been avoided in favor of techniques and information based on accepted practices.

It is important to note that this Handbook deals primarily with concrete masonry, poured concrete, and brick materials for thermal storage. Phase change materials and water storage components are alternatives that may also be considered but are not within the scope of this publication. Similarly, various other materials, such as special shading and movable insulating devices, are not discussed herein, but may be of interest to the designer.

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Over the past few years passive solar design has enjoyed a growing audience of enthusiasts working in a variety of areas, mostly on the periphery of the housing industry. These researchers, builders, economists, architects and others from a wide variety of disciplines have generated a significant body of information on passive solar technology. As is true of many innovative building technologies, this body of technical and analytical studies has preceded the development of standard passive solar construction procedures.

Parallel to the development of the technical foundations of passive solar design is a growing interest among builders and designers in incorporating passive concepts into their standard building practices. Unfortunately, the construction details and information which have developed out of the many successful passive solar projects are dispersed within the enormous volume of literature on passive design and are not readily available to the building community at large. The Passive Solar Construction Handbook represents a comprehensive effort to fill this gap by illustrating methods of adapting standard building practices to passive solar applications.

The information contained in the Handbook has been developed primarily for home builders. However, it is hoped that by providing a variety of construction and technical information that others involved in the building industry will find the contents of value.

The Handbook focuses specifically on the construction of passive solar, single-family detached residential buildings. It will be evident, however, that much of the construction information can be successfully adapted to other building types.

Discussions of construction, of course, cannot stand apart from considerations of design. Where appropriate in the text, basic concepts in the design of passive homes are discussed and general design guidelines are offered. It should be emphasized that these basic principles are presented only in a general way. More specific design information can be obtained from any of a variety of passive solar design primers currently available (see BIBLIOGRAPHY, Section 5.0000). In fact, it is strongly recommended that this Handbook be used as a companion volume to one of these primers.

As the role of passive solar design expands into a major force in the home building industry, new construction methods will emerge and old ones become outdated. In order that the Handbook continue to be a growing and valuable resource, a format and numbering system has been developed which can readily accept periodic updates. When the version printed for a three-ring binder is used, new pages may be added or substituted and old pages may be removed as they become obsolete. Also, the design detail is presented so that almost all of the essential construction information is on a single sheet. This permits convenient reference and should make the handbook a more useful tool.

The illustrations used throughout the text are intended to aid the reader in interpreting the basic concepts of passive solar design. They are general in nature, as are the small graphic symbols which appear at the top of many of the Handbook pages, and are not intended to convey a specific or preferred method of design. The small graphic

symbols (see Figure 1.1) represent each of the so-called basic passive solar systems discussed in Sections 2.0000 and 3.0000.

It should be emphasized that the Handbook is intended to be national in scope. As a result, the construction information and details tend to be general in nature, not focusing on specific regional building practices. Many construction-related concerns which would ordinarily be identified and discussed in a regionally oriented text are, therefore, simply identified as areas of regional concern.

Included in this list of regional issues are: the use and location of vapor barriers, the use of termite shields and soil poison, pressure treating wood, attic ventilation, and various special structural requirements in seismic areas. These and other regional construction considerations will need to be overlayed onto the basic construction information presented in the drawings and text. The details illustrated in Section 3.0000 will then need to be adapted, conforming to local building practices and codes. Thus, the information presented in the Handbook is intended to serve as a general construction guide and to convey the basic principles of passive solar design and construction.

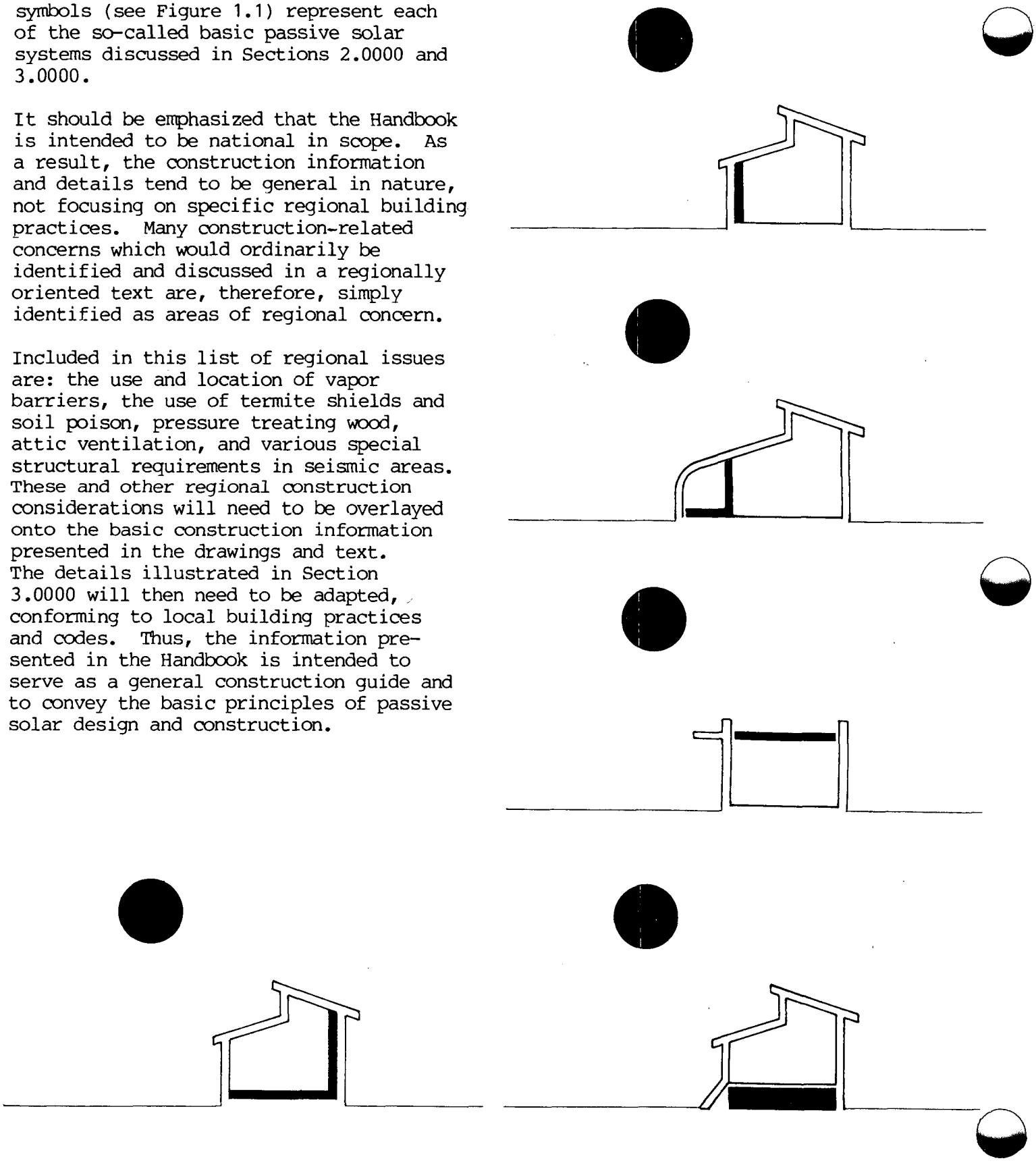


Figure 1.1

The Handbook is intended to be a working document and to serve as a constant source of construction information, ideas and direction. The text is organized into Sections and Appendices in a manner designed to maximize the efficient use of the information covered. The discussion which follows briefly outlines this organization, the topics covered in each section, and methods for quickly and efficiently obtaining the information.

Passive Solar Fundamentals (Section 2.) - In Section 2. many of the basic elements of passive solar design are reviewed. The discussions are intended to: (1) introduce the reader to the unique design constraints present in passive homes; (2) provide a framework for cataloging passive solar home "types;" and, (3) briefly describe many of the salient issues influencing design decisions (e.g., economic and energy use analyses). The reader, familiar with the topics presented may wish to skim the discussions but is advised to carefully read the paragraphs describing Basic Passive Systems, a section which delineates the organizational framework for the remainder of the text.

It should be reiterated that, although many significant considerations in designing passive solar homes are outlined in FUNDAMENTALS, the section is not intended to substitute for any of the readily available passive solar design guides (see BIBLIOGRAPHY discussion below).

Passive Solar Construction (Section 3.) - Passive solar construction is the first of the two "working" sections of the Handbook. The information contained in this section will serve as a constant guide in the design and construction phases of building passive homes.

The section is subdivided according to Passive System Type, an organization introduced in FUNDAMENTALS. Each system type subsection includes: (1) a general discussion or "Design Overview" of the important design and construction issues which apply to the particular system under review; (2) an indexing system to the construction details based on "Key Pages"; the construction details, or "Detail Pages"; and (3) Case Studies illustrating designed and built examples of the system type.

In using one of these subsections, the "Design Overview" should be carefully reviewed, noting the major advantages and disadvantages of the system type as well as the more specific "Rules of Thumb" for design and construction. These rules will aid in selecting and constructing the passive design and are highlighted in the text by an orange box.

The Key Pages illustrate materials used in the various building constructions (e.g., walls, floors) which can serve as components in a passive system. The actual Detail Pages generally illustrate the intersection of two or more such components. Therefore these Key Pages are designed as an indexing system, instructing the Handbook user as to which pages contain details/intersections of interest. For example, Key Page 3.1174 illustrates a slab-on-grade construction used in the "Direct Gain" floor system. Referring to the "Index to Details" which appears beneath the drawing, page numbers for details illustrating the intersection of a slab-on-grade floor with a variety of other construction components can be located. In this example a detail of the connection of the slab-on-grade floor with a concrete masonry cavity wall is found on page 3.1460. All the construction details illustrated in the Handbook

can be located in this manner.

The Case Studies at the end of each subsection describe the design and construction of successful passive solar homes with particular emphasis on the construction detailing.

Passive Solar Materials (Section 4.) - While quickly thumbing through the Key and Detail Pages it may be noted that, although material types are indicated, specific products and material dimensions are not. These designations and selections can be made with the aid of the information contained in the second "working" section, MATERIALS. This section is used in conjunction with the CONSTRUCTION section and provides guidance to the available and suitable materials for the various passive solar applications. The information in this section is of particular value if used in conjunction with the Rules of Thumb in the CONSTRUCTION section.

Continuing with the example above, assume that in the Rules of Thumb it is recommended that the interior wythe of concrete masonry, illustrated on Detail Page 3.1460, be 2" to 4" thick. Pages 4.2101 through 4.2109 present information on a range of specific materials, 2" to 4" thick, which can be used in this wall. Selection of a specific unit can be based on, but should not be limited to, this information. Other materials and products which satisfy the conditions of the Section 3. Rules of Thumb should also be considered.

Bibliography (Section 5.) - For further reading an extensive BIBLIOGRAPHY is listed in Section 5. Each entry is coded with a category number indicating the primary type of material contained in that entry. As noted it is suggested that one of the Design Primers (category < 1 >) be used as a companion volume to this Handbook.

Glossary (Section 6.) - Throughout the text a variety of terms are used which may be unfamiliar. A GLOSSARY has been included to clarify these terms.

Appendices - To supplement many of the discussions in the text, a number of APPENDICES have been included at the end of the Handbook. It is anticipated that as other issues arise the number of APPENDICES will be increased, enhancing the scope and value of the Handbook.

The implications of dwindling fossil fuel supplies are creating a marked awareness within the building community of the need to conserve energy in the design of residential buildings. Prospective homeowners are, with increasing frequency, requesting the "energy-efficient" or "passive solar" model. With each revision, building codes and standards become increasingly stringent with regard to the selection of energy use related materials and components. Utilities are providing incentives and assistance, and, in some cases, are requiring that the home builder use energy conservation techniques in new residential construction as a basis for providing service. Significantly, lending institutions are recognizing the financial attractiveness of energy conserving designs which, by reducing operating costs, tend to lower investment risk.

There are numerous techniques and opportunities for conserving energy in residential design. Most remain virtually untapped by the vast majority of home builders nationwide. Simple and familiar techniques, such as increased insulation levels or multiple glazings instead of single glazing are, of course, effective and expedient measures to reduce energy use. These and other energy "conservation" techniques are primarily useful as climatic "buffers," protecting against the deleterious effects of, for example, cold outdoor temperatures. They reduce the demand for energy in the home.

There is, however, a variety of additional techniques which effectively utilize the forces of nature to provide energy to the home, reducing, and in some cases eliminating, the need for conventional fossil fuel fired heating and cooling equipment. In residential design most of these techniques are based upon the use of solar radiation to provide space and water heating, and, occasionally, space cooling. These solar techniques can be subdivided into two basic categories: active and passive. Although the distinction between them is not always clear cut, in general, passive solar techniques or systems heat and/or cool without the need for energy from other nonrenewable sources such as electric power to run a pump. On the other hand, the familiar roof-mounted solar panels, which require pumps and fans whose consumption of electricity may be significant relative to the amount of energy generated by the overall system, are classified as active systems.

In the development of passive solar designs, the range of possibilities should not be limited by strict adherence to this definition of solar types. If a small fan will improve the efficiency of a certain passive installation, it should be used even if the resulting system is not a purely passive one. Similarly, the use of passive techniques should not preclude the use of active components. So-called "hybrid" systems which combine active and passive elements can be very effective at providing a home's energy needs.

It should be emphasized that passive solar techniques are only effective in reducing energy use if they are combined with, not substituted for, standard energy conservation techniques. Any energy gains which a passive system might generate can be easily offset by the energy losses that will occur in a poorly designed and constructed building. It is for this reason that the incorporation of energy conservation measures, in both the design and construction phases of the building, are an absolute prerequisite for an effective passive solar instal-

lation. A partial list of recommendations for improving the energy conserving capability of a building includes the following:

- Insulate the house as well as possible.
- Reduce windows and other openings on the north side of the building.
- Orient the building to maximize the effects of summer breezes and minimize those of winter winds.
- Utilize landscape elements to increase thermal performance by providing shade, blocking unwanted winds, etc.
- Take advantage of overhangs and projections to shade the building during the cooling season.
- Use earth berming where possible to increase the insulating capacity of walls and/or roofs, and to block unwanted winds.
- Ventilate the roof properly to avoid condensation problems and consequent loss of insulating capability.
- Provide adequate vapor barriers.
- Insulate openings by using double or triple glazing or storms on windows and doors.
- Use insulating shades and shutters instead of standard uninsulated units.
- Reduce air infiltration by properly weatherstripping and caulking all openings, and by using proper sill sealers.
- Use air-lock entries.

All of the above recommendations will help create an "energy conserving" structure which will reduce the demand for supplemental energy sources. The next step in the design process is to include passive systems which will allow the structure to actually provide for its own energy requirements. The result will be a truly "energy conscious" home. This Handbook provides some basic guidelines for the design of such a home, but concentrates primarily on the materials and methods of construction for the passive solar components. For more precise information regarding overall design strategies, any of the variety of passive solar design primers listed in the BIBLIOGRAPHY can be consulted. It is, in fact, strongly recommended that this Handbook be used as a companion volume to one or more of these primers.

Principles of Passive Solar Design

Passive solar systems rely on the intelligent design and organization of the spaces in a home, and the careful selection of building materials, to derive heating and cooling benefits from the free and abundant energy available in the natural environment. Such systems depend on two basic material properties for their effect: (1) the ability of certain materials (predominantly masonry materials) to store large amounts of heat and release that heat slowly to the living spaces of the home; and, (2) the ability of glass and many other glazing materials to transmit solar radiation (light) but to remain opaque to thermal radiation (heat). When a passive system admits sunlight through its south-facing windows, this light strikes objects and surfaces within the space and is transformed into heat. This radiant heat is prevented from passing back out through the windows because the glazing is opaque to this form of radiation. This phenomenon, known as the "greenhouse effect," will be familiar to anyone who has opened the door to a car that has been sitting in the sun with its windows closed on a summer day.

To date, most research and development in the area of passive solar has centered on heating rather than cooling. Thus, the basic passive systems developed and presented in this Handbook have been designed primarily for heating and only secondarily for cooling. In fact, the essential processes of a "passive" system (collection and storage) are specifically oriented toward gaining heat rather than rejecting it. This is not to say that aspects of a system cannot be adapted for cooling. Storage elements can be used to store "coolth" and absorb heat from the living space (thereby cooling it) during summer days.

Introduction

Based on differences in physical configuration, there are five basic systems for utilizing solar energy passively: Direct Gain, Thermal Storage Wall, Attached Sunspace, Convective Loop, and Thermal Storage Roof. Each of these systems (discussed in detail below) can be visualized as an assembly of components, each of which performs a unique function and all of which are required for the effective operation of the overall system.

The basic passive systems are each comprised of five mutually dependent basic components: collector, absorber, storage, distribution and control.

Collector: The solar collector component is composed of transparent or translucent glazing, sealed in a frame and located on the south-facing side of the home. The collector glazing surface can be positioned vertically, as in windows, or sloped, as in a skylight on the roof.

Absorber: The absorber is a solid surface, usually dark colored, that is exposed to the sunlight entering through the collector glazing. The absorber "converts" the solar radiation into heat which is either delivered directly into the space for immediate use or stored in a "storage" component.

Storage: The storage component is composed of one or more materials which have the capacity to retain heat for a period of hours or perhaps days. The mass of a material is an important measure of its capacity to store heat. Residential construction materials, such as masonry, which are high in mass will be appropriate for storage components. The slow rate of heat discharge from the storage materials helps maintain a steady, comfortable temperature within the spaces to be heated. In some cases, the storage materials can be used to store "coolth" (coolth is to cooling as warmth is to heating) by absorbing heat from the living spaces and effectively cooling them. The storage material is sized according to the amount of solar heat the collector is intended to provide and is usually located in, or adjacent to, the rooms it is intended to heat and/or cool. The absorber and storage components are often one and the same, as in a masonry floor or wall.

Distribution: The distribution component delivers the collected and/or stored heat or "coolth" into the living spaces to be conditioned. Distribution can be by natural means, such as the radiation of heat from a wall or the movement of air by natural convection, or can be assisted by small pumps or fans which blow heat away from the absorber to the living spaces or to remote storage.

Control: Control components regulate the heat loss or gain into and out of the passive system. There are three basic types of control components: (1) shading devices which reduce the amount of solar radiation allowed to pass through the collector glazing; (2) reflectors which increase the amount of solar radiation passing through the collector glazing; and, (3) movable insulation which reduces heat flow through the collector and into adjacent spaces.

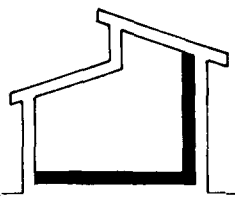
In summary, all these components interact in the following manner:

- the collector admits solar radiation onto the absorber;
- the absorber "converts" the radiation into heat;
- the storage medium retains the heat not immediately used;

Introduction

- the distribution component transfers heat between absorber and/or storage and the living spaces; and,
- the controls reduce heat loss and increase solar radiation gain in the heating season and/or shade the collector during the cooling season, reducing heat gain.

The precise configuration and appropriate materials for each of the components vary depending upon the system type. Each of the Basic Passive Systems is described in the following sections, as well as the arrangement of components which characterizes each.



Of all the passive solar types a Direct Gain system is perhaps the easiest to envision and construct. A Direct Gain design is one in which solar radiation directly enters and heats the living spaces. The home itself can be visualized as the collector of solar heat. Direct Gain is primarily a heating type system mainly applicable to mild and moderate climates.

In the heating season during the daylight hours, sunlight enters through south facing windows, glass doors, clerestories and skylights, all common collector components in Direct Gain homes. The solar radiation strikes and is absorbed and stored by elements within the space. The most common or primary absorber/storage components within a Direct Gain home are the floors and walls (see Figure 2.1).

Gain storage component materials are most readily incorporated in the floors and walls, which frequently serve a structural function (e.g., a masonry bearing wall). Typically, the distribution of heat is not crucial to the operation of a Direct Gain system as the heat is stored in the same space in which it is used. Heat flow which does occur is by natural convection, usually from one room to another through doorways and stairwells.

In a Direct Gain design, the amount of solar heat which is collected and retained can be controlled by two types of components. During the daylight hours components which reflect sunlight can be placed on the exterior of the home, usually adjacent to the collector components, to increase the amount of solar radiation entering the Direct Gain space (see Figure 2.2).

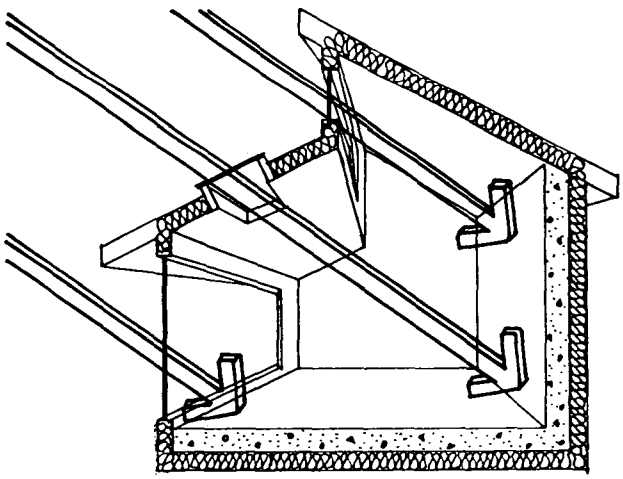


Figure 2.1

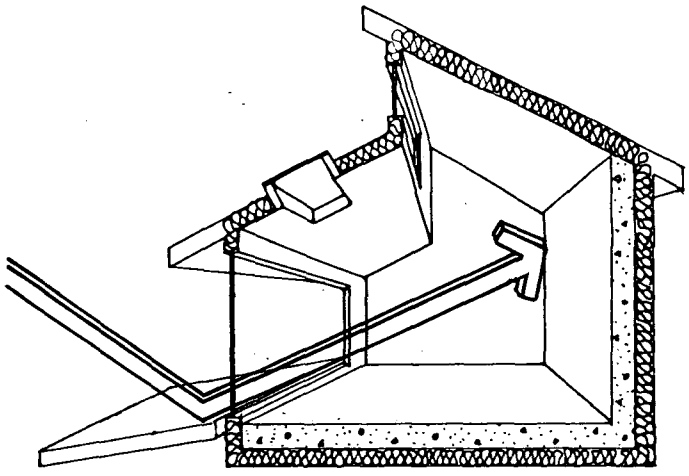


Figure 2.2

Although ceilings and other elements (e.g., furniture) within the space can be designed to store heat, common Direct

Essentially the reflecting component increases the effective collector area without increasing the actual square

footage, and the accompanying heat losses, of the collector.

At night, insulating components can be moved into place to prevent heat flow back out through the collectors. This movable insulation can be mounted either externally or internally. Frequently, in cases where a reflecting component is employed, the reflector serves a dual role by covering and insulating the collector in the evening (see Figure 2.3).

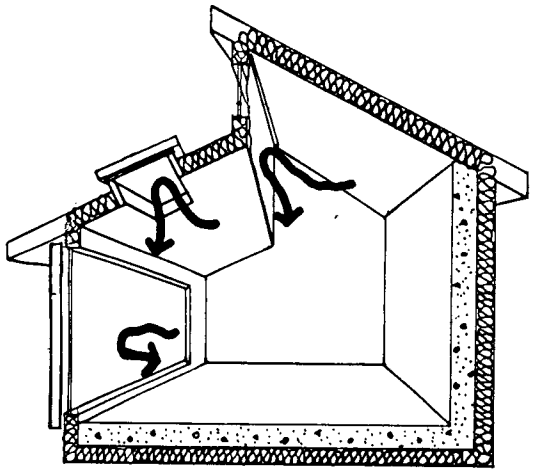
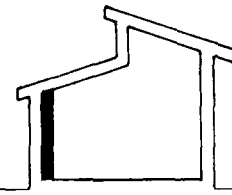


Figure 2.3

During times of the year when heating is not required, the Direct Gain collector should be shaded to control the amount of solar radiation reaching it. The most effective shading components are externally mounted, intercepting the sunlight before it passes through the collector. Interior shades (such as venetian blinds) can also be effective, reflecting some or most of the direct and diffuse sunlight, but will allow some heat build-up to occur. Failure to adequately shade the collectors may result in overheating of the Direct Gain spaces, increasing the cooling load. The movable insulating component can also be used to block solar radiation and reduce heat gain during the cooling season.



A Thermal Storage Wall system is characterized by placement of the storage component between the collector and living space. The storage wall typically provides structural support in addition to serving as the system storage component. Thermal Storage Walls are primarily used to supplement the space heating requirements, with secondary application as a cooling method. In general, Thermal Storage Walls should be considered for areas which experience mild to severe winters.

In the heating season solar radiation is allowed to pass through the collector glazing and is absorbed and stored by the wall. The wall heats up, transferring some of its heat to the living space and some to the column of air between collector and wall. This column of air can be exhausted directly into the living space, in which case it is referred to as a "vented" or "trombe" wall (see Figure 2.4); or can simply remain trapped between the glazing and the wall, in which case it is an "unvented" or "stagnating" wall (see Figure 2.5).

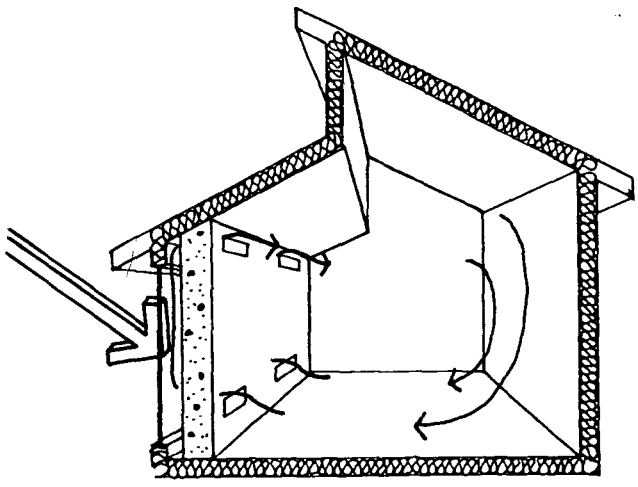


Figure 2.4

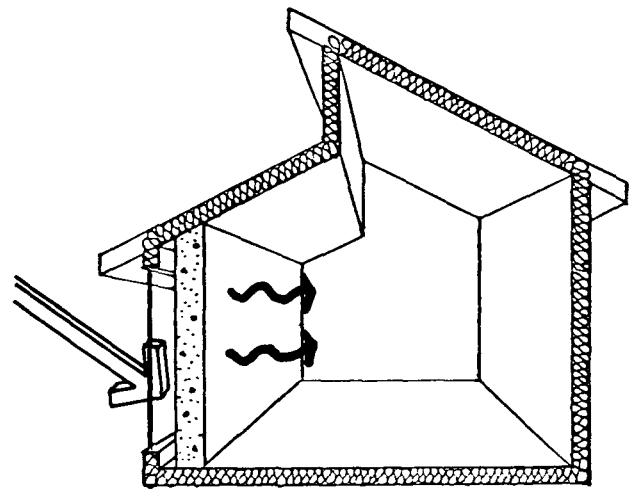


Figure 2.5

In both cases the heat in the wall will radiate to the adjacent living space throughout the day and evening hours.

Beyond the action of the vents in the "trombe" wall, distribution components are not fundamental to either type of Thermal Storage Wall. In some cases warmed air is ducted from the airspace between the collector and storage wall to remote living spaces, but this is not characteristic of the system operation and should be avoided if possible.

In a manner similar to the operation of the Direct Gain system, the performance of the Thermal Storage Wall can be regulated by control components. During the heating season, a reflector can enhance the amount of solar radiation striking the wall and, in the evening hours, an insulating component can be

placed either between storage and collector or outside the collector component to reduce heat flow from the wall to the exterior (see Figures 2.6 and 2.7).

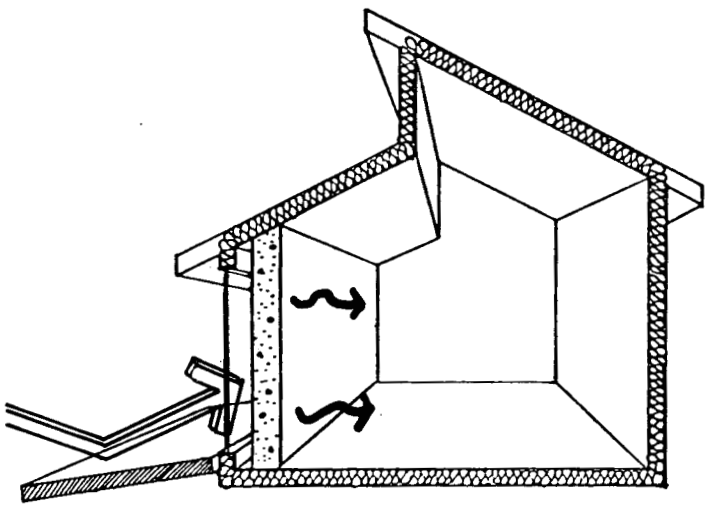


Figure 2.6

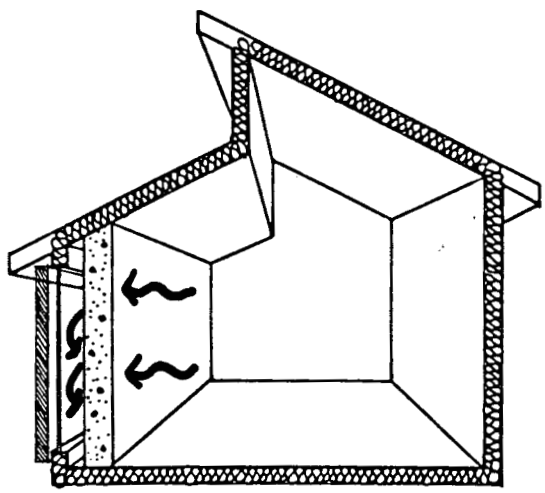


Figure 2.7

In the cooling season the impact of solar radiation should be controlled by shading the collector and storage components. Shading components are most effective when placed on the exterior but can also be installed between the collector and storage wall (see Figure 2.8).

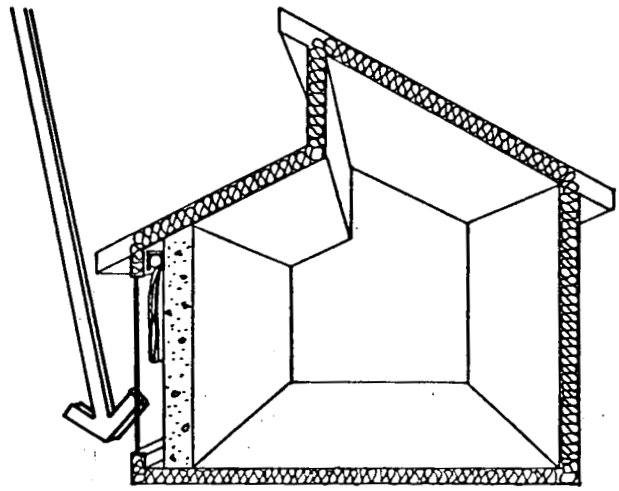
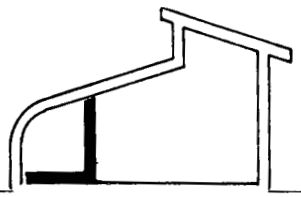


Figure 2.8

If designed properly, the movable insulation used to control nighttime heat flow out of the home during the heating season can be operated in the daytime during the cooling season to control unwanted solar heat gain. To further promote cooling, the airspace between collector and storage components can be vented to the outside. This is particularly effective in regions where the nighttime temperatures drop below the indoor temperatures. Venting the airspace will cool the storage wall in the evening, allowing it to absorb heat from the space during the day, reducing the space cooling requirements.



Attached Sunspaces are typically built as glass enclosed spaces, frequently constructed as extensions to homes. They are generally considered secondary use spaces in which heat is collected and either stored for later use or exhausted directly into the living space. The solar energy collected and absorbed by an Attached Sunspace is used to heat both the Sunspace itself and the adjacent living areas. The ways in which this energy is stored and distributed form the basis for distinguishing five separate Attached Sunspace "subsystems" which differ significantly from each other in terms of their operation, construction, and configuration of basic components. These are:

1. Open Wall Subsystem
2. Direct Gain Subsystem
3. Air Exchange Subsystem
4. Thermal Storage Wall Subsystem
5. Remote Storage Subsystem

During the heating season, sunlight enters the Attached Sunspace through the south facing collector (an expanse of glass or plastic), is absorbed by elements within the Sunspace, and is converted to heat. This basic process is the same for all the Attached Sunspace subsystems. It is only in the operation and location of the storage, distribution and control components that these subsystems differ significantly from each other (for further information see Section 3.3000).

All Attached Sunspaces will be designed for one of two basic modes of operation. In the first, the Sunspace is thermally isolated from the living area (see Figure 2.9). As a result of this isolation, the Sunspace is not treated as a conditioned space and its temperature is allowed to fluctuate outside the comfort range (e.g., during the night).

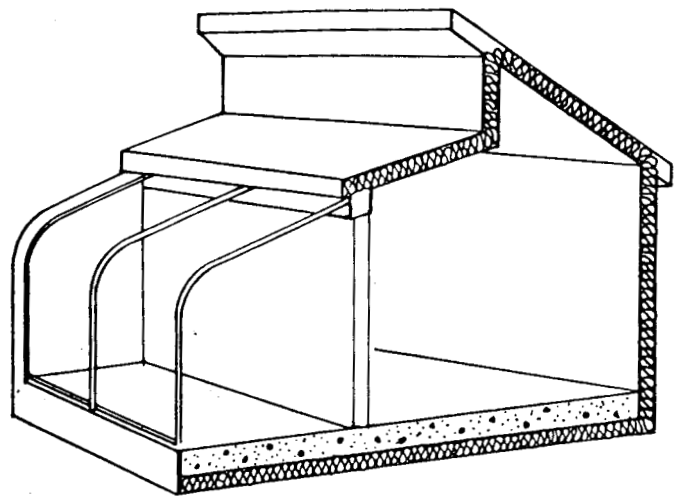


Figure 2.9

In the second mode, the Sunspace is not thermally isolated but is treated as an additional living space (see Figure 2.10).

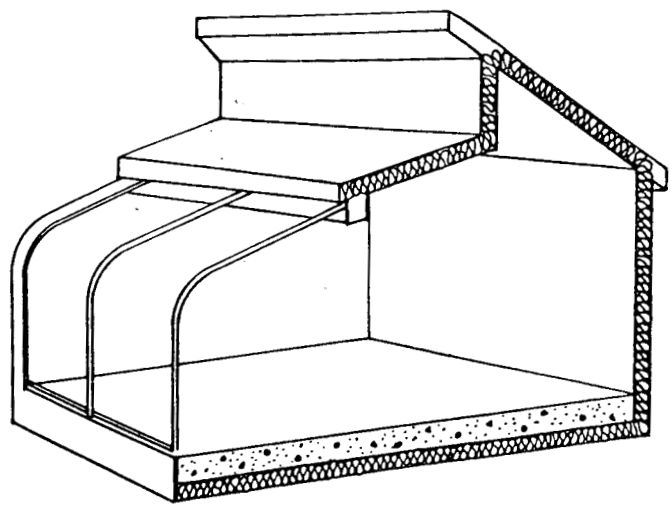


Figure 2.10

In this case, temperatures are not allowed to fluctuate but are maintained, by an auxiliary energy system when necessary, within the comfort range.

Similarly, the design and selection of the control components will vary with the selection of subsystem and operational characteristics. To prevent heat loss, a movable insulating component is typically placed along the collector glazing or between the Sunspace and adjacent living spaces depending upon the type of operation (see Figure 2.11). It is also possible to enhance solar heat gain by the use of a reflecting component.

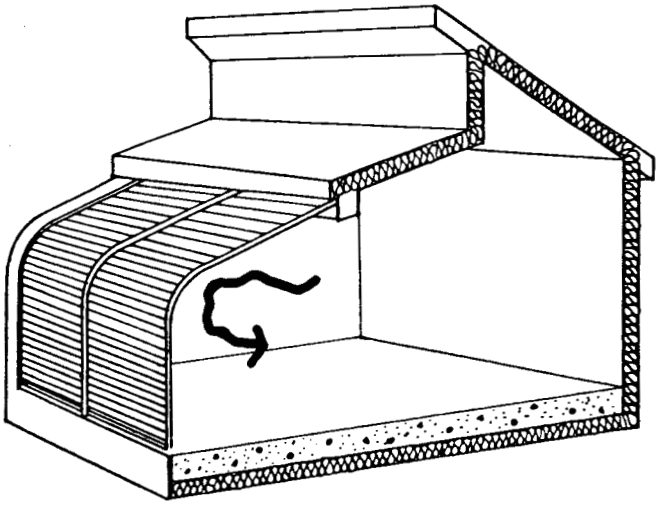
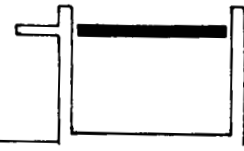


Figure 2.11

In the cooling season, the Attached Sunspace is particularly susceptible to overheating. Control of solar heat gain by shades and ventilation is critical to proper system functioning. In climates where the nighttime temperatures drop below comfort levels it is often possible to use the Attached Sunspace mass for storing "coolth," reducing daytime cooling loads.



As the name implies, the storage mass in a Thermal Storage Roof system (usually water or masonry) is located on the roof of the home. It is typically supported by some form of roof decking (metal or concrete) which serves as the ceiling for the space below and which provides for the efficient and even transfer of heat from the mass above. The location and operation of the storage component make Thermal Storage Roofs an appropriate passive system type for desert climates, where they can provide both effective heating and cooling.

Thermal Storage Roofs are unique in that they do not require a collector component. During the day, the storage component is simply exposed to the sky and heated by direct radiation from the sun. This heat is stored and slowly transferred through the ceiling deck to the living spaces below (see Figure 2.12).

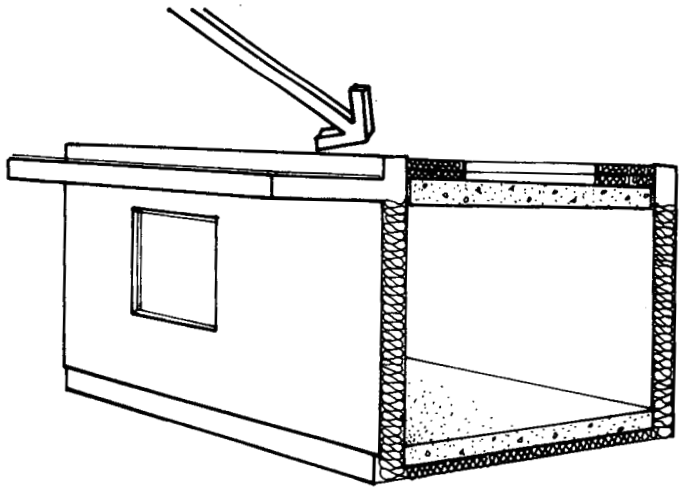


Figure 2.12

At night and during prolonged overcast periods, some form of movable insulation is provided to cover the storage component and reduce heat losses to the cool night sky and air (see Figure 2.13).

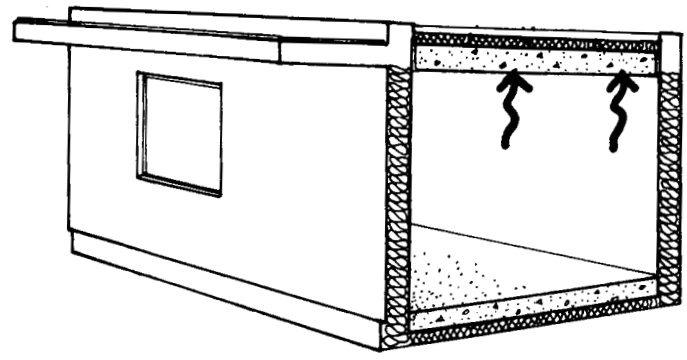


Figure 2.13

The primary control component is movable insulation which is typically mounted on tracks and moved into position using a small motor. Reflectors may be desirable to increase solar radiation during the heating season when the sun is low in the sky.

Of all the basic passive systems Thermal Storage Roofs are perhaps the most effective technique for providing passive cooling. During the cooling season, in areas with high diurnal temperature swings and clear night skies, the exposed storage component will be cooled at night. Loss of the collected "coolth" can be controlled by movable insulation which is placed over the storage component during the daytime to provide insulation and shading. The storage component will absorb heat from the living area during this period, and will effectively

cool the living space. At night the insulation is removed and the diurnal cycle is repeated (see Figures 2.14 and 2.15).

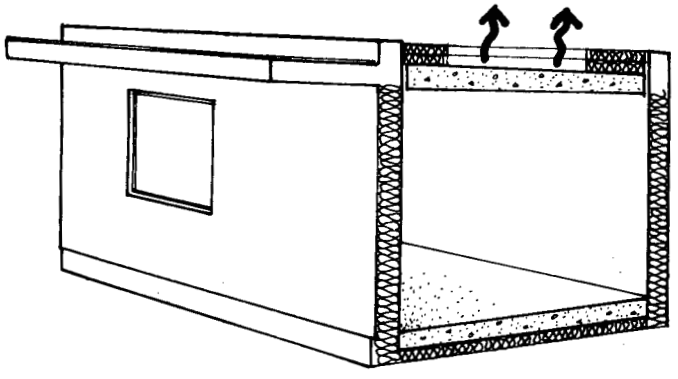


Figure 2.14

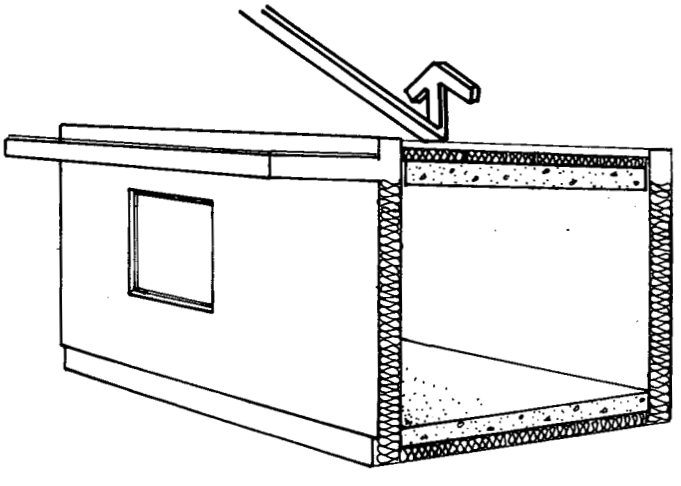
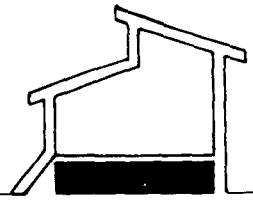


Figure 2.15



The Convective Loop is primarily a heating type system most appropriate in areas experiencing moderate to severe winters. It is based on the principle that a fluid, such as air, will rise when heated.

During the heating season, the Convective Loop collector admits sunlight which in turn strikes an absorber surface and is converted to heat. This heat is transmitted to the air in the space between the absorber surface and the collector. As the heat is collected at the lowest point in the system, the heated air rises up, passing out through a duct located at the top of the absorber, to be replaced by cooler return air drawn in from below. This warm air can be dumped directly into the living spaces or it can be diverted into a remote storage area, such as a rock bed, and used to provide heat as required (see Figure 2.16).

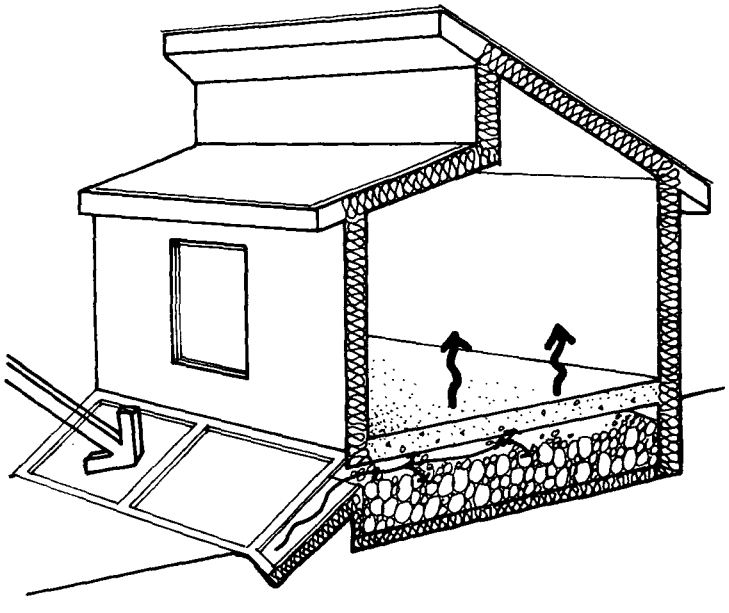


Figure 2.16

The major control component required by this system is some method for preventing the loop from reversing itself at night or during prolonged cloudy periods, drawing heated air out of storage. Simple backdraft or automatic thermostatically controlled dampers can be used to prevent this back flow. If such controls are provided it will not be necessary to insulate or shade the collector during the heating season.

It may be desirable to provide some form of reflector to enhance the amount of solar radiation striking the collector. Such reflectors are particularly appropriate for a Convective Loop because the system is thermally isolated, and often physically separated, from the living spaces. Common reflector problems associated with excessive radiation and glare in the living spaces are thus avoided.

During the cooling season the collector should be well shaded (see Figure 2.17) or covered to prevent possible damage to

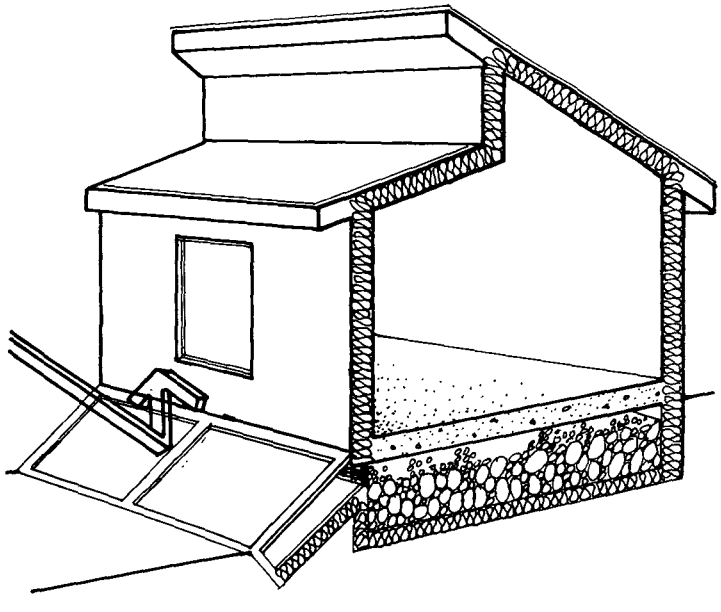


Figure 2.17

the absorber surface as a result of excessive heat build-up in the system.

Typically a Convective Loop system is constructed directly on the south wall of a home, or is a separate structure placed slightly in front of and below the first floor. In either configuration heat flow is by natural means. No fans or pumps are required, which constitutes a chief difference between this and typical active hot air systems.

A well designed passive home should not be considered as simply an extension of conventional design principles with the addition of "mass and glass." On the contrary, the desire to create a home which is attractive while also saving energy passively will require serious consideration of some basic precepts of passive and energy planning.

Many of these precepts are only briefly introduced in the Handbook, as the text is intended to be used in conjunction with a more detailed design primer. The design issues that are discussed in greater depth are those which directly impact the actual construction of the home and are, therefore, closely tied to the basic purpose of this document.

For example, in a well-designed passive home the living spaces should be placed on the south. Although this planning principle is implied throughout the text there is no comprehensive discussion on passive solar space planning, a topic which only indirectly influences the construction of the home. On the other hand, the dimensions of, for instance, the storage component in a Thermal Storage Wall, is a design issue which will impact construction and is, therefore, covered in a design rule of thumb. There are, however, two design-related areas which require some elaboration: selecting the appropriate system; and, specifying the components. These discussions, which follow below, are intended to provide a link between the design and construction detailing of the passive home.

This section ends with a review of various techniques for evaluating the passive design both in terms of energy and economic savings. These techniques are briefly introduced and, together with the Appendices, provide the reader with ready access to many of the analysis tools.

Selecting a System

The selection of an appropriate passive system will include many criteria well beyond the scope of the Handbook. However, it is clear from much of the research conducted to date that each of the individual systems described in FUNDAMENTALS will perform best, and tend to be most cost effective, in particular climate regions. Throughout the discussion of the systems in "Basic Passive Systems" above and in Section 3., five climate types are mentioned: mild, moderate, moderate-severe, severe, and desert. Each individual system discussion includes a basic recommendation as to the appropriate climate region(s) for that system.*

The map in Figure 2.18 indicates the boundaries for each of these climate regions (excluding the desert areas). The recommendations used throughout the text can be summarized as follows:

System	Appropriate Climate(s)
Direct Gain	Mild to Moderate
Thermal Storage Wall	Moderate to Severe
Attached Sunspace	Moderate to Severe
Thermal Storage Roof	Desert
Convective Loop	Moderate to Severe

* These climate region definitions and system location recommendations are extracted from work conducted at the Los Alamos Scientific Laboratories by D. Balcomb, et al.

It should be strongly emphasized that these recommendations are intended to serve only as a general guide to system selection and should be superseded by a specific economic/energy analysis, prior experience, or particular preference. However, it should be kept in mind that these recommendations do indicate, to some extent, the climates to which the inherent operating characteristics of the systems are best suited.

Specifying the Components

Once a system is selected the components which comprise the system need to be specified. As discussed briefly in the INTRODUCTION, once a construction detail is chosen the exact selection and sizing of the materials comprising that detail will require the information and data contained in Sections 3. and 4.

In most cases the specification procedure is a simple and straightforward one. For example, if in selecting the Thermal Storage Wall system the storage component is to be specified, the first step is to consult the storage rules of thumb in the CONSTRUCTION section (see Page 3.2006). These rules of thumb are basic design guides which define the parameters for efficient operation of the system. They also indicate criteria for material selection and sizing. Once such criteria are established, the MATERIALS section is referenced and particular materials are selected for use.

Continuing with the example above, if the detail selected illustrates a Thermal Storage Wall with a masonry storage component, sizing criteria can be obtained from the storage rules of thumb and particular masonry materials can be specified from the information in Section 4.2000, "Storage Components."

In other cases, such as the specification of the collector component, the process must be taken one step further. The materials information contained in Section 4.1000, "Collector Materials," is of a general nature due to the wide variety of applicable products on the market. For instance, glazing types are discussed (e.g., double glazing) but particular manufacturer's products are not presented. In these cases the exact material selections will require a check of the specific manufacturer's product specifications to verify conformance with the rules of thumb (Section 3.) and general selection criteria (Section 4.) before a particular material is specified.

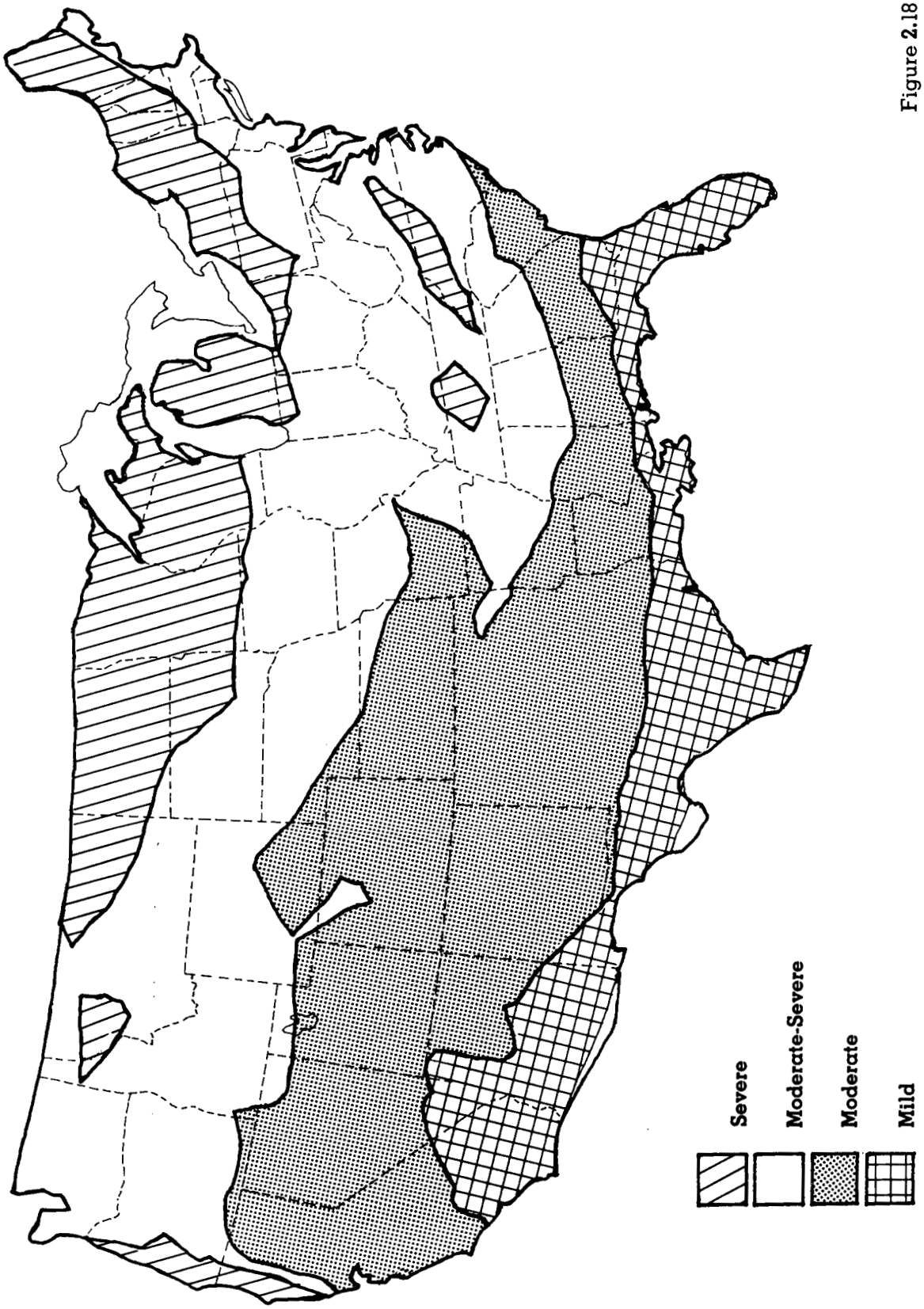


Figure 2.18

At many points in the design process it is useful to have access to design and energy use analysis methods for the purpose of sizing the passive solar components and estimating the energy use of the house. Depending upon the complexity of the design and required accuracy of results, a variety of methods is available for design and energy use analysis. These methods can be grouped into four categories reflecting the tools required to use the method and, to a limited extent, the degree of difficulty in using the method, the flexibility of the method to evaluate a range of design and material types, and the accuracy of the results. The four categories include: (1) manual procedures; (2) programmable calculator programs; (3) microcomputer programs; and, (4) computer programs. Each category is discussed briefly below. A description of specific programs can be found in Appendix C.

Manual Methods

The first category, manual procedures, includes methods in which the projected energy use can be calculated using paper and pencil and, frequently, preprinted charts, tables and graphs.

The manual methods are often simplifed codifications of computer programs. In the process of simplification, however, many characteristics of the passive building which the computer can treat as variables, become fixed as constant values, often referred to as assumptions or "default values." For example, in estimating the performance of a Thermal Storage Wall most manual methods assume the wall is eighteen inches thick. In latter sections it will become evident that such a wall can have a range of thicknesses. Unfortunately, the user of these manual methods may not have the flexibility to vary the material dimension and must, therefore, expect that the projected energy use will be in slight error if a thickness other than eighteen inches is used. The computer program from which the manual method was derived may have allowed the user to vary the thickness, but the manual method may only be applicable if characteristics, such as the wall thickness of the home to be analyzed, are similar to the assumptions. Innovative designs may not be able to be accurately evaluated. The manual methods are, therefore, only applicable within a certain range of assumptions, yielding only gross estimates of estimated building energy use. Most require a one to two day familiarization period. A single analysis can take a few minutes to a few hours, depending upon the method.

Programmable Calculator Programs

The programmable calculator programs are typically magnetic cards prepared for use with hand-held calculators. Frequently, the accuracy and applicability is similar to the manual methods described above for the same reason: the programs are simplified versions of computer programs requiring numerous fixed characteristics. The advantage of using the calculator programs is the speed with which the analysis can be performed. A single analysis rarely requires more than about fifteen minutes and, frequently, less. For most passive solar home designs the accuracy of the programmable calculators should suffice. The programmable calculators required to utilize the magnetic cards currently cost approximately $200 ($350 with a compatible printer).

Microcomputer Methods

The next level up from the programmable calculator in both ability to perform energy analyses quickly and degree of flexibility in describing the home is the microcomputer. The use of microcomputers begins to free the designer from the limitations of the manual and programmable calculator methods described above. The results of microcomputer analyses tend, therefore, to be more refined and accurate for relative comparisons of energy use, and able to accommodate wider variations in design than either the manual or programmable calculator methods. A single energy use analysis of a designed home will typically require about fifteen minutes. The cost of a microcomputer system can vary significantly, although units costing less than $1,000 are currently available.

Computer Programs

By far the most flexible, complex and detailed analysis methods are the computer programs. These programs compute, in a few moments, the energy usage patterns of the designed home at one hour increments for a calendar year (8,760 hours). A similar analysis, performed manually, would require months of calculation by a knowledgeable mathematician. This high degree of accuracy in computing energy may, in fact, be well out of proportion to the design being evaluated. To program a single home may require several days. For most residential designs one of three methods previously described should be sufficient. Computers are, perhaps, more applicable to commercial or multifamily structures whose complexity demands a sophisticated analysis method. When using a computer program it is often most economical to purchase computer time from a so-called "timesharer." A single analysis will vary in cost depending upon the program desired and timesharer's rates.

One frequently overlooked aspect of all the energy use analysis methods discussed above and in Appendix C is the accuracy of such techniques in estimating the actual energy use of the home when constructed. Because of the uncertainties involved in the operation of the home, including the habits and lifestyles of the homeowners, any correlation of projected and actual energy use is coincidental. This fact should not cloud the real value of employing one of the large variety of energy use analysis methods available. The value of these tools lies in their relative accuracy of projected energy use.

For example, two homes are analyzed: one poorly insulated with little solar contribution, the other well insulated and designed to provide a large portion of the space heating and cooling requirements from passive solar. The energy use, projected by one of the methods discussed above, would indicate to the designer the relative merits of the two solutions. If the poorly insulated design requires a projected five hundred gallons of oil per year for heat and the second home two hundred and fifty gallons, the designer should consider that the solar design will reduce energy use fifty percent, but not necessarily save exactly two hundred and fifty gallons of oil.

The relative accuracy of the various analysis methods appears to vary primarily depending upon the passive system being analyzed and the location of the home (the subtleties of applicability of the various methods are discussed in Appendix C). This situation is illustrative of the state-of-the-art in passive solar analysis. However, a variety of activities is currently underway intended to develop a consensus on how passive solar residential buildings should be evaluated.

Again, this should not dissuade the reader from selecting and using one of the analysis techniques. After a short time analyzing various designs and passive systems the designer will develop an intuitive sense of the relative performance of design alternatives. It is in helping to develop this intuition that the analysis tools have greatest value.

Whether or not a home sells has traditionally been a function of a number of factors, not the least of which is cost, specifically first cost. In the past, other costs associated with homeownership, specifically operating costs, rarely entered into buyer/seller discussions. Consequently most economic decisions relating to design, material selection and site planning tended to be made based upon first cost criteria. By far the major costs of homeownership were monthly mortgage payments, a reflection of the first cost and current interest rates. Due to low fuel cost, energy efficiency was seldom a factor in home sales.

At present, as energy cost increases continue to outstrip inflation, the first cost approach to decision making is being replaced by an economic indicator capable of reflecting the impact of energy costs. This measure combines both the first costs and the operating costs of a home into a measure reflecting the overall "economic efficiency" of the home. This measure replaces the simple first cost and consequent monthly mortgage payments with a value which can reflect the full range of homeownership costs.

As a simple example, suppose a home built in New York State costs $100,000. The buyer makes an initial payment of 20% or $20,000 and takes an $80,000 mortgage. Assuming a 15%, 30-year term rate, the monthly mortgage payments are $1,015. An analysis of the energy use indicates an average monthly expenditure of $124 or $1,493 per annum on fuel. The total monthly cost to the homeowner is, therefore, 1,015 + 124 = $1,139.

Another buyer purchases an equivalent home except the design has been modified to incorporate passive solar and energy conservation features. The passive home uses an Attached Sunspace and additional insulation to reduce the home heating requirements (see Figures 2.19 and 2.20).



Figure 2.19

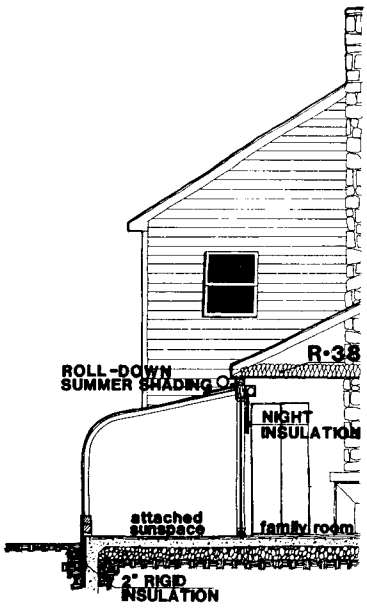


Figure 2.20

Economic Analysis

The following table summarizes the significant criteria for comparing the homes:

Case Study

Description:
4 bedroom home in New York State
Heated Area:
2124 sq. ft.
Solar Features:
Attached Sunspace with Movable Insulation

Manufactured Sunspace:	$1,800.
Additional Masonry:	500.
Exterior Shades:	200.
Movable Insulation:	800.
Added Insulation:	300.
TOTAL	$3,600.

Monthly Expenses:

Base Case:	Mortgage:	$1,015.
	Fuel:	124.
	TOTAL:	$1,139.
Passive Home:	Mortgage:	$1,051.
	Fuel:	74.
	TOTAL:	$1,125

It is evident from the above that the incremental or additional costs attributable to the solar features add $3,600 to the first cost of the base case home. Again assuming that 80% of the total cost ($103,600) is financed, the initial cash outlay is $20,720, or $720 higher than the base case. With the 15%, 30-year term mortgage the monthly payments are increased to $1,051, $36 above the base case home. However, due to the energy saving features, the estimated costs for fuel are now $881 per year or $74 per month average. The total monthly homeowner expenditures equal $1,125 or $14 less than the base home. With this $168 per year savings, the initial additional outlay of $720 is recovered in just over four years. In addition to continually accruing these savings (relative to the less energy efficient home), the owner of the passive solar home has the additional amenity of the Sunspace! Expressed in these terms the economics of an energy efficient home can provide a powerful marketing tool.

One procedure developed for determining the costs and benefits which accrue over the lifetime of a home as a result of including energy conserving features is the Life Cycle Cost Analysis. Life Cycle Costing (LCC) analyzes the costs of energy used by the building, together with the net costs of purchase installation (less any salvage value), maintenance, repair/replacement, and any other costs which accrue as a result of the energy conservation investment.

The LCC analysis is a useful tool in evaluating the economic efficiency of the passive solar techniques described in this text. Essentially, the passive solar technique with the lowest LCC, while satisfying other design considerations, is the preferred investment.

The general formula for LCC is as follows:

$$LCC = P + M - S + R + E$$

P, Purchase and Installation Costs

M, Maintenance and Repair Costs

S, Salvage Value

R, Replacement Costs

E, Energy Costs

The method can be used to evaluate alternative investment strategies, such as energy conservation and passive solar versus conventional heating and cooling equipment investments.

In addition to the LCC analysis three other energy related tools are available which can be used to evaluate investments in a comprehensive manner. Included in this categorization are the following:

1. Net Benefits or Savings (B-C): The net benefits method is used to determine the difference between the life-time dollar savings and costs of

the energy reducing investment. The preferred investment is the one which maximizes the Benefit-Cost difference.

2. Savings-to-Investment Ratio (SIR): In this case the savings and investment associated with an energy reducing option are expressed as a ratio. Any investment yielding a ratio greater than one is cost effective. Furthermore, the higher the ratio, the greater the savings per dollar invested.

3. Internal Rate of Return (IRR): The IRR is the compound rate of interest which, when used to discount life cycle costs and benefits, will cause the two to be equal. The IRR is compared to the investor's minimum acceptable IRR to determine if the investment is acceptable.

A last method for deriving a measure of economic efficiency should be mentioned. The "Discounted Payback" is a tool which measures the required elapsed time to recover an investment. The measure is discounted to account for the time value of money. If not discounted the measure is called "simple payback." In the example stated above the approximate 4-year term to recoup the investment is a simple payback expression.

Ultimately the decision as to whether or not to invest in a passive solar technique should be an economic one. Throughout the text numerous design recommendations and rules of thumb are presented to aid in the design process. Design guides should be checked and, if required, superseded by design decisions based upon one of the economic analysis methods described above. Detailed explanations of all these methods are available (see BIBLIOGRAPHY).

To date, few publications have been widely distributed which focus on the construction detailing of passive solar homes. In most respects the construction of a passive solar residence utilizes standard construction procedures, although the actual configuration of the materials may not be typical. The intent of this section of the Handbook is to identify the unique aspects of passive construction and to offer some guidelines for designing and detailing passive homes.

The section is organized by system type. The systems, introduced in PASSIVE SOLAR FUNDAMENTALS (Section 2.0000), are Direct Gain, Thermal Storage Wall, Attached Sunspace, Thermal Storage Roof and Convective Loop.

(Author's note: Thermal Storage Roof and Convective Loop are not included as they are to be the subject of a future update of the Handbook.)

Each section is divided into subsections, the first of which reviews and expands upon the general system descriptions introduced in PASSIVE SOLAR FUNDAMENTALS. The system operating characteristics are described, as well as general guidelines for system design and sizing. Specific information on each of the passive components and its use in the system is also presented.

Because of the number and variety of construction details presented for each passive system an indexing method has been developed based upon the use of what are called "Key Pages."

These Key Pages follow the general system description and each covers a specific construction material or combination of materials in a particular passive configuration. For example, in the Direct Gain system a concrete masonry wall can be employed as a storage component. A Key Page with a cross-section through such a wall is presented along with an index indicating those pages which contain details of this wall used as a passive component.

The Key Pages are arranged by component type in the following order: Collector, Absorber, Storage, Control, and Distribution. In the systems where the same component serves both an Absorber and Storage function, the Key Page is listed only under Storage. Furthermore, in cases where one or more of the component types may be the subject of a future update of the Handbook (e.g., Control Components for Direct Gain Systems) the Key Pages are simply omitted.

The exception to this organization is the Attached Sunspace system in which the Key Pages illustrate the five subsystem organizations as discussed in PASSIVE SOLAR FUNDAMENTALS. Each Attached Sunspace Key Page contains information regarding all of the applicable components.

The backs of all Key Pages contain notes providing basic construction guidelines. These notes supplement the construction notes which accompany the details.

The Construction Detail Pages follow the Key Pages and illustrate a recommended method for building the component. Each detail is described on two pages. On the first is a drawing of the detail, in most cases a floor/wall or wall/roof connection. Relevant Construction Notes are presented on the following page. These notes, in conjunction with the Key Page notes, identify major considerations in the construction of the detail. In most instances appropriate alternative details are also presented.

The system sections end with a series of Case Studies. Each Case Study includes a rendered elevation, floor plan(s), building section, and relevant detail(s) of a passive home utilizing the specific system being reviewed. The intent of the Case Studies is to illustrate how the details and concepts presented in the Handbook have actually been incorporated into homes designed and built to save energy. Many of the details highlighted are similar to those illustrated in the Handbook, while others convey potential alternative approaches. All should be treated as possible models for specific applications as well as inspirations for innovative new solutions.

Design Overview

Direct Gain systems are designed to be used primarily for heating and are most effective in areas with mild or moderate winter climates. In a Direct Gain system the collection, absorption, and storage of solar energy occur directly within the living space. The conceptual simplicity of this arrangement is compelling. As a result of intelligent planning and minor modifications in standard building practice the home itself becomes the passive solar system. Living within the system can, however, pose certain problems for the residents and attention must be paid, during the design of the building, to questions of space planning, privacy, natural lighting, glare, overheating, and fading and deterioration of fabrics exposed to direct sunlight.

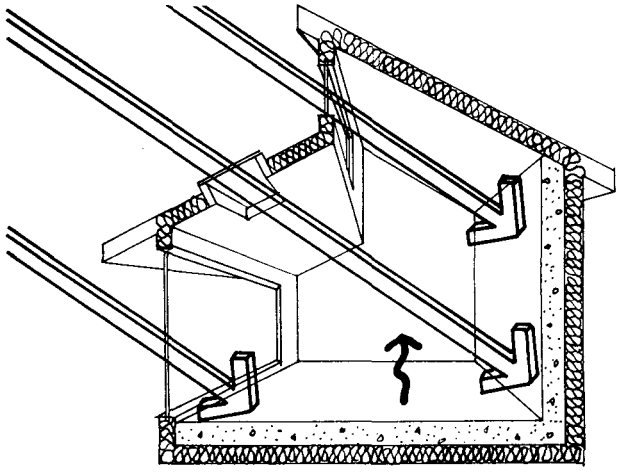


Figure 3.1

Seasonal Operation (Heating)

During the heating season, sunlight enters the living space through an expanse of south facing collector (usually glass). This solar radiation is in turn absorbed by elements in the space (e.g., floor, walls, ceiling and furnishings) and converted to heat, which either warms the air in the space or is stored in interior storage elements for later use (see Figure 3.1).

These storage elements are generally made of high mass materials, typically masonry, and most often serve as basic structural components (e.g., walls and floors) of the building.

Interior storage mass should be as evenly distributed as possible throughout the spaces to be heated, rather than concentrated in one area. For example, 400 square feet of 4" thick exposed mass is more effective than 200 square feet of 8" thick material. It is also recommended that as much mass as possible be located so that sunlight strikes it directly. It is often difficult, however, when distributing mass throughout a Direct Gain space, to provide direct sunlight over the entire surface area. Mass not located in direct sun will absorb heat from warmed air, but may not absorb and store as much heat as mass in direct sun. Therefore, in cases where storage mass is evenly distributed through the space, some method for distributing the sunlight to this mass might be investigated (see Figure 3.2).

Reflecting sunlight from light colored non-storage surfaces is one technique. Another is to use a glazing which diffuses and scatters the light. Either of these approaches should be considered in combination with standard glazing depending on specific design conditions.

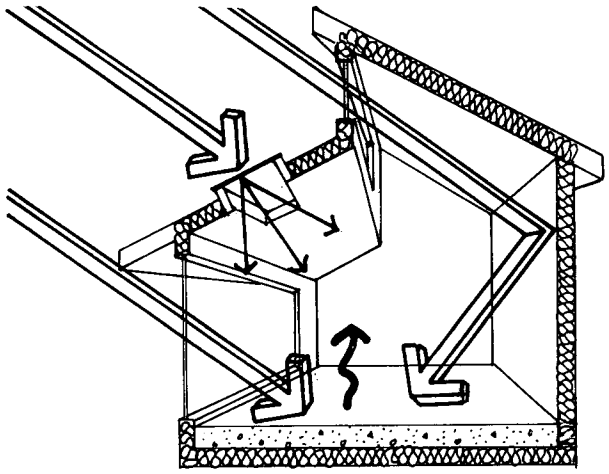


Figure 3.2

Seasonal Operation (Cooling)

During the cooling season, the south facing collector should be well shaded to prevent excessive heat gain (see Figure 3.3).

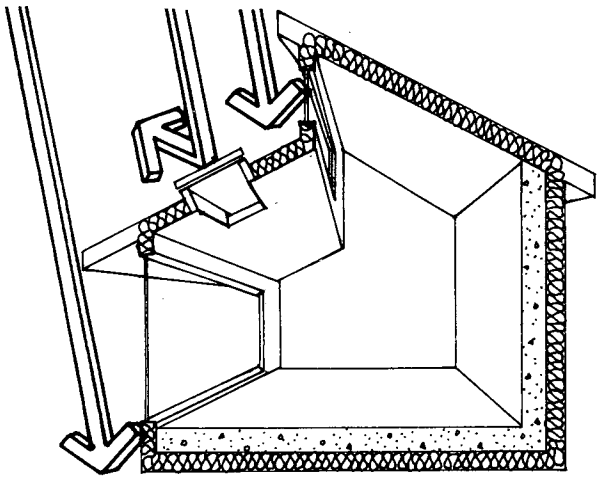


Figure 3.3

Shading elements such as overhangs should be sized so as to maximize overall system performance. If they are too large, overhangs may completely prevent unwanted solar gain during the cooling season, but will also block a significant amount of radiation during the early part of the heating season. Conversely, if they are too small solar gain will be maximized when heat is needed, but overheating will occur during the late part of the cooling season, adding to the overall load on the auxiliary energy system.

Advantages

- Conceptually the most straightforward, Direct Gain can also be the easiest to build using standard construction materials and methods.
- The system does not radically alter the appearance of the home.
- Considerations of privacy make it more likely that movable insulation will be utilized, at least at night, because the Direct Gain living space is often directly visible from the exterior.
- The system provides natural light and view in addition to energy savings and can, therefore, reduce lighting energy consumption.
- The system can have a very low additional cost, relative to identical buildings without "solar" and to other passive systems.

Disadvantages

- Large expanse of south facing glazing can cause glare and privacy problems.
- Ultraviolet radiation in sunlight can fade and degrade fabrics.
- Manual operation of movable insulation may meet with homeowner resistance, decreasing

performance and reducing marketability.

Collector

The principal function of a Direct Gain collector is to admit and trap solar energy so that it can be absorbed and stored by elements within the Direct Gain space. Although generally perceived as energy losers, the large expanses of south facing collector used in Direct Gain applications can, if properly designed, gain significantly more energy than they lose.

There are three basic types of Direct Gain collectors: Solar Windows, Clerestories, and Skylights (see Figure 3.4).

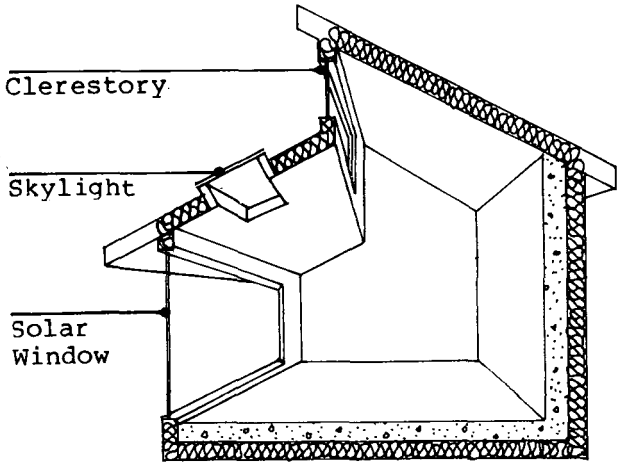


Figure 3.4

Solar Window

A "Solar Window" is simply a standard off-the-shelf window or patio door, installed in a south facing Direct Gain wall using conventional construction methods. The collector frame can be wood or metal and should be well caulked and weatherstripped. If metal is used, the frame should contain thermal breaks.

The solar window can be vertical or it can be tilted so as to maximize the amount of incoming solar radiation. A tilted collector is often difficult to install and may require tempered glass. It can also be hard to shade and may pose significant overheating problems during the cooling season.

Glazing materials other than glass can be used in solar windows, although they are not generally available in preframed, off-the-shelf configurations. Such materials include various forms of fiberglass, acrylics, and polycarbonates (possible local building code restrictions on the use of these alternate materials should be investigated before they are specified). Materials that will diffuse and scatter the incoming light should receive special consideration as they can improve the overall performance of a Direct Gain system by increasing the amount of radiation reaching the distributed mass.

Double glazing is recommended for most climates. Triple glazing should be used in severe climates especially if some form of movable insulation is not provided. Single glazing can be used in mild climates if movable insulation is provided.

Clerestory

Clerestories serve the same function as solar windows but can avoid problems with privacy, glare and fading of fabrics. They also allow light to penetrate deeper into a space than may be possible with windows alone, often enabling the light, for example, to strike the north wall of the home. In situations where site obstructions, such as trees, prevent light from reaching standard solar windows, clerestories can be used to admit solar radiation to a Direct Gain space. As in solar windows, clerestories can be vertical or tilted and the problems associated with the latter configuration are the same for both collector types.

Special attention should be paid to properly sealing and caulking the clerestory, especially in tilted installations.

The full range of collector materials available for "solar windows" can also be used in clerestories. If glass is chosen, double glazing is again recommended, and special glazing may be necessary in tilted configurations to prevent breakage. Several clerestories can be used together in a "sawtooth" pattern in order to increase the total amount of solar radiation entering a building (see figure 3.5).

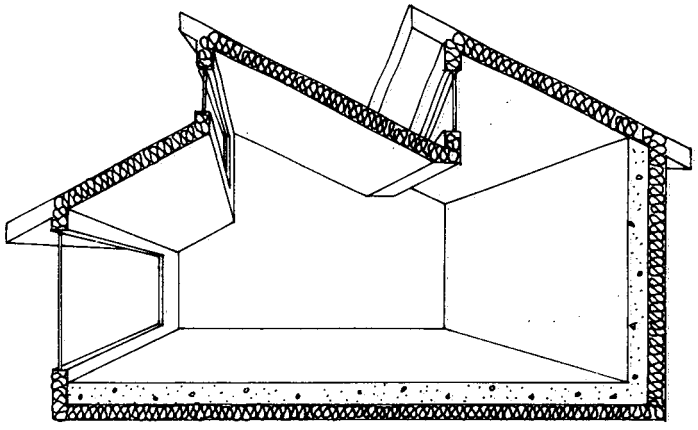


Figure 3.5

Skylight

Skylights serve the same function as the other Direct Gain collectors and can be placed flat on a flat roof or tilted in a south facing roof. As the horizontal position does not receive a great deal of sunlight during the heating season (when the sun is low in the sky), it is recommended that a reflector be used in this configuration to enhance the amount of solar energy hitting the collector (see Figure 3.6).

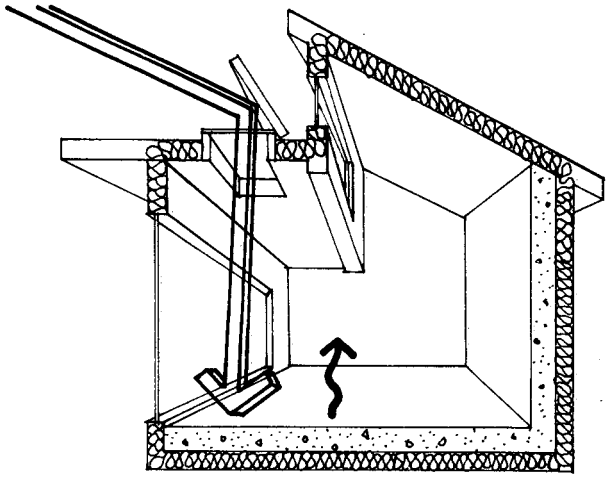


Figure 3.6

As in clerestory installations, special attention should be paid to properly sealing and caulking a skylight because of the increased potential for water leakage in a flat or tilted configuration. Once again, the full range of collector materials can be used, subject to local building code restrictions. In many cases lighter, translucent materials may be preferable to glass because of their optical and handling characteristics, and a variety of plastic "bubble" skylights is available off-the-shelf. If glass is used, special glazing may be required.

Rules of Thumb

All Collectors

- Orientation:
  Collector wall must face south. Variations up to 20° east or west of true south, however, will not significantly affect thermal performance. A slight east of south orientation may be desired to allow the sun to "wake up" the living space in the morning.

- Collector Area:
  The recommended collector area per square foot of floor area to be heated can be determined from Table 3.1.

Table 3.1

Average Winter Outdoor Temperature (Clear Day)*	Glazing/Floor Area** 36°NL	40°NL	44°NL	48°NL
COLD CLIMATES				
20°F	.24	.25	.29	.31 (w/NI)
25°F	22	.23	.25	.28 (w/NI)
30°F	.19	.20	.22	.24
TEMPERATE CLIMATES				
35°F	.16	.17	.19	.21
40°F	.13	.14	.16	.17
45°F	.10	.11	.12	.13

Note: NI indicates Night Insulation.

* Temperatures listed are for December and January, usually the coldest months.

** These ratios apply to a well insulated space with a heat loss of 8 btu/degree day/square foot of floor area/°F. If space heat loss is more or less than this figure, adjust the ratios accordingly.

For example for Madison, Wisconsin, at 43°NL with an average January temperature of 21.8°F (data available from local and/or national weather bureau), the intersection of the closest latitude (44°NL) and the closest "Average Winter Outdoor Temperature" (20°F) indicates that 0.29 square feet of glazing per square foot of floor area is required. For a living space with a floor area of 200 square feet to be heated, 58 square feet (200 x 0.29) of south facing glazing will be required.

- Number of Glazings:
  Double glazing is recommended for most installations. Triple glazing should be used in severe climates, especially if movable insulation is not provided. Single glazing can be used in mild climates if movable insulation is provided.

- Operation:
  All collectors should be operable to provide natural ventilation during the cooling season.

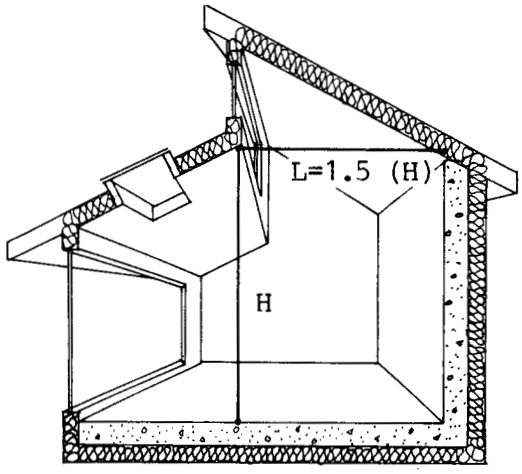


Figure 3.7

Clerestory

- Color:
  The ceiling adjacent to the clerestory should be light in color to reflect sunlight into the Direct Gain space and onto interior storage elements.

- Location:
  Clerestories should be placed in front of a Direct Gain storage wall at a distance of roughly 1.0 to 1.5 times the height of the wall (see Figure 3.7).

- Sawtooth Clerestories:
  The angle of a sawtooth clerestory (as measured from the horizontal) should be equal to, or less than, the altitude of the sun at noon on December 21, the winter solstice (see local climate data for information). For example, at 36°NL angle A will equal 30° (see Figure 3.8).

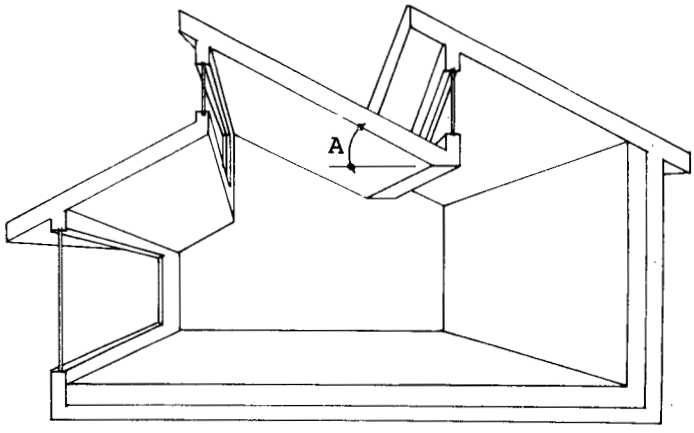


Figure 3.8

Skylight

- Reflector:
  A reflector is recommended for horizontal skylights to increase winter solar gain (see "Control" below).

Storage

In Direct Gain systems, solar energy can be stored in the floor, walls, ceiling, and/or furnishings of the living space if these components have sufficient capacity to absorb and store heat and to reradiate this heat to the living space slowly. Most common high-mass construction materials (concrete masonry, concrete, brick) have this capability and can be used effectively in Direct Gain applications (see Figure 3.9).

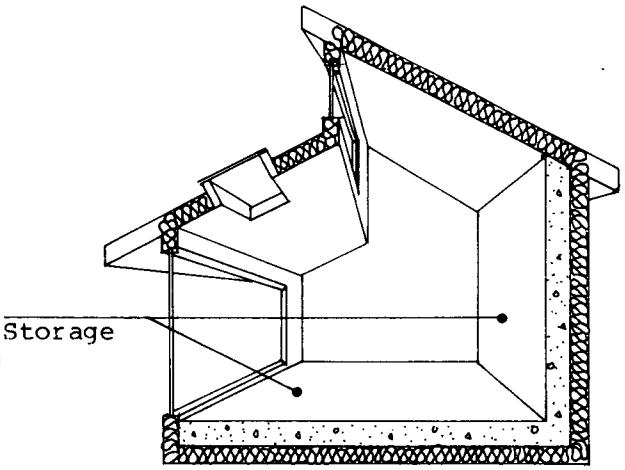


Figure 3.9

The amount of distributed mass required for effective performance will vary depending upon the requirements of each specific installation. In general, within the thickness ranges covered in the Rules of Thumb below, thin material spread over a large area will perform better than thick material concentrated in one portion of the space. Care should be taken to ensure a balanced distribution of mass throughout the space.

Storage materials should be located so that they are struck by direct or diffuse sunlight for as much of the day as possible. Storage mass which is heated only by convected air from the living space requires roughly 4 times the square foot area as the same mass in direct sun. Storage mass which is located in direct sunlight will perform slightly better in a vertical (wall) rather than in a horizontal (floor, ceiling) configuration.

If pavers are used in a storage floor, they should be laid so that no voids exist between adjacent units. Good thermal contact should be maintained (by grouting or actual physical contact) between all units to ensure efficient transfer and even distribution of heat.

Storage floors, walls, and ceilings in direct sunlight should be dark in color to increase the absorption of solar energy. All adjacent non-mass surfaces should be light colored in order to reflect as much solar radiation as possible onto the storage surfaces.

If walls and floors are both used for storage, walls can be light if the floor is dark. Interior finishes over the storage materials (other than dark paint) will reduce the ability of the mass to absorb and reradiate heat. Plaster and wallpaper will reduce performance only slightly and gypsum board can be acceptable (although it is not recommended) if care is taken during installation to apply a very thick coat of construction adhesive in order to increase the thermal connection between the wall and the gypsum board. Wall to wall carpet over a storage floor is emphatically not recommended.

Rules of Thumb

- Area:
  It is recommended that for every square foot of south facing glazing area, 3 square feet of storage mass, designed to receive direct sun, be provided.

- Thickness (Floor):
  Recommended thickness of the storage floor material: 2" to 6" (generally 4").*

- Thickness (Wall):
  Recommended thickness of storage wall materials: 2" to 4".*

  *NOTE: Dimensions cited are actual not nominal. If restrictions on local availability of materials require using thicknesses outside the ranges listed, it is generally more thermally efficient to employ thicker rather than thinner units. (At thicknesses greater than 4" performance will increase, but not significantly. At thicknesses greater than 8" performance can decrease.)

- Color:
  Storage mass exposed to direct sunlight should be a dark color.

- Masonry Grouting:
  Masonry units should be solid or have grout-filled cores. A full mortar bedding is recommended.

Control

Shading

To avoid excessive heat gain in summer and increase overall system performance, it is recommended that some method be provided for shading the Direct Gain collector. The most thermally effective shading devices are those placed on the exterior of the home, such as simple overhangs (fixed or adjustable), trellises, vegetation (deciduous trees, etc.), awnings, louvers (horizontal or vertical, fixed or adjustable) and wing walls (see Figure 3.10).

Interior shading devices, while often not as thermally effective as exterior units, are generally easier to operate and maintain. Common interior shading devices include: roller shades, blinds, drapes, and movable panels. For optimum overall performance of the system, these interior shading elements should also be designed to provide insulation during the day in summer and at night in winter (see "Insulation" below).

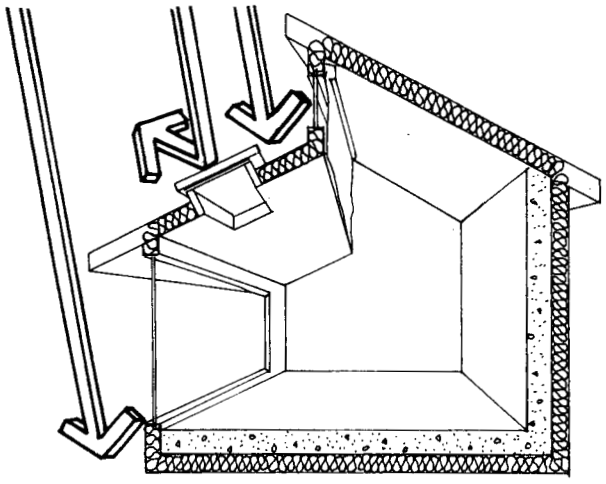


Figure 3.10

Reflecting

Reflectors placed horizontally above or below a collector can help increase overall system performance by increasing the amount of sunlight reaching the collector (see Figure 3.11).

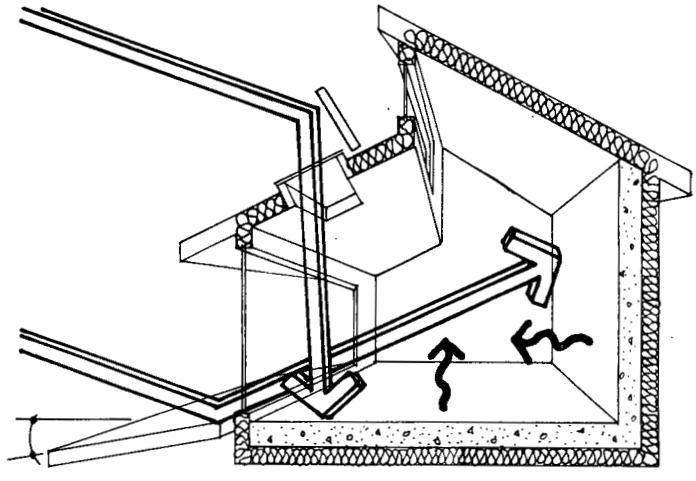


Figure 3.11

In certain cases where physical obstruc-

tions (e.g., trees or other buildings) on or around the building site shade the collector, the provision of reflectors can often increase solar collection 30 to 40%. Reflectors are also recommended for skylights placed in a flat roof as they may not receive sufficient winter sunlight in the horizontal position.

Reflectors are usually panels, coated on one side with a material of high reflectance, which are placed directly in front of the vertical south facing collector, or behind a horizontal collector (skylights). When the collector goes all the way to the ground (e.g., patio door) the reflector is simply laid on the ground in front of it. In the case of collector openings higher up in the wall, or in cases where the reflector is placed above the collector, some form of support will need to be provided. Reflectors for horizontal skylights can be placed vertically on the roof on the north side of the skylight.

All horizontal panels should be placed so that they slope slightly away from a vertical collector to increase the amount of reflected sunlight and to facilitate drainage (5° is recommended). To be economically and/or aesthetically justifiable they should also be designed to serve as movable insulation when not in the reflecting mode. It should be noted that reflecting panels may cause glare and/or overheating problems within the Direct Gain living spaces. Light colored exterior landscape elements such as patios or terraces can also serve as reflectors. They will not perform as efficiently as panels with high reflectances, but they will reduce glare and overheating (see Figure 3.12).

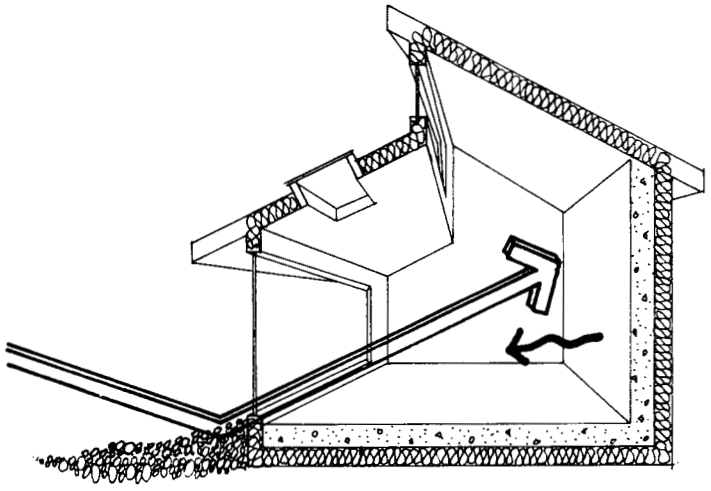


Figure 3.12

Insulating (Fixed Exterior Insulation)

Direct Gain storage walls and floors which are exposed to the outside should be insulated on their exterior surfaces. Insulating the interior surface of a Direct Gain storage wall effectively nullifies any thermal storage capability which the wall might have because it prevents solar energy from being absorbed by the wall and then reradiated back into the Direct Gain space. Therefore, insulation should be placed on the outside of any exterior wall, above or below grade, which is used for Direct Gain storage (see Figure 3.13).

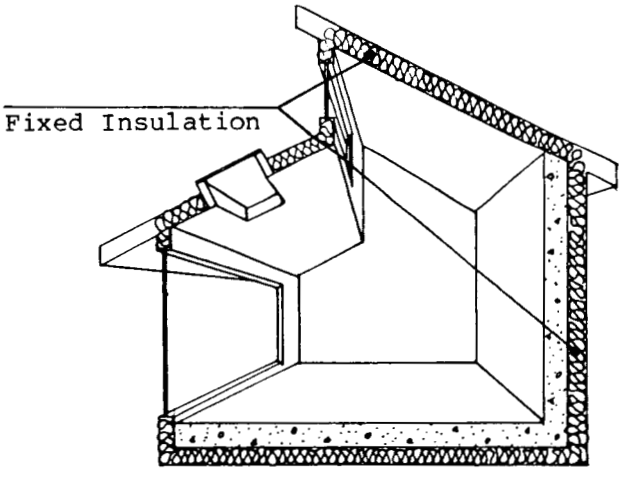


Figure 3.13

The case of Direct Gain storage floors is a bit more complicated. Storage floors supported by wood frame construction over vented crawl spaces should be insulated

and standard batt insulation will work well. The effectiveness of insulating under a slab-on-grade will depend on factors such as the moisture content and minimum winter temperatures of the ground under the slab. If the moisture content is high or the minimum temperature low (less than 50°F), the tendency for heat to be lost through the floor to the ground will increase. In these instances insulating under the slab, for a minimum of 2 feet along the entire perimeter and preferably under the entire slab, is recommended. Two inches of rigid insulation (R-11) is appropriate for Direct Gain slabs-on-grade.

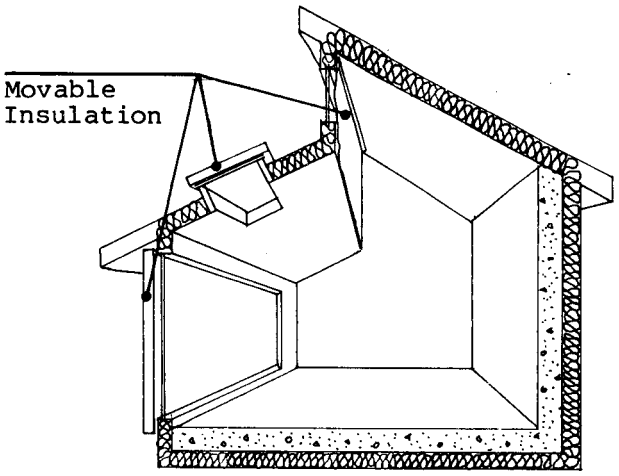


Figure 3.14

Insulating (Movable Insulation)

Although Direct Gain collectors can admit and trap a great deal of solar energy during clear, sunny days, they can also lose a great deal of heat during prolonged overcast periods and at night. Providing some form of movable insulation for use during these periods of heat loss can result in very significant increases in overall thermal performance. In fact, in the more severe climates certain Direct Gain configurations may be net energy losers if movable insulation is not provided. Movable insulation can also be used to prevent excessive heat gain during the cooling season.

As in the case of shading devices, there are two basic types of movable insulation: those applied to the outer face of the collector and those applied on the inside. Both can be effective at reducing heat losses during the heating season and, when used like shades, at preventing excessive heat gain during the cooling season.

Insulation on the inside is generally easier to operate and maintain and is not subject to degradation due to weathering. Exterior insulation, on the other hand, is more efficient at reducing heat gain during the cooling season because it intercepts the solar radiation before it can penetrate the collector and be converted to heat (see Figure 3.14).

There is a variety of possible insulating devices including: rigid panels (if placed on the exterior, these can also be used as reflectors, see "Reflecting" above), insulating shutters, insulating drapes and shades, and even double glazing with insulation integrated into the airspace.

These devices can be hand operated or motor driven. In choosing the appropriate technique, the willingness of the prospective homeowner to become involved in the day to day management of these elements must be carefully weighed. No matter what technique or product is finally chosen, care must be taken to assure a very tight seal between the insulation and the collector to avoid heat loss around the edges of the insulation.

Rules of Thumb

Shading

- Overhang:
  The projection of the overhang that will be adequate (provide 100% shading at noon on June 21) at particular latitudes can be quickly calculated by using the following formula:

Projection = $\frac{\text{window opening (height)}}{\text{F (see table below)}}$

North Latitude	F Factor*
28°	5.6-11.1
32°	4.0- 6.3
36°	3.0- 4.5
40°	2.5- 3.4
44°	2.0- 2.7
48°	1.7- 2.2
52°	1.5- 1.8
56°	1.3- 1.5

* Select a factor according to your latitude. The higher values will provide 100% shading at noon on June 21, the lower values until August 1.

A slightly longer overhang may be desirable at latitudes where this formula does not provide enough shade during the latter part of the cooling season (see Figure 3.15).

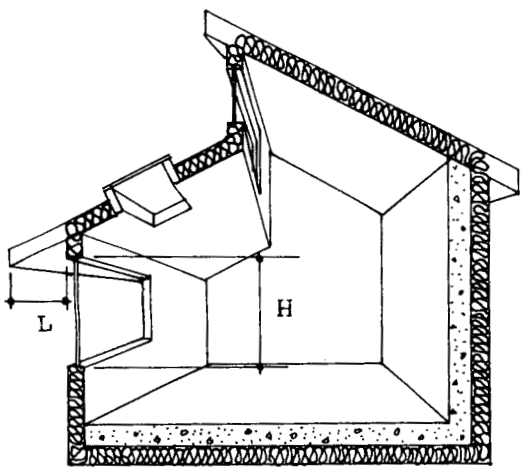


Figure 3.15

For, example for Madison, Wisconsin, at 43°NL, select an F factor between 2.0 and 2.7 (values for 44°NL). Assuming shade is desired until August 1, choose the lower value of 2.0. If the collector height (h) is 8 feet, the projection (l) of the overhang placed at the top of the collector will be: $\frac{8}{2.0}$ = 4 feet.

Reflecting

- o Sizing:
  If reflectors are used, they should be sized according to the following:
  1. Solar windows and clerestories: same width as the collector and roughly 1 to 2 times the height.
  2. Skylights: roughly equal in size to the collector.

- o Slope:
  A downward slope (away from the collector) of roughly 5° is recommended for drainage (see Figure 3.16).

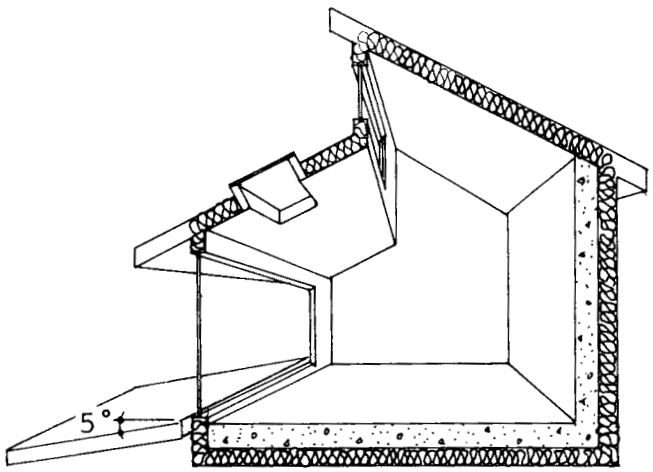


Figure 3.16

Insulating

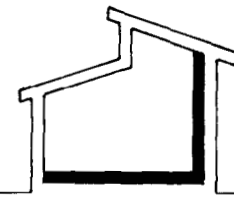
- o R-Values (Fixed Insulation):
  Fixed exterior insulation R-values should meet or exceed the levels that would be maintained by the same element in a non-solar building, which should in turn meet or exceed local building code requirements.

- o R-Values (Movable Insulation):
  Movable insulation should have an R-value between R-4 and R-9, subject to cost-benefit considerations.

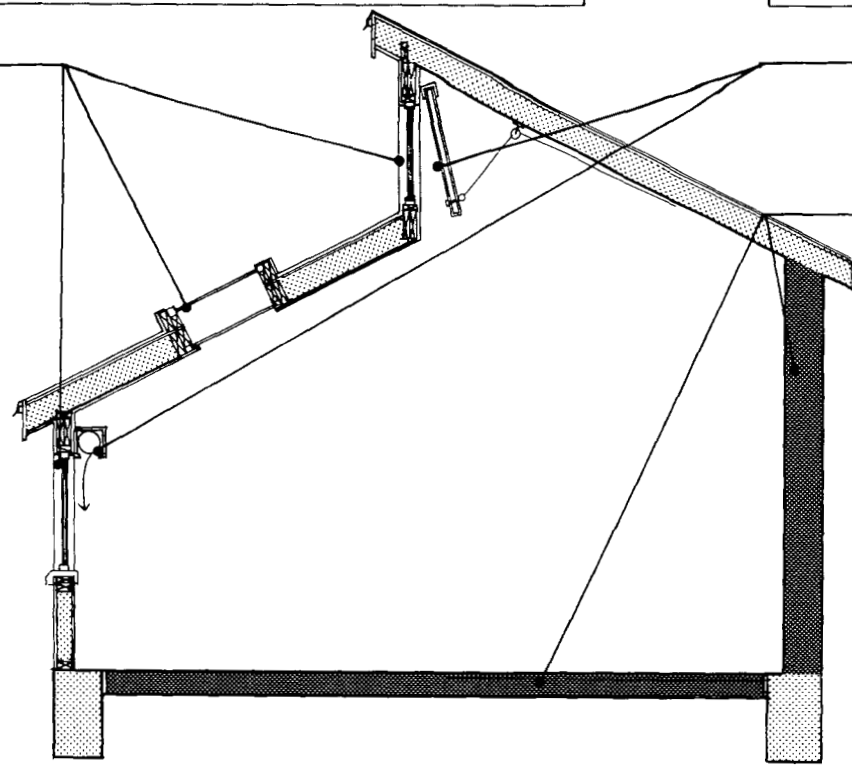
- Seals:
  All insulation should provide a tight seal to avoid problems with heat loss at its edges.

Direct Gain
Collector Component
Generic Collector Types

3.1100
Key



Collector and Frame



Movable Insulation

Storage Mass

Index to Details

	Wood Frame Wall	Pitched Roof	Flat Roof
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Conventional Window	3.1200		
Patio Door	3.1202		
SKYLIGHT		3.1204	3.1206
CLERESTORY WINDOW		3.1208	3.1210

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

COLLECTOR

o Double glazing is generally recommended to ensure optimum thermal performance. A 1/2" airspace between the glazing layers is recommended where feasible.

o The glazing material can be glass or plastic. For specific material information see Section 4.1100.

COLLECTOR FRAME

o Standard preframed wood or metal frame windows are suitable for both solar windows and clerestories Where metal frame units are specified, it is generally recommended that those fabricated with thermal breaks be specified. For further information on frame materials and configurations see Section 4.1200. Patio doors may be desirable for solar window applications. Prefabricated "bubbles" may be specified for skylight applications.

MOVABLE INSULATION

o Movable insulation should be provided to reduce nighttime heat loss during the heating season and daytime heat gain during the cooling season.

o Insulating shades, drapes and shutters for interior applications may be used. Installation and operation should be per manufacturer's specifications. For further information, see Section 4.4300.

o Movable insulation may be placed on the exterior of the collector component. This type of insulation must be resistant to the effects of weather. Insulating shutters and panels can be used. Care must be taken to ensure a tight fit between the insulation and the collector to reduce heat loss at the panel or shutter edges.

STORAGE COMPONENTS

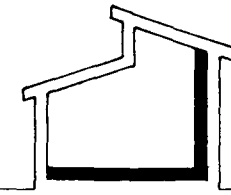
o For specific information on storage materials and configurations see Key Pages 3.1120 and following.

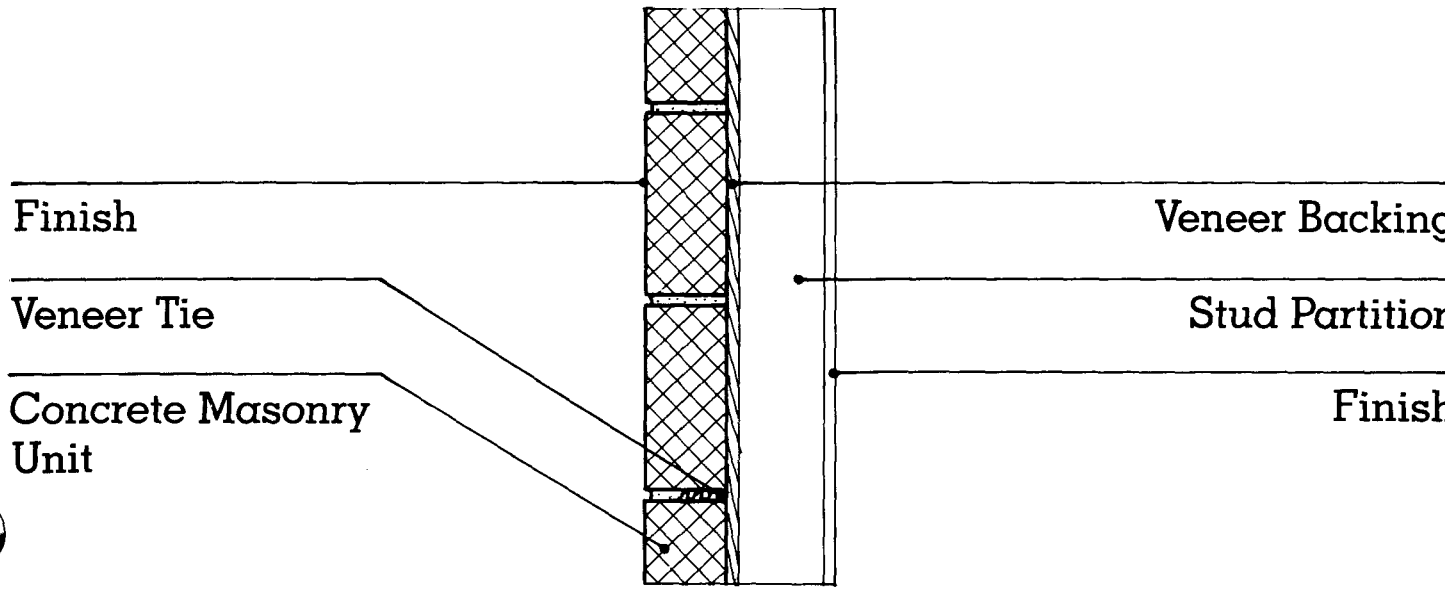
Direct Gain

Storage Component
CMU Veneer Interior Wall

3.1120

Key





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CONNECTION DETAIL AT:

CMU Paver/Slab-On-Grade	3.1400
CMU Paver/Wood First Floor	3.1402
Concrete/Wood First Floor	3.1404
CMU Paver/Wood Upper Floor	3.1406
Concrete/Wood Upper Floor	3.1408
Roof	3.1410

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

o CMU Veneer may be attached to the frame wall using either anchored or adhered construction methods. In anchored construction (as shown), metal ties are used to attach the CMUs to a veneer backing (e.g.plywood or building paper) or directly to the frame wall studs. In adhered construction the CMUs are secured to a veneer backing material using a binding material such as mortar. Units specified for adhered construction are generally limited to a maximum weight of 15 lb. per square foot.

FINISH

o For optimum thermal performance masonry should be a dark color and left exposed wherever feasible. Certain finishes (e.g. plaster and gypsum board) can be acceptable if properly applied. Particular colors can also be specified from the manufacturer or the masonry can be stained or painted. For further information on finishes and their effect on thermal performance see Sections 3.1000 and 4.2100.

CONCRETE MASONRY UNIT

o Concrete block, concrete brick, or architectural facing units such as split, slump, fluted, scored or recessed block may be used for thermal storage. To ensure optimum thermal performance, units must be solid or hollow with grout-filled cores. For further material information see Section 4.2100. For recommended thicknesses see Section 3.1000.

o Veneer is assumed to support no load other than its own weight.

VENEER BACKING

o In 'anchored' veneer construction (as shown) veneer backing is not required, although some form of backing (e.g. plywood, gypsum board or building paper) can make wall construction easier and may be desirable.

o In 'adhered' veneer construction (not shown) some form of veneer backing is required. Plywood, gypsum board, metal lath over building paper or other similar materials are suitable.

VENEER TIE

o Corrosion-resistant, corrugated metal ties of a minimum 22 gauge thickness and 7/8" width are typically specified. Corrosion-resistant 8d nails, located at the bend in the tie and having a minimum penetration of 1 1/2" into stud, are recommended. The tie should be embedded a minimum of 2" into the mortar joint at the veneer. Spacing of the ties to be determined by local building code requirements and/or standard practice.

STUD PARTITION

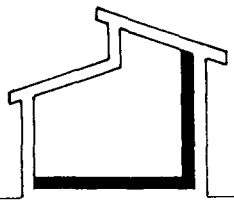
o The interior stud partition walls can be of standard wood or metal frame construction.

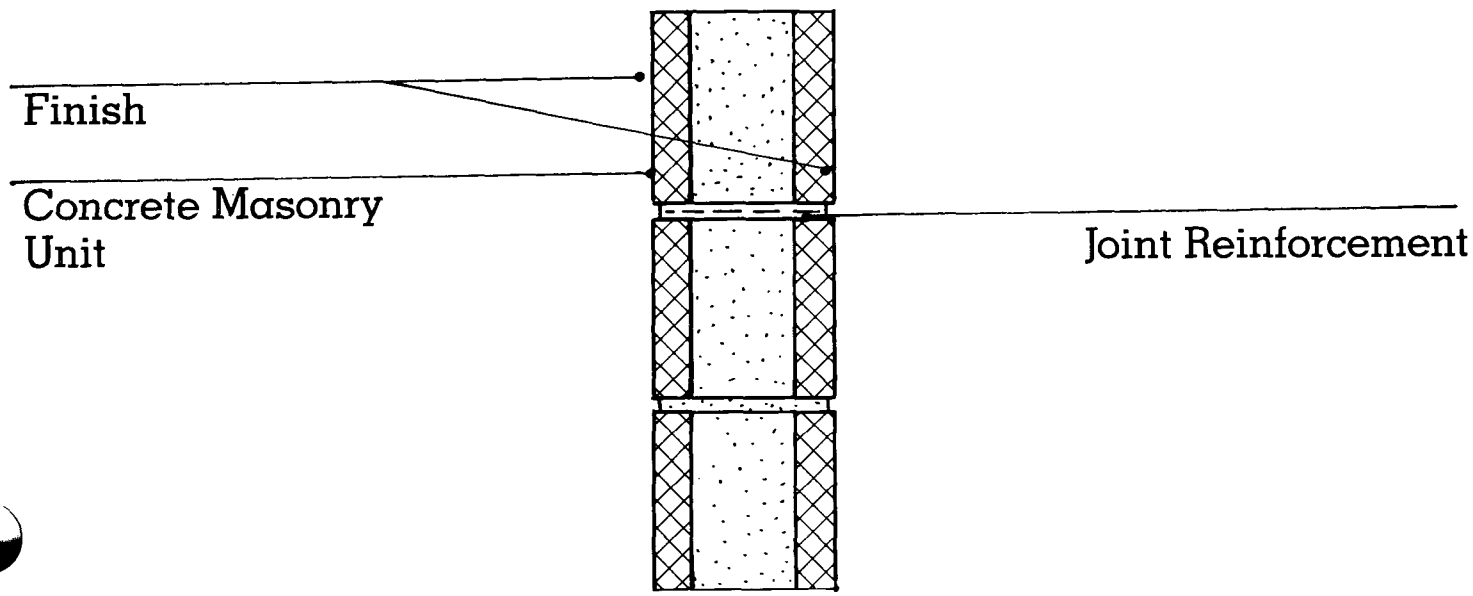
FINISH

o Wall finish on non-veneer side of wall construction has no effect on thermal performance and may be specified per builder's option.

Direct Gain
Storage Component
CMU Interior Wall

3.1122
Key





Index to Details

CONNECTION DETAIL AT:

Concrete Slab-On-Grade	3.1412
CMU Paver/Wood First Floor	3.1414
Concrete/Wood First Floor	3.1416

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

o Single wythe masonry units may be built with conventional mortar joints or may be surface bonded. For further information on surface bonding see Section 4.2100.

o Openings in masonry walls may be spanned by arches, steel angle lintels, or reinforced masonry lintels (constructed using standard and/or special-shaped masonry units, mortar, grout, and reinforcing steel). Specifications for all three should conform to local building code requirements depending on load, span, and type of wall construction.

FINISH

o For optimum thermal performance masonry should be a dark color and left exposed wherever feasible. Certain finishes (e.g. plaster and gypsum board) can be acceptable if properly applied. Particular colors can also be specified from the manufacturer or the masonry can be stained or painted. For further information on finishes and their effect on thermal performance see Sections 3.1000 and 4.2100.

CONCRETE MASONRY UNIT

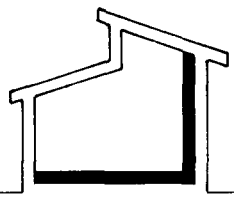
o Concrete block, concrete brick or architectural facing units such as split, slump, fluted, scored or recessed block may be used for thermal storage. To ensure optimum thermal performance, units must be solid or hollow with grout-filled cores. For further material information see Section 4.2100. For recommended thicknesses see Section 3.1000.

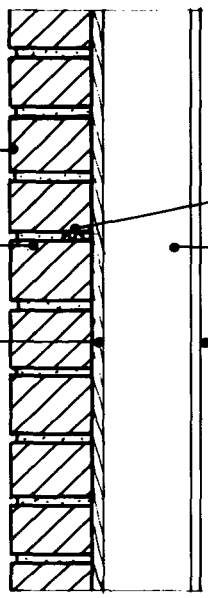
JOINT REINFORCEMENT

o Joint reinforcement should be provided to control cracking caused by thermal movement and shrinkage. Truss, ladder, or x-tie configurations are suitable and can be embedded in the wall at vertical intervals per local code requirements or industry recommendations. Splices in reinforcing should be lapped a minimum of 6" and the width of the reinforcement should be 2" less than the nominal width of storage wall.

Direct Gain
Storage Component
Brick Veneer Interior Wall

3.1124
Key





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CONNECTION DETAIL AT:

Brick Paver/Slab-On-Grade	3.1418
Brick Paver/Wood First Floor	3.1420
Concrete/Wood First Floor	3.1422
Brick Paver/Wood Upper Floor	3.1424
Concrete/Wood Upper Floor	3.1426
Roof	3.1428

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

FINISH

o For optimum thermal performance masonry should be a dark color and left exposed wherever feasible. Certain finishes (e.g. plaster and gypsum board) can be acceptable if properly applied. Particular colors can also be specified from the manufacturer or the masonry can be stained or painted. For further information on finishes and their effect on thermal performance see Sections 3.1000 and 4.2300.

BRICK

o Any of the wide variety of standard bricks are suitable for thermal storage. To ensure proper thermal performance bricks must be solid or hollow with grout-filled cores. For further material information see Section 4.2300. For recommended thicknesses see Section 3.1000.

o Veneer is assumed to support no load other than its own weight.

VENEER BACKING

o In 'anchored' veneer construction (as shown) veneer backing is not required, although some form of backing (e.g. plywood, gypsum board or building paper) can make wall construction easier and may be desirable.

o In 'adhered' veneer construction (not shown) some form of veneer backing is required. Plywood, gypsum board, metal lath over building paper or other similar materials are suitable.

VENEER TIE

o Corrosion-resistant, corrugated metal ties, of a minimum 22 gauge thickness and 7/8" width are typically specified. Corrosion-resistant 8d nails, located at the bend in the tie and having a minimum penetration of 1 1/2" into stud, are recommended. The tie should be embedded a minimum of 2" into the mortar joint at the veneer. Spacing of the ties to be determined by local building code requirements and/or standard practice.

STUD PARTITION

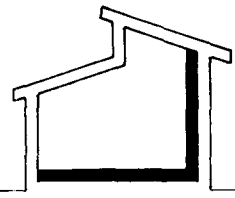
o The interior stud partition walls can be of standard wood or metal frame construction.

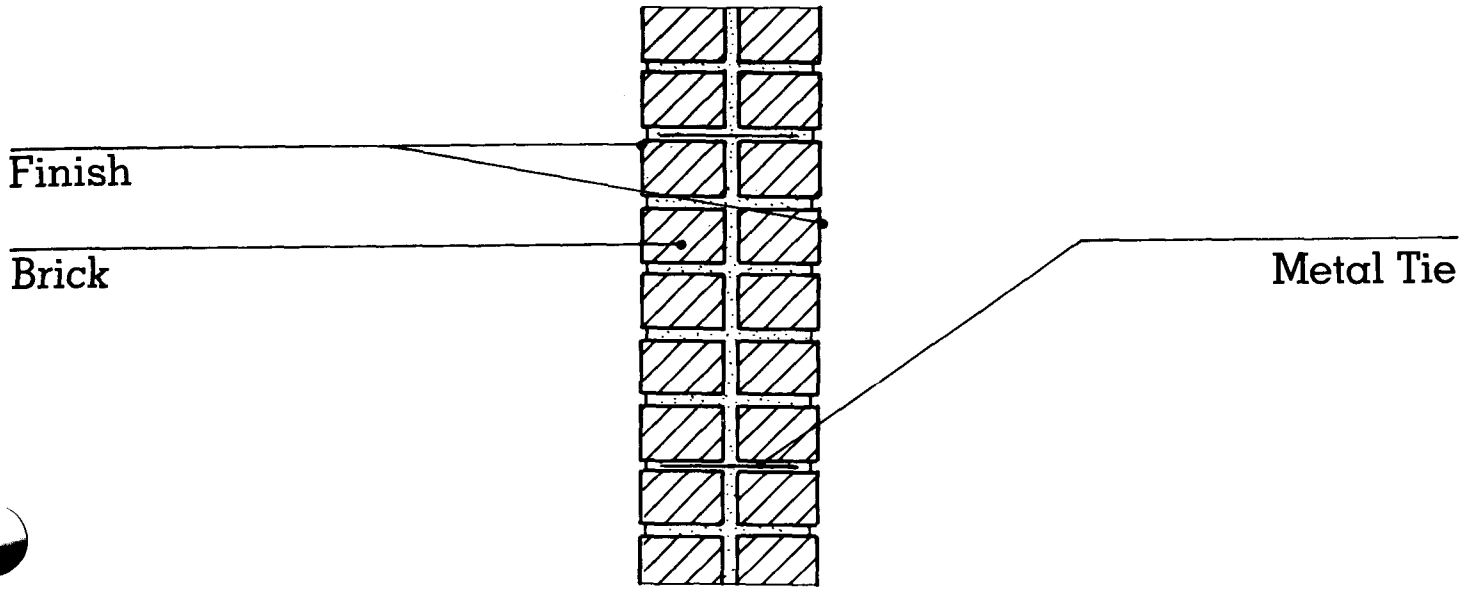
FINISH

o Wall finish on non-veneer side of wall construction has no effect on thermal performance and may be specified per builder's option.

Direct Gain
Storage Component
Solid Brick Interior Wall

3.1126
Key





Index to Details

CONNECTION DETAIL AT:

Concrete Slab-On-Grade	3.1430
Brick Paver/Wood First Floor	3.1432
Concrete/Wood First Floor	3.1434

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

o Openings in brick walls may be spanned by arches, steel angle lintels, or reinforced brick lintels (constructed using standard and/or special-shaped brick units, mortar, grout, and reinforcing steel). Specifications for all three should conform to the Brick Institute of America recommendations and local building code requirements depending on load, span, and type of wall construction.

FINISH

o For optimum thermal performance brick should be a dark color and left exposed wherever feasible. Certain finishes (e.g. plaster and gypsum board) can be acceptable if properly applied. Particular colors can also be specified from the manufacturer or the masonry can be painted. For further information on finishes and their effect on thermal performance see Sections 3.1000 and 4.2300.

BRICK

o Any of the wide variety of standard bricks are suitable for thermal storage. To ensure proper thermal performance, bricks must be solid or hollow with grout-filled cores. For further material information see Section 4.2300. For recommended thicknesses see Section 3.1000.

o Through-the-wall units may also be specified for thermal storage. Such units are generally cored and must be fully grouted to ensure proper performance.

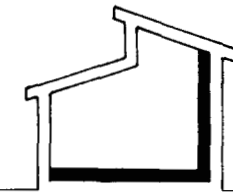
METAL TIE

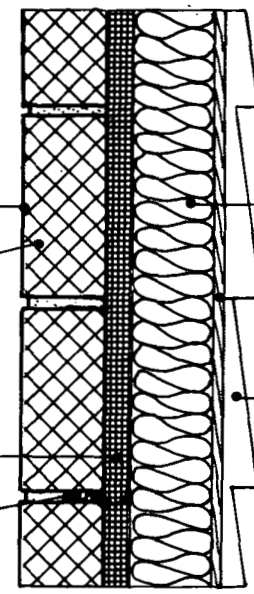
o Adjacent wythes must be tied together. Use of 3/16" corrosion-resistant steel ties or metal tie wire of equivalent stiffness, embedded in the horizontal mortar joints, is generally recommended. Use one tie for each 4 1/2 square feet of wall area. The maximum vertical distance between ties should not exceed 36". Individual ties in alternate courses should be staggered.

o Continuous horizontal wall ties (joint reinforcement) of either truss or ladder type may be used instead of individual metal ties. Individual lengths of reinforcement should be lapped at least 6" at points of intersection to provide continuity. Vertical spacing of joint reinforcement at 8", 16", or 24" is recommended, depending on length and height of wall and the number of openings.

Direct Gain
Storage Component
CMU Veneer Exterior Wall

3.1140
Key





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CONNECTION DETAIL AT:

CMU Paver/Slab-On-Grade	3.1436
CMU Paver/Wood First Floor	3.1438
Concrete/Wood First Floor	3.1440
CMU Paver/Wood Upper Floor	3.1442
Concrete/Wood Upper Floor	3.1444
Roof	3.1446

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

o CMU Veneer may be attached to the frame wall using anchored veneer construction methods. In anchored construction (as shown), metal ties are used to attach the CMUs to a veneer backing (e.g.plywood or building paper) or directly to the frame wall studs.

FINISH

o For optimum thermal performance masonry should be a dark color and left exposed wherever feasible. Certain finishes (e.g. plaster and gypsum board) can be acceptable if properly applied. Particular colors can also be specified from the manufacturer or the masonry can be stained or painted. For further information on finishes and their effect on thermal performance see Sections 3.1000 and 4.2100.

CONCRETE MASONRY UNIT

o Concrete block, concrete brick, or architectural facing units such as split, slump, fluted, scored or recessed block may be used for thermal storage. To ensure optimum thermal performance, units must be solid or hollow with grout-filled cores. For further material information see Section 4.2100. For recommended thicknesses see Section 3.1000.

o Veneer is assumed to support no load other than its own weight.

RIGID INSULATION

o Use of rigid insulation between masonry veneer and frame wall may be necessary to develop an acceptable R-value for the exterior wall.

VENEER TIE

o Corrosion-resistant, corrugated metal ties, of a minimum 22 gauge thickness and 7/8" width are typically specified. Corrosion-resistant 8d nails, located at the bend in the tie and having a minimum penetration of 1 1/2" into stud, are recommended. The tie should be embedded a minimum of 2" into the mortar joint at the veneer. Spacing of the ties to be determined by local building code requirements and/or standard practice.

STRUCTURAL FRAMING

o The structural frame walls can be of standard wood or metal frame construction.

SHEATHING

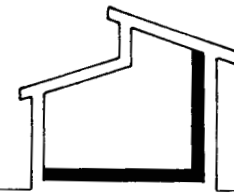
o Plywood, building board, or other similar materials can be specified as sheathing. The use of structural insulative sheathing, as a substitute, will reduce air infiltration, and improve overall thermal performance if properly installed.

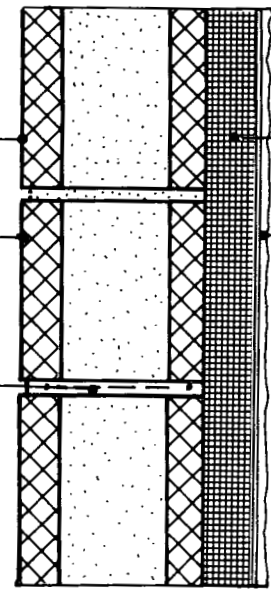
SIDING

o Material selection and color of siding per builder preference.

Direct Gain
Storage Component
CMU Exterior Wall

3.1142
Key





Finish

Concrete Masonry Unit

Joint Reinforcement

Rigid Insulation

Stucco

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CMU Paver/Slab-On-Grade	3.1448
CMU Paver/Wood First Floor	3.1450
Concrete/Wood First Floor	3.1452
CMU Paver/Wood Upper Floor	3.1454
Concrete/Wood Upper Floor	3.1456
Roof	3.1458

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

FINISH

o For optimum thermal performance masonry should be a dark color and left exposed wherever feasible. Certain finishes (e.g. plaster and gypsum board) can be acceptable if properly applied. Particular colors can also be specified from the manufacturer or the masonry can be stained or painted. For further information on finishes and their effect on thermal performance see Sections 3.1000 and 4.2100.

CONCRETE MASONRY UNIT

o Concrete block, concrete brick or architectural facing units such as split, slump, fluted, scored or recessed block may be used for thermal storage. To ensure optimum thermal performance, units must be solid or hollow with grout-filled cores. For further material information see Section 4.2100. For recommended thicknesses see Section 3.1000.

JOINT REINFORCEMENT

o Joint reinforcement should be provided to control cracking caused by thermal movement and shrinkage. Truss, ladder, or x-tie configurations are suitable and can be embedded in the wall at vertical intervals per local code requirements or industry recommendations. Splices in reinforcing should be lapped a minimum of 6" and the width of the reinforcement should be 2" less than the nominal width of storage wall.

RIGID INSULATION

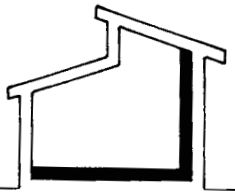
o Rigid insulation may be applied directly to the masonry with adhesive (type and application per insulation manufacturer's recommendation and/or standard practice).

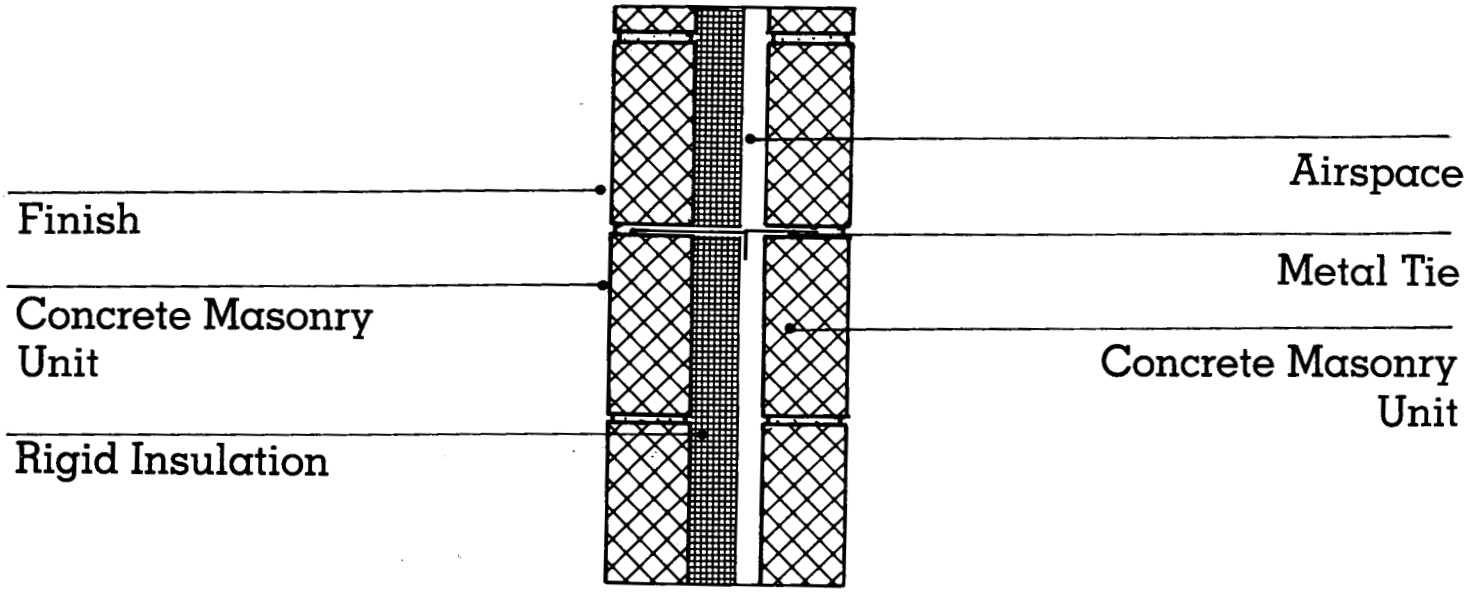
STUCCO

o Wire mesh or expanded metal lath for stucco finishes is laid over the rigid insulation and mechanically fastened to the concrete masonry. In general, the insulation surface must be free of mud and dust before stucco finish is applied.

Direct Gain
Storage Component
CMU Cavity Exterior Wall

3.1144
Key





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CONNECTION DETAIL AT:

CMU Paver/Slab-On-Grade	3.1460
CMU Paver/Wood First Floor	3.1462
Concrete/Wood First Floor	3.1464
CMU Paver/Wood Upper Floor	3.1466
Concrete/Wood Upper Floor	3.1468
Roof	3.1470

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

FINISH

o For optimum thermal performance masonry should be a dark color and left exposed wherever feasible. Certain finishes (e.g. plaster and gypsum board) can be acceptable if properly applied. Particular colors can also be specified from the manufacturer or the masonry can be stained or painted. For further information on finishes and their effect on thermal performance see Sections 3.1000 and 4.2100.

CONCRETE MASONRY UNIT

o Concrete block, concrete brick or architectural facing units such as split, slump, fluted, scored or recessed block may be used for thermal storage. To ensure optimum thermal performance, units must be solid or hollow with grout-filled cores. For further material information see Section 4.2100. For recommended thicknesses see Section 3.1000.

RIGID INSULATION

o Rigid insulation may be applied directly to the masonry with adhesive (type and application per insulation manufacturer's recommendation and/or standard practice).
o Loose insulation may be used as an alternative. Weep holes should be wicked or other precautions taken to prevent the outflow of the insulating material.

AIRSPACE

o A 1" minimum airspace is required where rigid insulation is installed in the cavity.
o An airspace is not required where loose insulation is specified.

METAL TIE

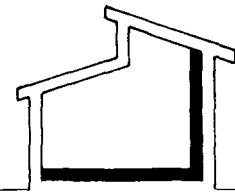
o Adjacent wythes must be tied together. Use of 3/16" corrosion-resistant steel ties or metal tie wire of equivalent stiffness, embedded in horizontal mortar joints, is generally recommended. Use one tie for each 4 1/2 square feet of wall area. Where cavity is more than 3 1/2" use one tie for each 3 square feet of wall area. The maximum vertical distance between ties should not exceed 36". Individual ties in alternate courses should be staggered.
o Continuous horizontal wall ties (joint reinforcement) of either truss or ladder type may be used instead of individual metal ties. Individual lengths of reinforcement should be lapped at least 6" to provide continuity. Vertical spacing of joint reinforcement at 8", 16", or 24" is recommended, depending on length and height of wall and the number of openings.
o Where rigid insulation is used install the metal ties so as to avoid puncturing insulation.

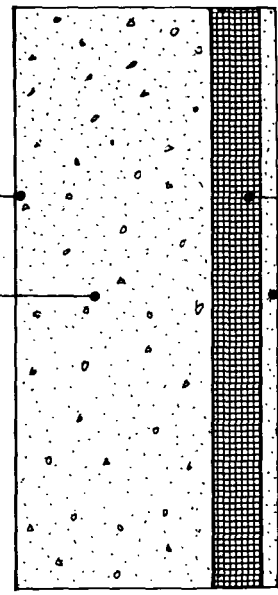
CONCRETE MASONRY UNIT

o Concrete block, concrete brick or architectural facing units such as split, slump, fluted, scored or recessed block may be used as the exterior wythe. Units can be solid or hollow at builders option. For further material information see Section 4.2100.

Direct Gain
Storage Component
Concrete Exterior Wall

3.1146
Key





Finish

Concrete

Rigid Insulation

Stucco

Index to Details

CONNECTION DETAIL AT:

CMU Paver/Slab-On-Grade	3.1439,3.1463
Concrete/Wood First Floor	3.1441,3.1465,3.1477 3.1489
Brick Paver/Wood First Floor	3.1475,3.1487

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

FINISH

o For optimum thermal performance concrete should be a dark color and left exposed wherever feasible. Textured finishes can be obtained using standard construction practice without significant impact on thermal performance.

o Certain finishes (e.g. plaster and gypsum board) can be acceptable if properly applied. Particular colors can also be specified from the supplier or the concrete can be stained or painted. For further information on finishes and their effect on thermal performance see Sections 3.1000 and 4.2200.

CONCRETE

o The use of normal weight concrete (140-150 lb.) is generally recommended. Placement of formwork and pouring of concrete should follow standard practice and/or local building codes. For further information see Section 4.2200. For recommended material thicknesses see Section 3.1000.

RIGID INSULATION

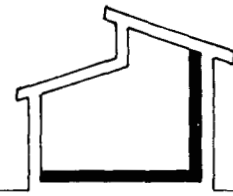
o Rigid insulation may be applied directly to the masonry with adhesive (type and application per insulation manufacturer's recommendation and/or standard practice).

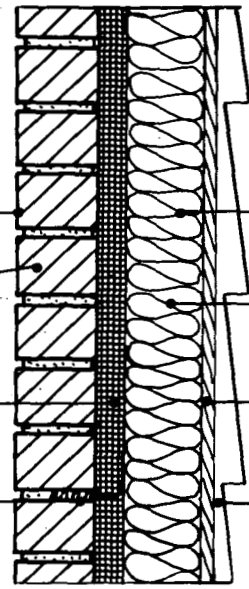
STUCCO

o Wire mesh or expanded metal lath for stucco finishes is laid over the rigid insulation and mechanically fastened to the concrete. In general, the insulation surface must be free of mud and dust before stucco finish is applied.

Direct Gain
Storage Component
Brick Veneer Exterior Wall

3.1148
Key





Finish
Brick
Rigid Insulation
Veneer Tie

Structural Framing
Insulation
Sheathing
Siding

Index to Details

CONNECTION DETAIL AT:

Brick Paver/Slab-On-Grade	3.1472
Brick Paver/Wood First Floor	3.1474
Concrete/Wood First Floor	3.1476
Brick Paver/Wood Upper Floor	3.1478
Concrete/Wood Upper Floor	3.1480
Roof	3.1482

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

FINISH

o For optimum thermal performance brick should be a dark color and left exposed wherever feasible. Certain finishes (e.g. plaster and gypsum board) can be acceptable if properly applied. Particular colors can also be specified from the manufacturer or the masonry can be painted. For further information on finishes and their effect on thermal performance see Sections 3.1000 and 4.2300.

BRICK

o Any of the wide variety of standard bricks are suitable for thermal storage. To ensure proper thermal performance bricks must be solid or hollow with grout-filled cores. For further material information see Section 4.2300. For recommended thicknesses see Section 3.1000.

o Veneer is assumed to support no load other than its own weight.

RIGID INSULATION

o Use of rigid insulation between masonry veneer and frame wall may be necessary to develop an acceptable R-value for the exterior wall.

VENEER TIE

o Corrosion-resistant, corrugated metal ties, of a minimum 22 gauge thickness and 7/8" width are typically specified. Corrosion-resistant 8d nails, located at the bend in the tie and having a minimum penetration of 1 1/2" into stud, are recommended. The tie should be embedded a minimum of 2" into the mortar joint at the veneer. Spacing of the ties to be determined by local building code requirements and/or standard practice.

STRUCTURAL FRAMING

o The structural frame walls can be of standard wood or metal frame construction.

INSULATION

o Selection of insulation materials for frame walls to be per local code requirements and/or standard practice.

SHEATHING

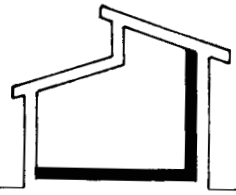
o Plywood, building board, or other similar materials can be specified as sheathing. The use of structural insulative sheathing, as a substitute, will reduce air infiltration, and improve overall thermal performance if properly installed.

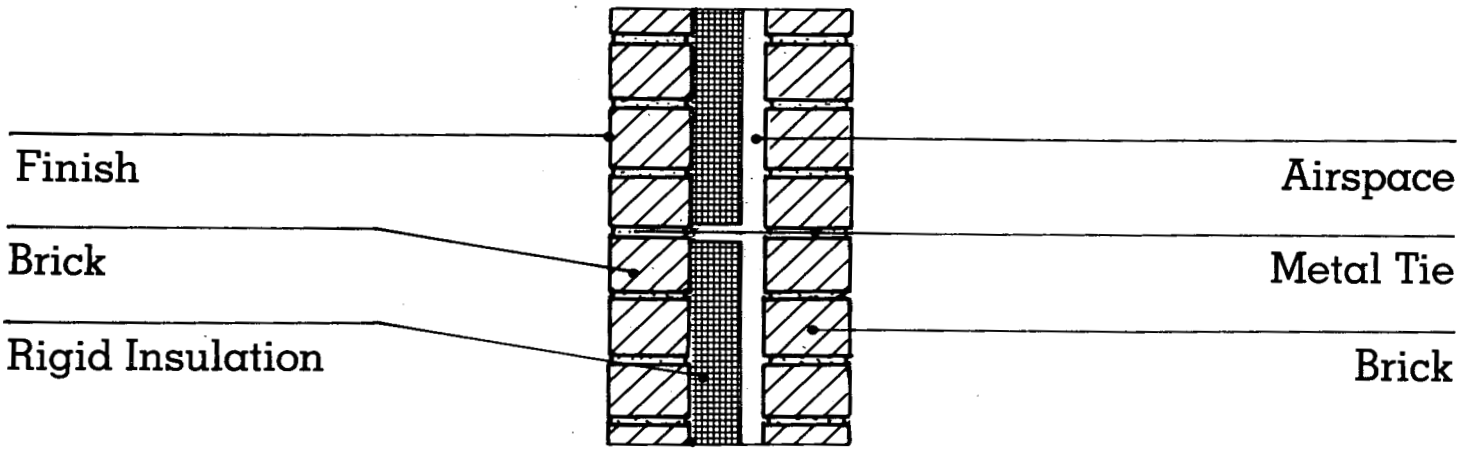
SIDING

o Material selection and color of siding per builder preference.

Direct Gain
Storage Component
Brick Cavity Exterior Wall

3.1150
Key





Index to Details

CONNECTION DETAIL AT:

Brick Paver/Slab-On-Grade	3.1484
Brick Paver/Wood First Floor	3.1486
Concrete/Wood First Floor	3.1488
Brick Paver/Wood Upper Floor	3.1490
Concrete/Wood Upper Floor	3.1492
Roof	3.1494

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

FINISH

o For optimum thermal performance brick should be a dark color and left exposed wherever feasible. Certain finishes (e.g. plaster and gypsum board) can be acceptable if properly applied. Particular colors can also be specified from the manufacturer or the masonry can be painted. For further information on finishes and their effect on thermal performance see Sections 3.1000 and 4.2300.

BRICK

o Any of the wide variety of standard bricks are suitable for thermal storage. To ensure proper thermal performance bricks must be solid or hollow with grout-filled cores. For further material information see Section 4.2300. For recommended thicknesses see Section 3.1000.

RIGID INSULATION

o Rigid insulation may be applied directly to the masonry with adhesive (type and application per insulation manufacturer's recommendation and/or standard practice).
o Loose insulation may be used as an alternative. Weep holes should be wicked or other precautions taken to prevent the outflow of the insulating material.

AIRSPACE

o A 1" minimum airspace is required where rigid insulation is installed in the cavity.
o An airspace is not required where loose insulation is specified.

METAL TIE

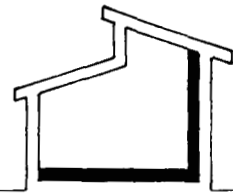
o Adjacent wythes must be tied together. Use of 3/16" corrosion-resistant steel ties or metal tie wire of equivalent stiffness, embedded in horizontal mortar joints, is generally recommended. Use one tie for each 4 1/2 square feet of wall area. Where cavity is more than 3 1/2" use one tie for each 3 square feet of wall area. The maximum vertical distance between ties should not exceed 36". Individual ties in alternate courses should be staggered.
o Continuous horizontal wall ties (joint reinforcement) of either truss or ladder type may be used instead of individual metal ties. Individual lengths of reinforcement should be lapped at least 6"to provide continuity. Vertical spacing of joint reinforcement at 8", 16", or 24" is recommended, depending on length and height of wall and the number of openings.
o Where rigid insulation is used install the metal ties so as to avoid puncturing insulation.

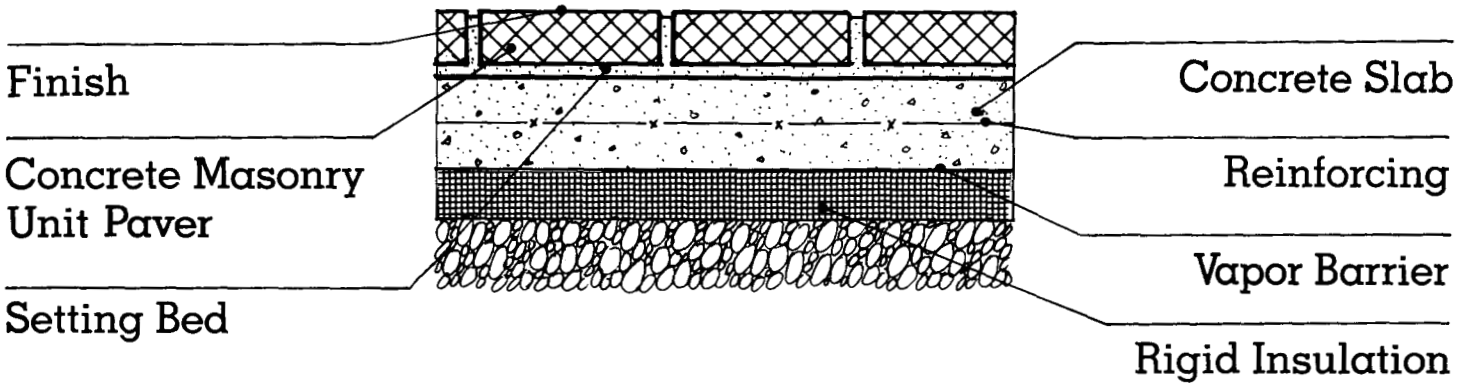
BRICK

o Any of the wide variety of standard bricks may be used for the exterior wythe. Units can be solid or hollow at builder's option. For further material information see Section 4.2300. For recommended thicknesses see Section 3.1000.

Direct Gain
Storage Component
CMU Paver/Slab-On-Grade

3.1170
Key





Index to Details

CONNECTION DETAIL AT:

CMU Veneer Interior Wall	3.1400
CMU Veneer Exterior Wall	3.1436
CMU Exterior Wall	3.1448
CMU Cavity Exterior Wall	3.1460

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

FINISH

o For optimum thermal performance pavers should be a dark color and left exposed wherever feasible. Covering the pavers with carpet is emphatically not recommended. Sealers can be used to provide an impervious finish for the pavers, making them easier to clean, without affecting thermal performance. For further information on finishes and their effect on thermal performance see Sections 3.1000 and 4.2100.

CMU PAVER

o Any of the wide variety of standard and interlocking CMU pavers are suitable for thermal storage. For further material information see Section 4.2100. For recommended thicknesses see Section 3.1000.

SETTING BED

o Pavers are generally laid in a mortar setting bed. Type N mortar is suitable for interior applications.

o Pavers can also be set in a dry mixture of sand and cement. After the pavers are laid, the surface is wetted down with water to set the mixture. In this application, pavers are typically laid without mortar joints.

o Pavers can be laid without mortar. Care must be taken to maintain continuous contact between units to ensure optimum thermal performance.

CONCRETE SLAB

o The concrete slab base for the masonry pavers should be installed following standard practice. For further material information see Section 4.2200.

REINFORCING

o Reinforcing is generally not recommended except where required by soil conditions and/or local building codes.

VAPOR BARRIER

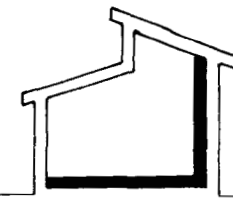
o A vapor barrier should be placed directly under the slab.

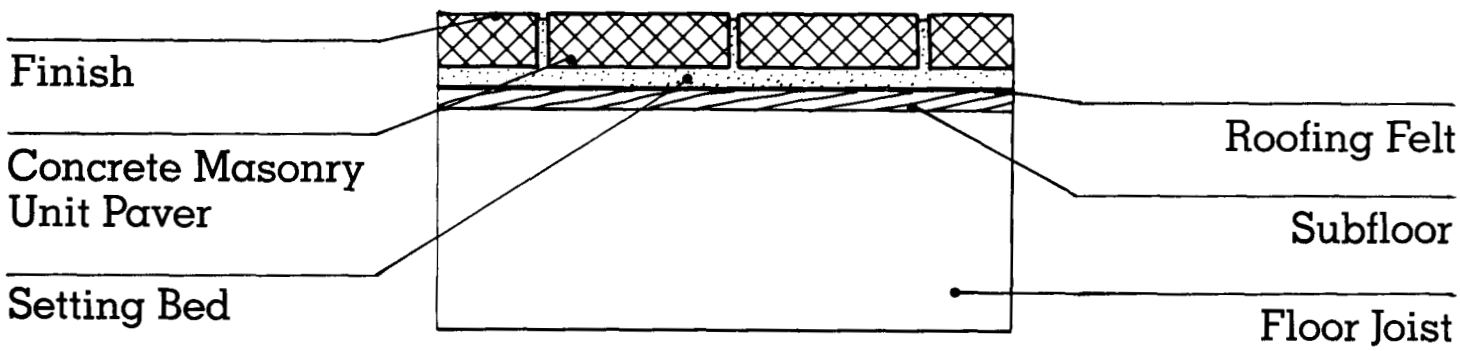
RIGID INSULATION

o In the cooler climates it is generally recommended that rigid insulation be placed under slab floors which are acting as Direct Gain storage components. For further information see Section 3.1000.

Direct Gain
Storage Component
CMU Paver/Wood Floor

3.1172
Key





Index to Details

CONNECTION DETAIL AT:

CMU Veneer Interior Wall	3.1402,3.1406
CMU Interior Wall	3.1414
CMU Veneer Exterior Wall	3.1438,3.1442
CMU Exterior Wall	3.1450,3.1454
CMU Cavity Exterior Wall	3.1462,3.1466

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

o The pavers and the setting bed act together as the thermal storage mass. The recommended overall thickness of the storage floor can be attained by increasing or decreasing the depth of the setting bed, depending on the thickness of the pavers specified. For recommended floor thickness see Section 3.1000.

FINISH

o For optimum thermal performance pavers should be a dark color and left exposed wherever feasible. Covering the pavers with carpet is emphatically not recommended. Sealers can be used to provide an impervious finish for the pavers, making them easier to clean, without affecting thermal performance. For further information on finishes and their effect on thermal performance see Sections 3.1000 and 4.2100.

CMU PAVER

o Any of the wide variety of standard and interlocking CMU pavers are suitable for thermal storage. For further material information see Section 4.2100. For recommended thicknesses see Section 3.1000.

SETTING BED

o Pavers are generally laid in a mortar setting bed. Type N mortar is suitable for interior applications.

o Pavers can also be set in a dry mixture of sand and cement. After the pavers are laid, the surface is wetted down with water to set the mixture. In this application, pavers are typically laid without mortar joints.

o Pavers can be laid without mortar. Care must be taken to maintain continuous contact between units to ensure optimum thermal performance.

ROOFING FELT

o The installation of two layers of 15 lb. roofing felt between the setting bed and the subfloor is recommended. The felt serves as a cushion for the masonry as well as a moisture barrier for the floor assembly. In mortarless applications, it aids in reducing the effects of minor surface irregularities in the base material.

o The felt also serves as a bond break between the setting bed and subfloor.

o Individual sections of roofing felt should be lapped 6".

SUBFLOOR

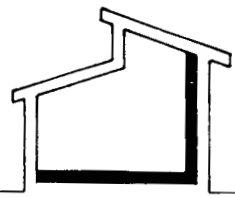
o Consideration must be given to the additional weight of the masonry when selecting the subfloor.

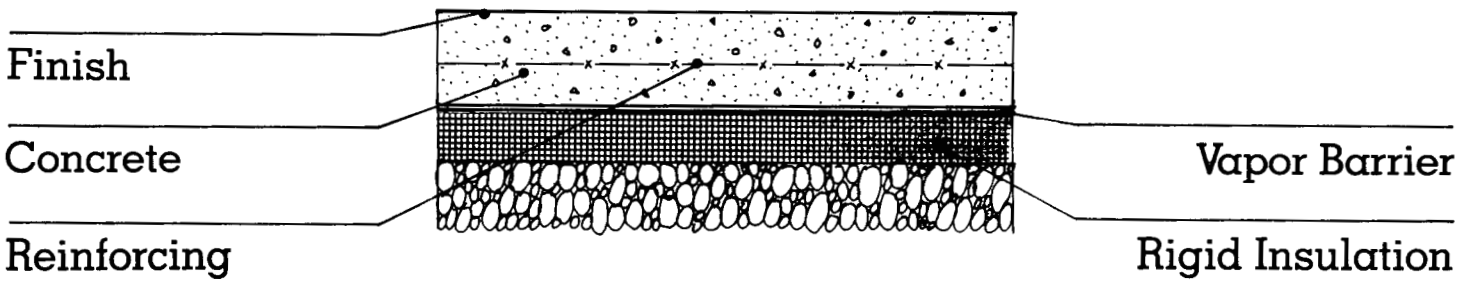
FLOOR JOIST

o Consideration must be given to the additional weight of the masonry when selecting and sizing the floor joists.

Direct Gain
Storage Component
Concrete Slab-On-Grade

3.1174
Key





Index to Details

CONNECTION DETAIL AT:

CMU Veneer Interior Wall	3.1400
Brick Veneer Interior Wall	3.1418
CMU Veneer Exterior Wall	3.1436
CMU Exterior Wall	3.1448
CMU Cavity Exterior Wall	3.1460
Brick Veneer Exterior Wall	3.1472
Brick Cavity Exterior Wall	3.1484

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

FINISH

o For optimum thermal performance the concrete slab should be a dark color and left exposed wherever feasible. Certain finishes (e.g. exposed aggregate, embossed surface, or thin vinyl tiles) will not significantly effect thermal performance and can be specified. Covering the concrete with carpet is emphatically not recommended. For further information on finishes and their effect on thermal performance see Sections 3.1000 and 4.2200.

CONCRETE SLAB

o Concrete slab-on-grade construction can be used for Direct Gain storage. For material information see Section 4.2200. For recommended thicknesses see Section 3.1000.

REINFORCING

o Reinforcing is generally not recommended except where required by soil conditions and/or local building codes.

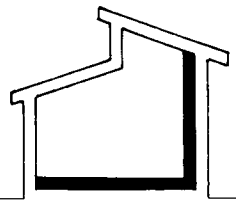
VAPOR BARRIER

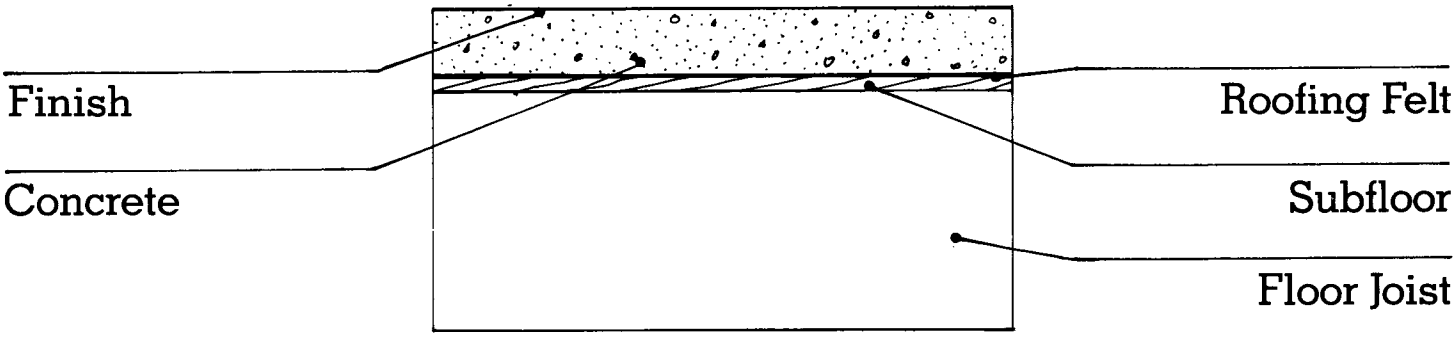
o A vapor barrier should be placed directly under the slab.

RIGID INSULATION

o In the cooler climates it is generally recommended that rigid insulation be placed under slabs-on-grade which are acting as Direct Gain storage components. For further information see Section 3.1000.

Direct Gain
Storage Component
Concrete/Wood Floor





Index to Details

CONNECTION DETAIL AT:

CMU Veneer Interior Wall	3.1404,3.1408
CMU Interior Wall	3.1416
Brick Veneer Interior Wall	3.1422,3.1426
Solid Brick Interior Wall	3.1434
CMU Veneer Exterior Wall	3.1440,3.1444
CMU Exterior Wall	3.1452,3.1456
CMU Cavity Exterior Wall	3.1464,3.1468
Concrete Exterior Wall	3.1441,3.1465,3.1477, 3.1489
Brick Veneer Exterior Wall	3.1476,3.1480
Brick Cavity Exterior Wall	3.1488,3.1492

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

FINISH

o For optimum thermal performance the concrete slab should be a dark color and left exposed wherever feasible. Certain finishes (e.g. exposed aggregate, embossed surface, or thin vinyl tiles) will not significantly effect thermal performance and can be specified. Covering the concrete with carpet is emphatically not recommended. For further information on finishes and their effect on thermal performance see Sections 3.1000 and 4.2200.

CONCRETE

o A structural lightweight concrete slab over floor joists can be used for Direct Gain storage.

For further material information see Section 4.2200. For recommended thicknesses see Section 3.1000.

ROOFING FELT

o The installation of two layers of 15 lb. roofing felt between the concrete and the subfloor is recommended. The felt serves as a cushion for the masonry and aids in reducing the effects of minor surface irregularities in the base material. It also acts as a bond break and moisture barrier.

o Individual sections of roofing felt should be lapped 6".

SUBFLOOR

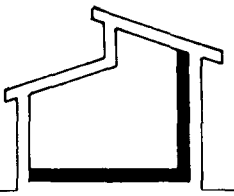
o Consideration must be given to the additional weight of the concrete when selecting the subfloor.

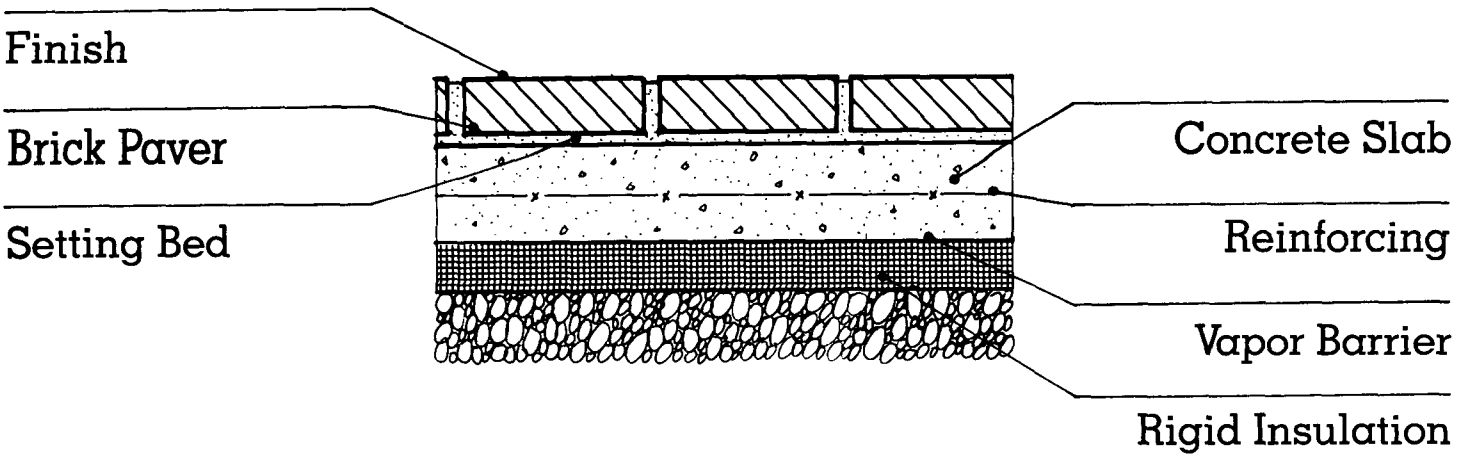
FLOOR JOIST

o Consideration must be given to the additional weight of the concrete when selecting and sizing the floor joists.

Direct Gain
Storage Component
Brick Paver/Slab-On-Grade

3.1178
Key





Index to Details

CONNECTION DETAIL AT:

Brick Veneer Interior Wall	3.1418
Brick Veneer Exterior Wall	3.1472
Brick Cavity Exterior Wall	3.1484

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

FINISH

o For optimum thermal performance pavers should be a dark color and left exposed wherever feasible. Covering the pavers with carpet is emphatically not recommended. Sealers can be used to provide an impervious finish for the pavers, making them easier to clean, without effecting thermal performance. For further information on finishes and their effect on thermal performance see Sections 3.1000 and 4.2300.

BRICK PAVER

o Any of the wide variety of standard brick pavers are suitable for thermal storage. For material information see Section 4.2300. For recommended thicknesses see Section 3.1000.

SETTING BED

o Pavers are generally laid in a mortar setting bed. Type N mortar is suitable for interior applications.

o Pavers can also be set in a dry mixture of sand and cement. After the pavers are laid, the surface is wetted down with water to set the mixture. In this application, pavers are typically laid without mortar joints.

o Pavers can be laid without mortar. Care must be taken to maintain continuous contact between units to ensure optimum thermal performance.

CONCRETE SLAB

o The concrete slab base for the masonry pavers should be installed following standard practice. For further material information see Section 4.2200.

REINFORCING

o Reinforcing is generally not recommended except where required by soil conditions and/or local building codes.

VAPOR BARRIER

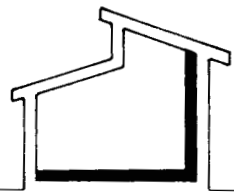
o A vapor barrier should be placed directly under the slab.

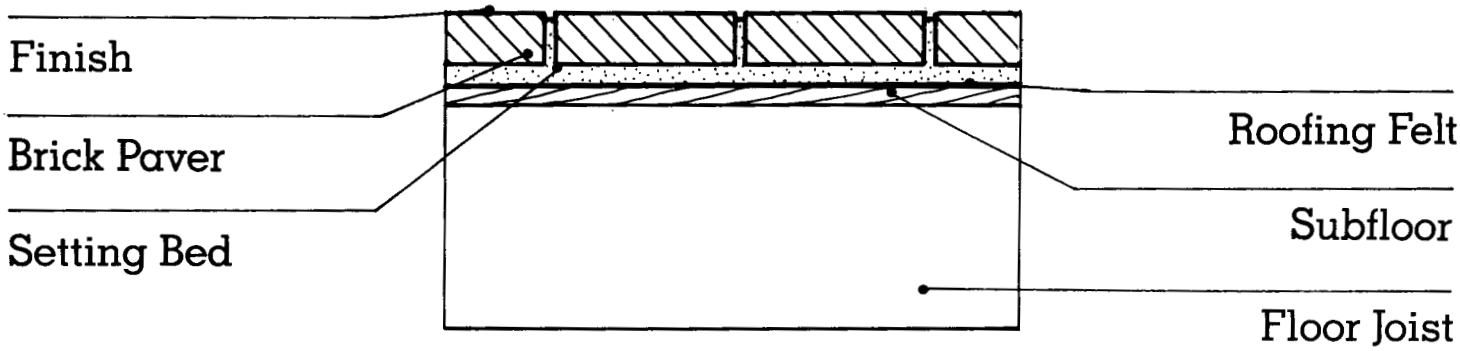
RIGID INSULATION

o In the cooler climates it is generally recommended that rigid insulation be placed under slab floors which are acting as Direct Gain storage components. For further information see Section 3.1000.

Direct Gain
Storage Component
Brick Paver/Wood Floor

3.1180
Key





Index to Details

CONNECTION DETAIL AT:

Brick Veneer Interior Wall	3.1420,3.1424
Solid Brick Interior Wall	3.1432
Brick Veneer Exterior Wall	3.1474,3.1478
Brick Cavity Exterior Wall	3.1486,3.1490

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

o The pavers and the setting bed act together as the thermal storage mass. The recommended overall thickness of the storage floor can be attained by increasing or decreasing the depth of the setting bed, depending on the thickness of the pavers specified. For recommended floor thickness see Section 3.1000.

FINISH

o For optimum thermal performance pavers should be a dark color and left exposed wherever feasible. Covering the pavers with carpet is emphatically not recommended. Sealers can be used to provide an impervious finish for the pavers, making them easier to clean, without effecting thermal performance. For further information on finishes and their effect on thermal performance see Sections 3.1000 and 4.2300.

BRICK PAVER

o Any of the wide variety of standard brick pavers are suitable for thermal storage. For material information see Section 4.2300. For recommended thicknesses see Section 3.1000.

SETTING BED

o Pavers are generally laid in a mortar setting bed. Type N mortar is suitable for interior applications.

o Pavers can also be set in a dry mixture of sand and cement. After the pavers are laid, the surface is wetted down with water to set the mixture. In this application, pavers are typically laid without mortar joints.

o Pavers can be laid without mortar. Care must be taken to maintain continuous contact between units to ensure optimum thermal performance.

ROOFING FELT

o The installation of two layers of 15 lb. roofing felt between the setting bed and the subfloor is recommended. The felt serves as a cushion for the masonry as well as a moisture barrier for the floor assembly. In mortarless applications, it aids in reducing the effects of minor surface irregularities in the base material.

o The felt also serves as a bond break between the setting bed and subfloor.

o Individual sections of roofing felt should be lapped 6".

SUBFLOOR

o Consideration must be given to the additional weight of the masonry when selecting the subfloor.

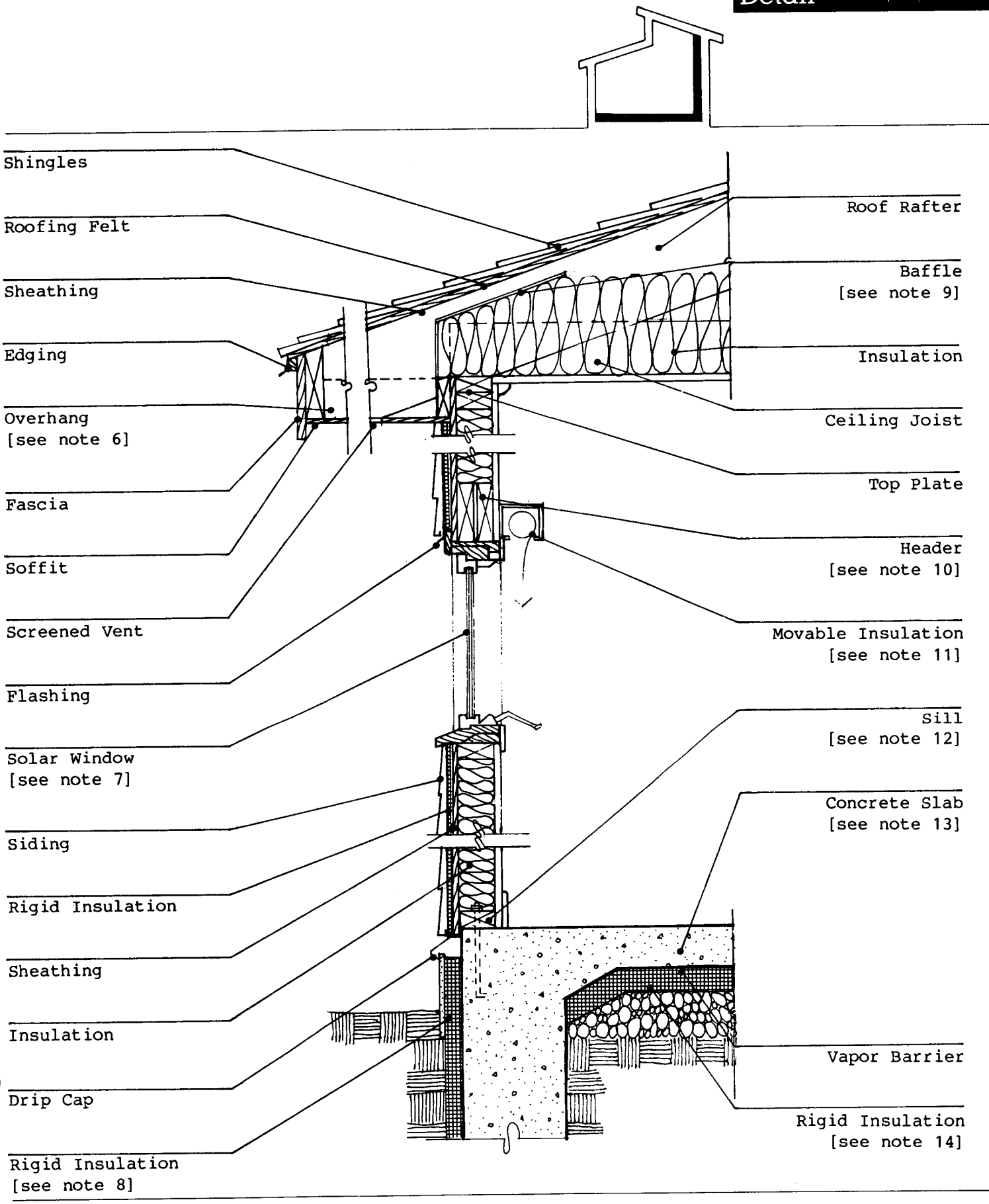
FLOOR JOIST

o Consideration must be given to the additional weight of the masonry when selecting and sizing the floor joists.

Direct Gain
Conventional Window
Wood Frame Wall

3.1200

Detail



Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code. Where ground water problems exist, provide sufficient granular fill at haunch to prevent water penetration at slab.

[2] Sizing of headers to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code.

[3] Insulation levels at foundation, floors, walls and ceiling must meet or exceed the requirements of the local building/energy codes.

[4] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections.

[5] Provide gutters and downspouts as required.

[6] Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information, see Sections 3.1000 and 4.4100.

[7] Double glazing is generally recommended. For glazing material variations, see Key Page 3.1100.

[8] Cement plaster (stucco) finish applied on wire lath over exterior insulation. Other finishes may be specified at builder's option, but rigid insulation must be protected where exposed above grade.

[9] Provide baffles where necessary to maintain 1" minimum airspace for venting attic.

[10] Provide insulation at header. Rigid insulation may be used at builder's option.

[11] Movable insulation should be provided to improve the system thermal performance. For further information, see Key Page 3.1100.

[12] Continuous sill sealer is recommended to provide protection against infiltration.

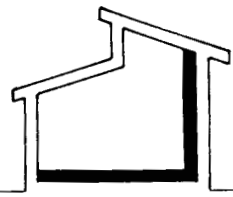
[13] Concrete slab-on-grade used as Storage component. For further information see Key Page 3.1170 and following.

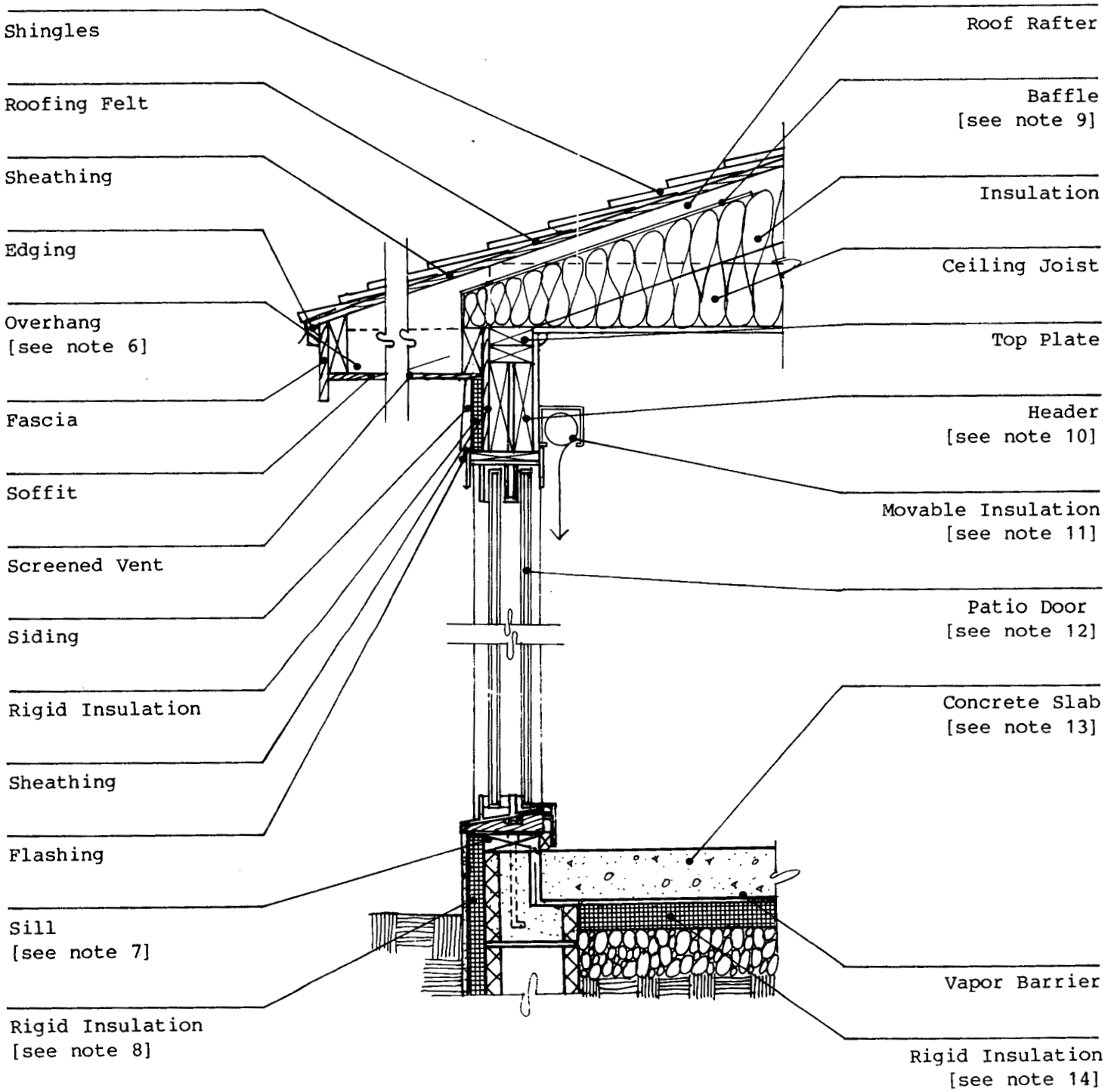
[14] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.

Direct Gain
Patio Door
Wood Frame Wall

3.1202

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.

[2] Sizing of headers to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels at foundation, floors, walls and ceiling must meet or exceed the requirements of the local building/energy codes.

[4] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections.

[5] Provide gutters and downspouts as required.

[6] Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information, see Sections 3.1000 and 4.4100.

[7] Continuous sill sealer is recommended to provide protection against infiltration.

[8] Cement plaster (stucco) finish applied on wire lath over exterior insulation. Rigid insulation must be protected where exposed above grade.

[9] Provide baffles where necessary to maintain 1" minimum airspace for venting attic.

[10] Provide insulation at header. Rigid insulation may be specified or other insulation may be used at builder's option.

[11] Movable insulation should be provided to improve the system thermal performance. For further information, see Key Page 3.1100.

[12] Double glazing is generally recommended. For glazing material variations and thermal performance characteristics, see Key Page 3.1100.

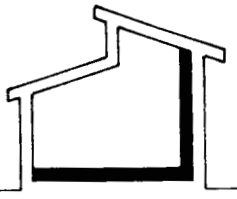
[13] Concrete slab-on-grade used as Storage component. Alternate storage floor materials may be specified at the builder's option. For further information, see Key Page 3.1170 and following.

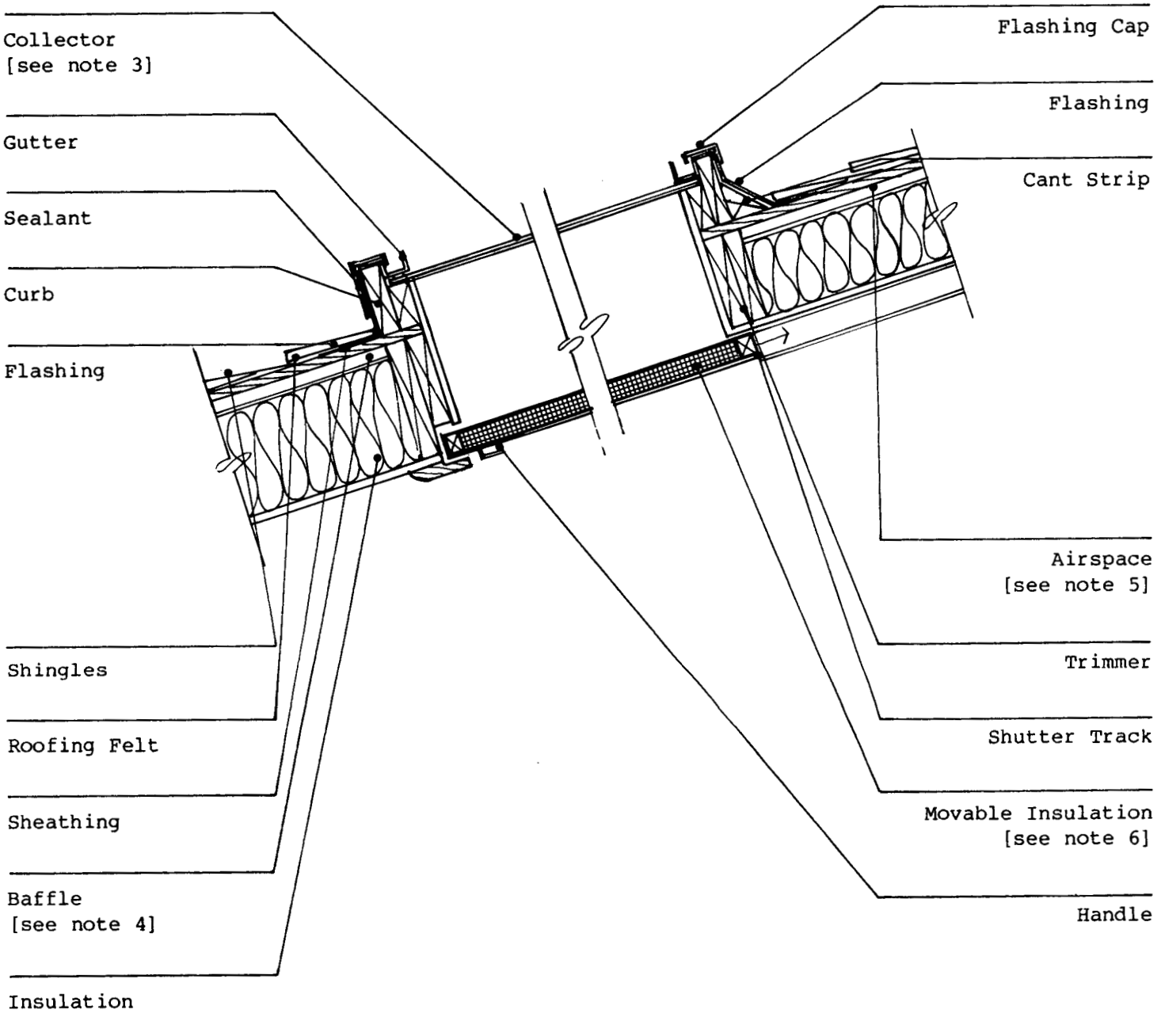
[14] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.

Direct Gain
Skylight
Pitched Roof

3.1204

Detail





Construction Notes

[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections.

[2] Insulation in ceiling must meet or exceed requirements of local building/ energy codes.

[3] Double glazing is generally recommended. For glazing material variations and thermal performance characteristics see Key Page 3.1100.

[4] Provide baffles where necessary to maintain 1" minimum airspace for venting roof.

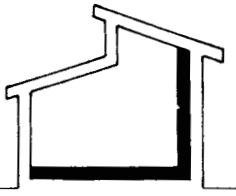
[5] The opaque roof must be vented to ensure proper performance of the insulation. Vents may be located at the sides of the roof or at the ridge depending upon the roof construction. An airspace is provided to allow for circulation.

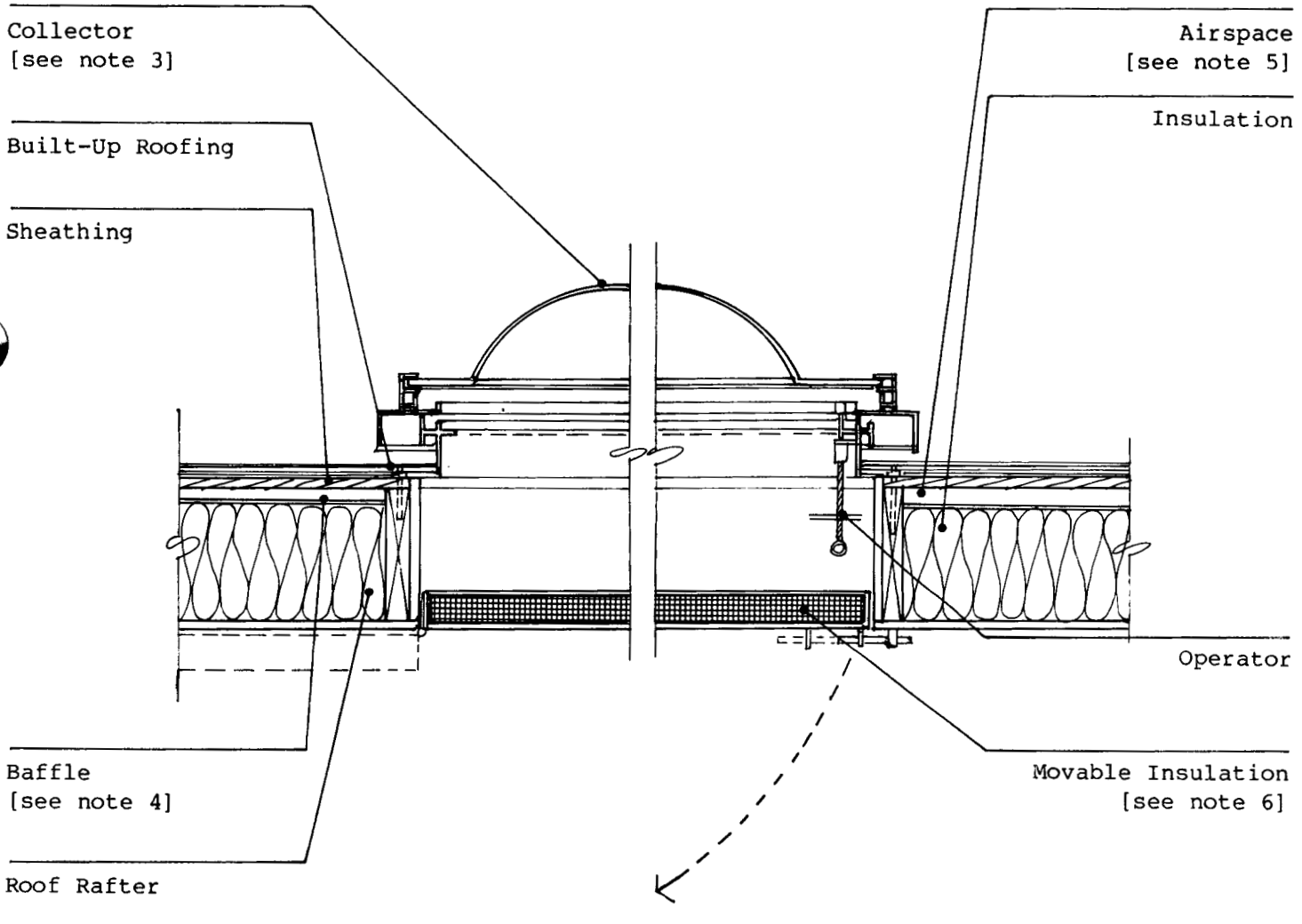
[6] Movable insulation should be provided to improve the system thermal performance. A sliding insulated shutter is suitable. For further information, see Key Page 3.1100.

Direct Gain
Skylight
Flat Roof

3.1206

Detail





Construction Notes

[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections.

[2] Insulation in ceiling must meet or exceed requirements of local building/ energy codes.

[3] Prefabricated skylight. Install per manufacturer's recommendation. For further information, glazing material variations and thermal performance characteristics see Key Page 3.1100.

[4] Provide baffles where necessary to maintain 1" minimum airspace for venting roof.

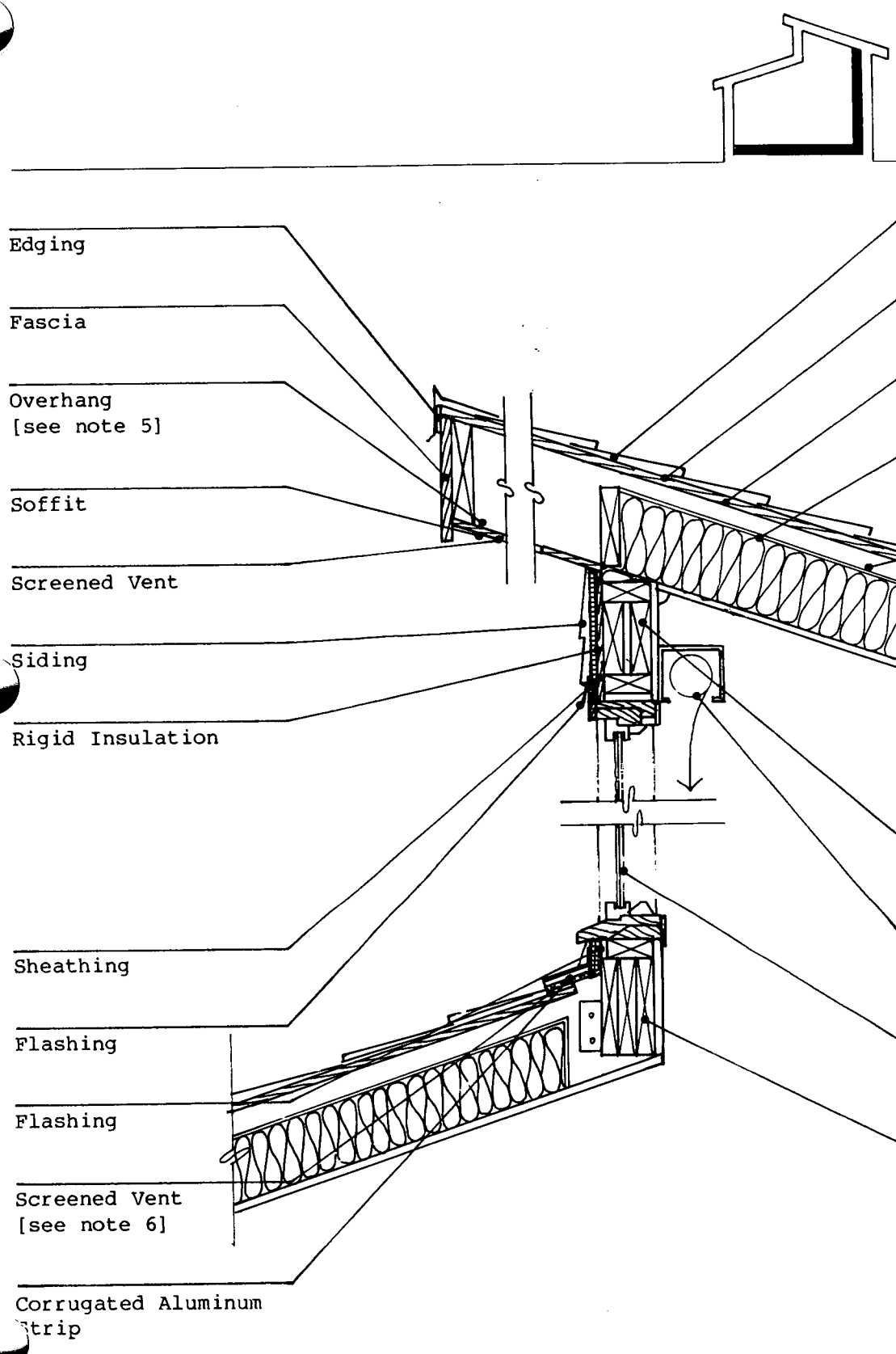
[5] The opaque roof must be vented to ensure proper performance of the insulation. Vents may be located at the sides of the roof or at the ridge depending upon the roof construction. An airspace is provided to allow for circulation.

[6] Movable insulation should be provided to improve the system thermal performance. A hinged insulated shutter is suitable. For further information, see Key Page 3.1100.

Direct Gain
Clerestory Window
Pitched Roof

3.1208

Detail



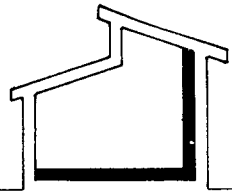
Construction Notes

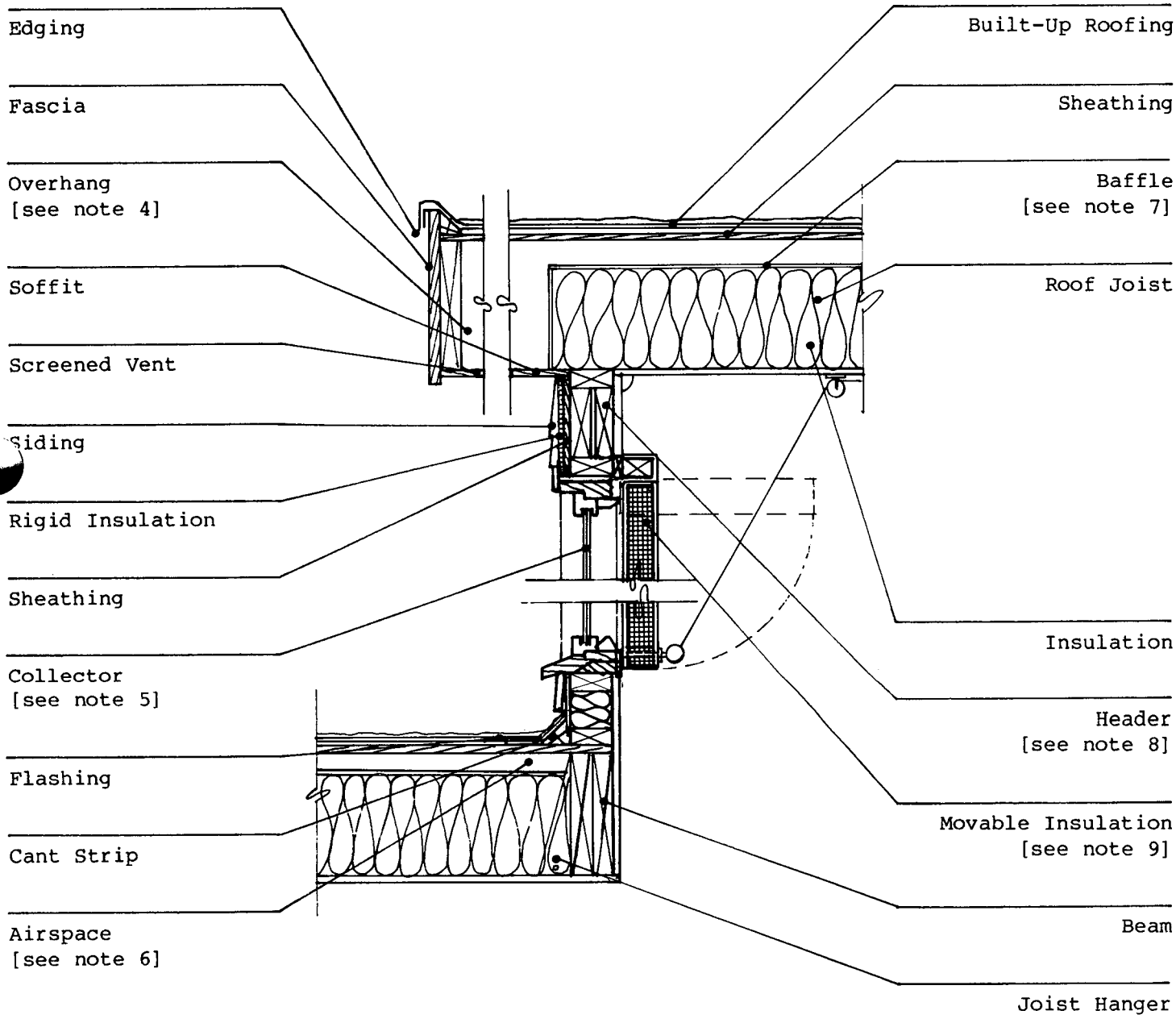
[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections.
[2] Provide gutters and downspouts as required.
[3] Sizing of headers and beams to be determined by loading, local codes and/or accepted practice.
[4] Insulation in ceiling must meet or exceed requirements of local building/ energy codes.
[5] Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information, see Sections 3.1000 and 4.4100.
[6] Opaque roof section must be vented to ensure proper performance of insulation.
[7] Provide baffles where necessary to maintain 1" minimum airspace for venting roof.
[8] Provide insulation at header. Rigid insulation may be specified or other insulation may be used at builders' option.
[9] Movable insulation should be provided to improve the system thermal performance. For further information, see Key Page 3.1100.
[10] Double glazing is generally recommended. For glazing material variations and thermal performance characteristics see Key Page 3.1100.

Direct Gain
Clerestory Window
Flat Roof

3.1210

Detail





Construction Notes

[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections.

[2] Sizing of headers and beams to be determined by loading, local codes and/or accepted practice.

[3] Insulation in ceiling must meet or exceed requirements of local building/ energy codes.

[4] Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information, see Sections 3.1000 and 4.4100.

[5] Double glazing is generally recommended. For glazing material variations and thermal performance characteristics see Key Page 3.1100.

[6] The opaque roof must be vented to ensure proper performance of the insulation. Vents may be located at the sides of the roof or at the ridge depending upon the roof construction. An airspace is provided to allow for circulation.

[7] Provide baffles where necessary to maintain 1" minimum airspace for venting roof.

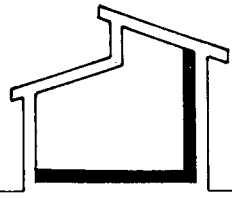
[8] Provide insulation at header. Rigid insulation may be specified or other insulation may be used at builders' option.

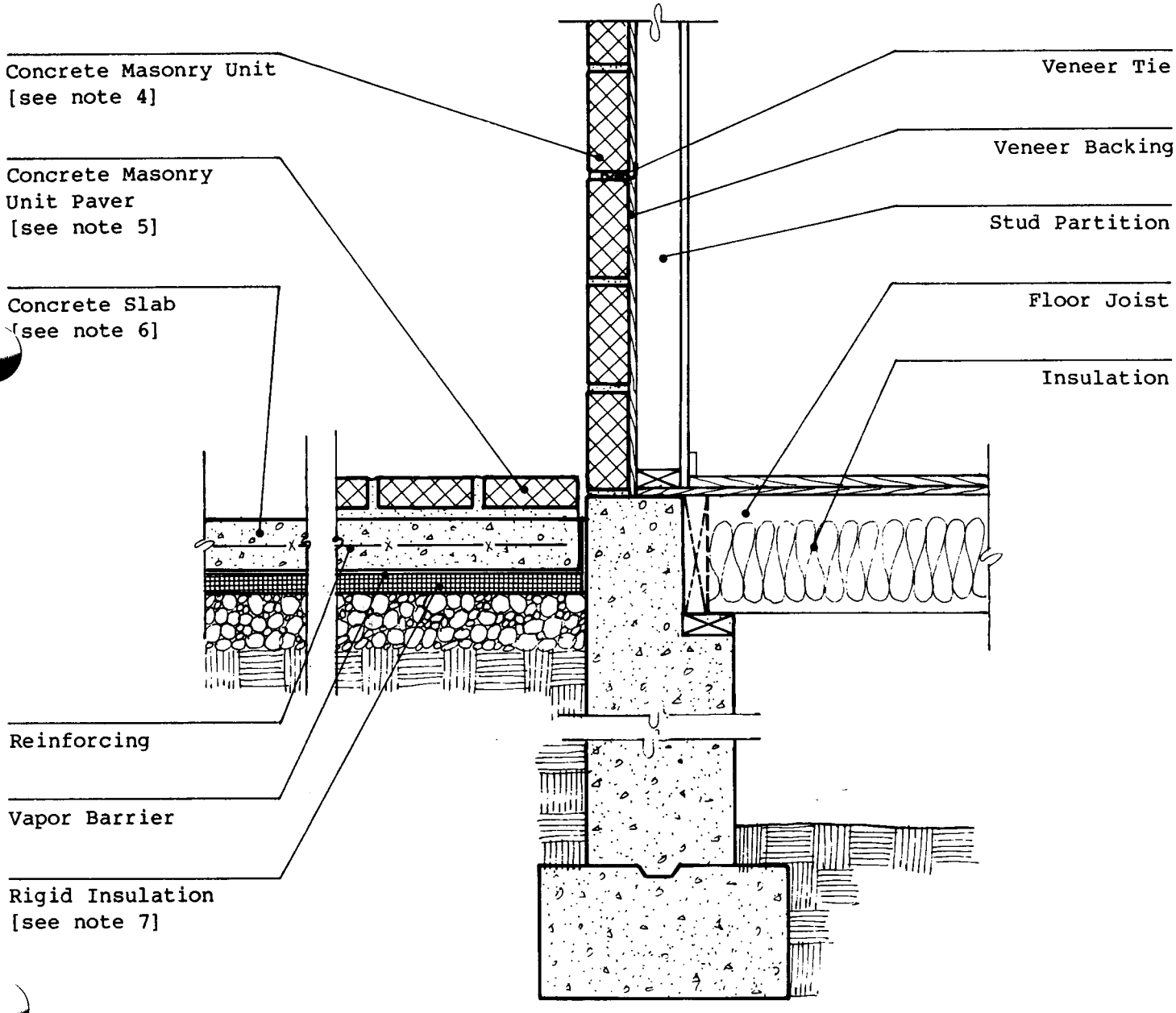
[9] Movable insulation should be provided to improve the system thermal performance. A hinged insulated shutter is suitable. For further information, see Key Page 3.1100.

Direct Gain

CMU Veneer Interior Wall
CMU Paver/Slab-On-Grade

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

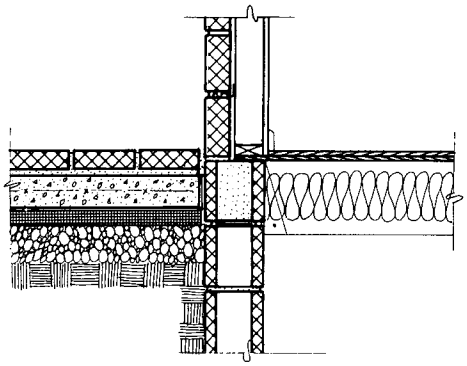
[3] Insulation levels in floors must meet or exceed requirements of local building/ energy codes.

[4] Interior CMU veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1120.

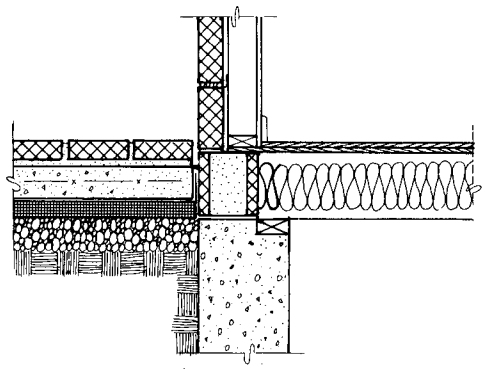
[5] For information on CMU pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1170.

[6] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.

[7] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.



Concrete Masonry Foundation

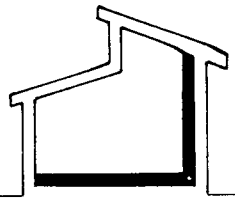


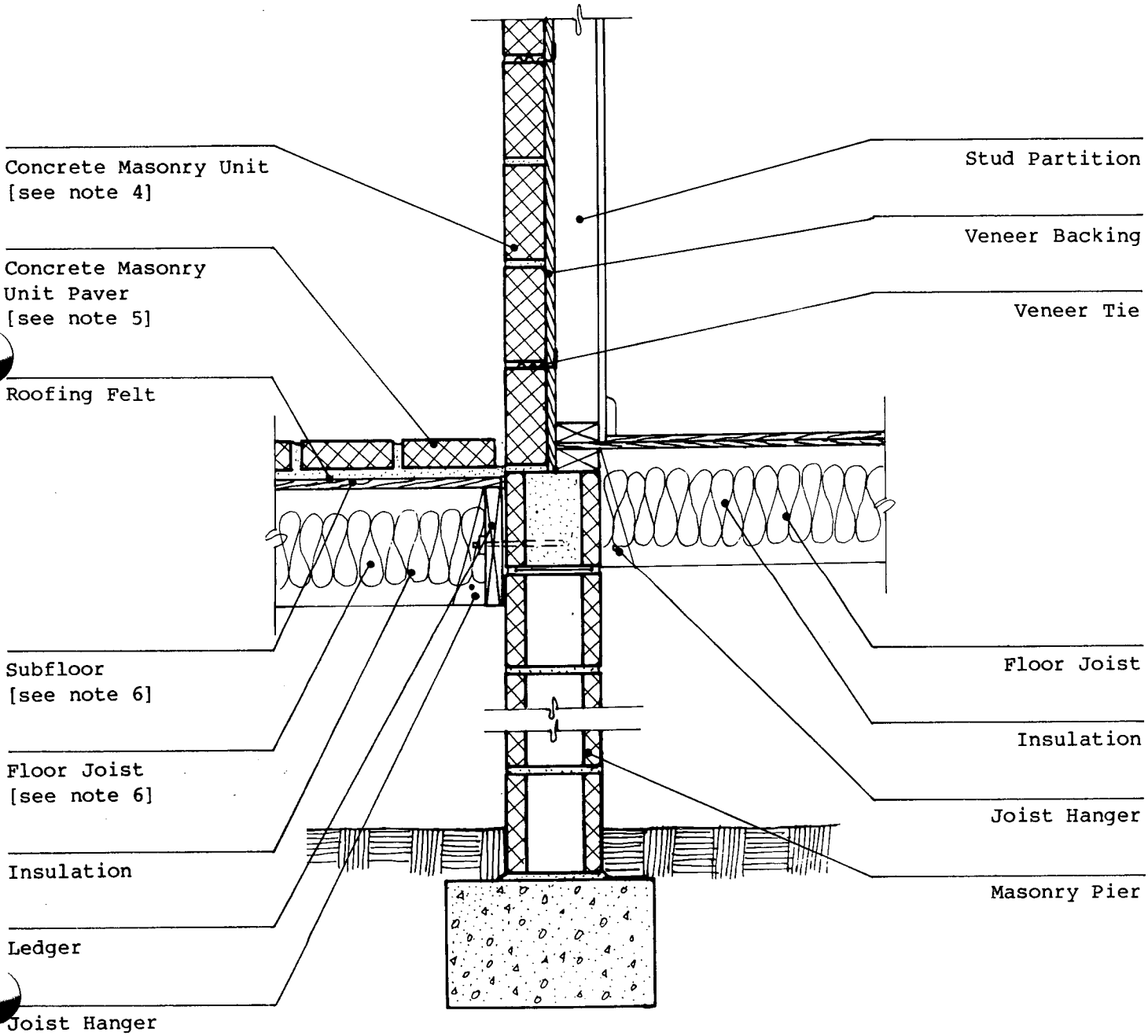
Concrete Masonry/Concrete Foundation

Direct Gain

CMU Veneer Interior Wall
CMU Paver/Wood First Floor

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

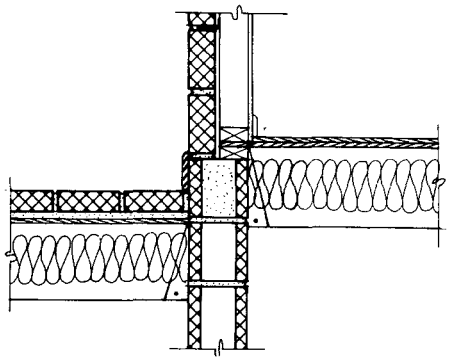
[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels in floors must meet or exceed requirements of local building/ energy codes.

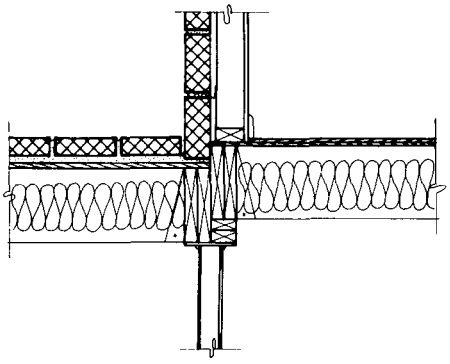
[4] Interior CMU veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1120.

[5] For information on CMU pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1172.

[6] Consideration must be given to the additional weight of pavers. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.



Uneven Floor Levels



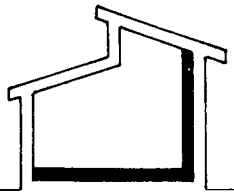
Post and Girder Support

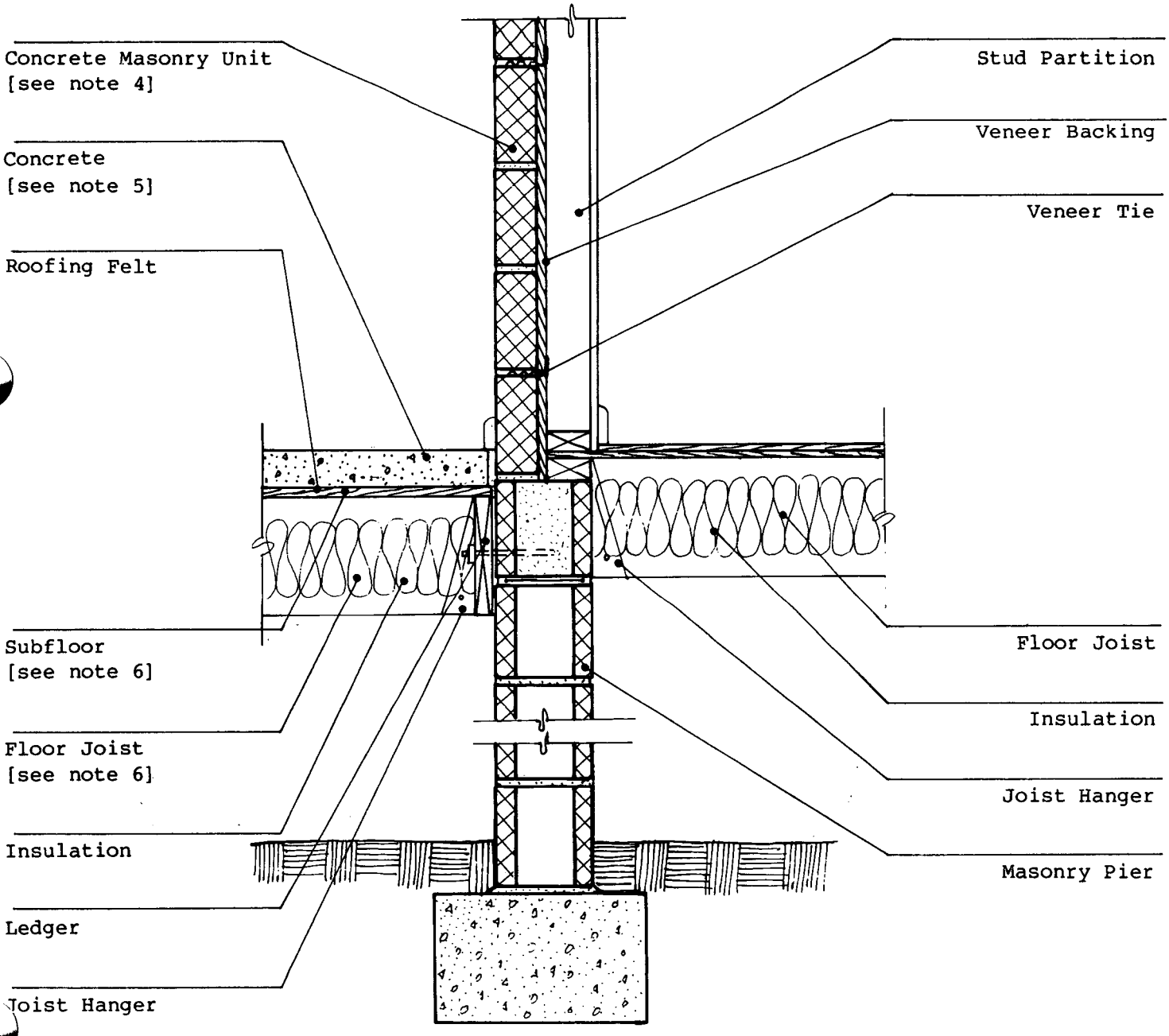
Direct Gain

CMU Veneer Interior Wall Concrete/Wood First Floor

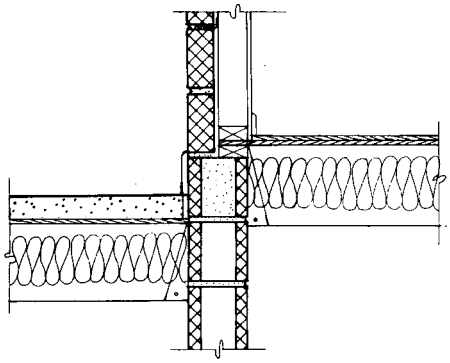
3.1404

Detail

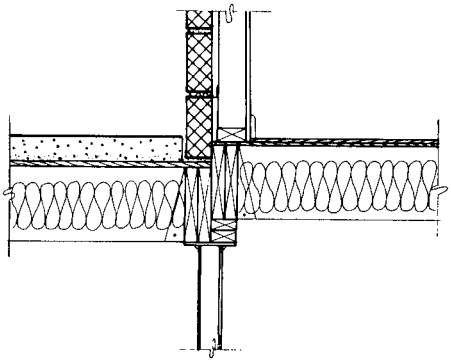




[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.
[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.
[3] Insulation levels in floors must meet or exceed requirements of local building/ energy codes.
[4] Interior CMU veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1120.
[5] For information on Concrete used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1176.
[6] Consideration must be given to the additional weight of Concrete. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.



Uneven Floor Levels

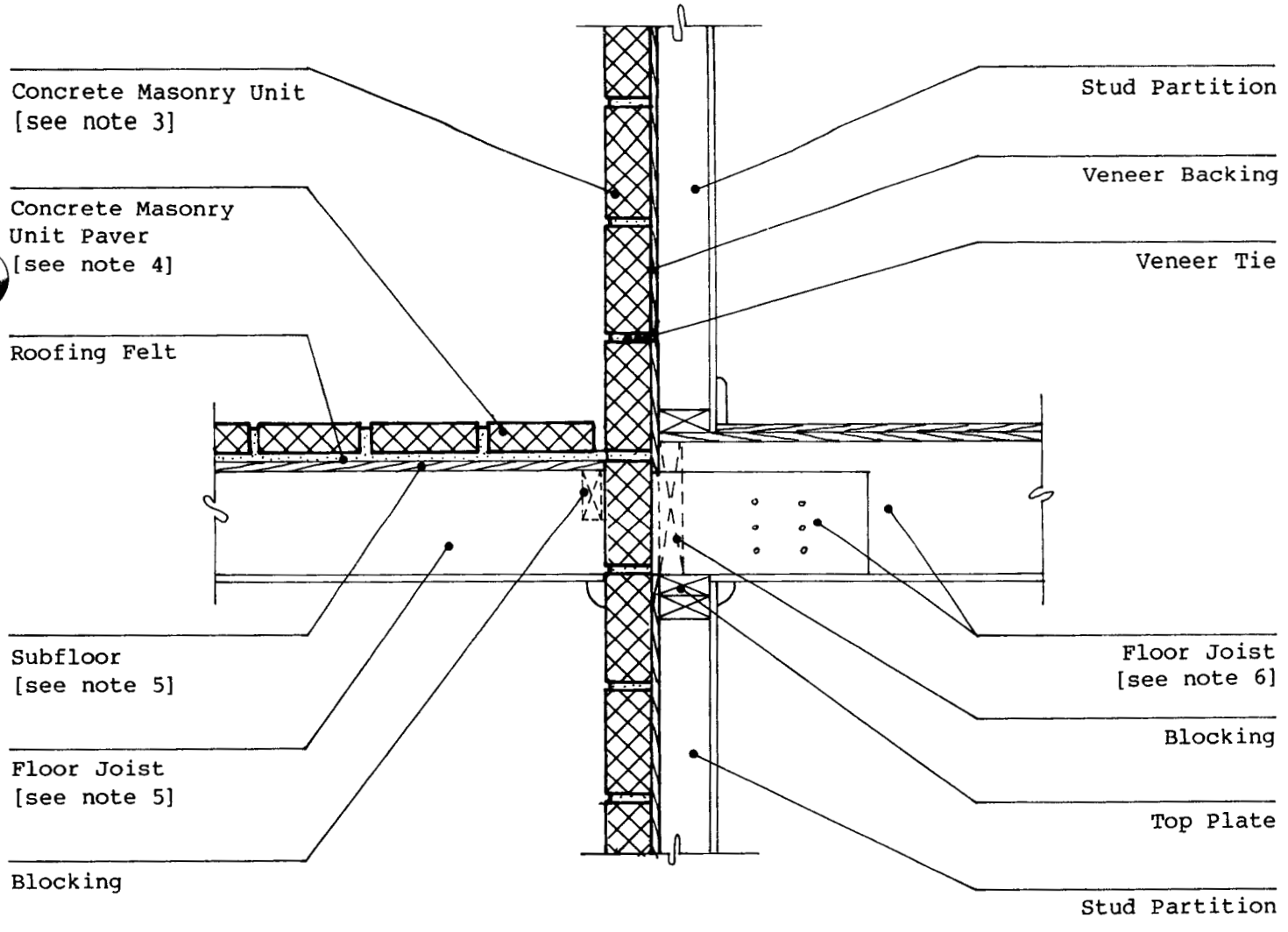


Post and Girder Support

Direct Gain

CMU Veneer Interior Wall
CMU Paver/Wood Upper Floor

Detail

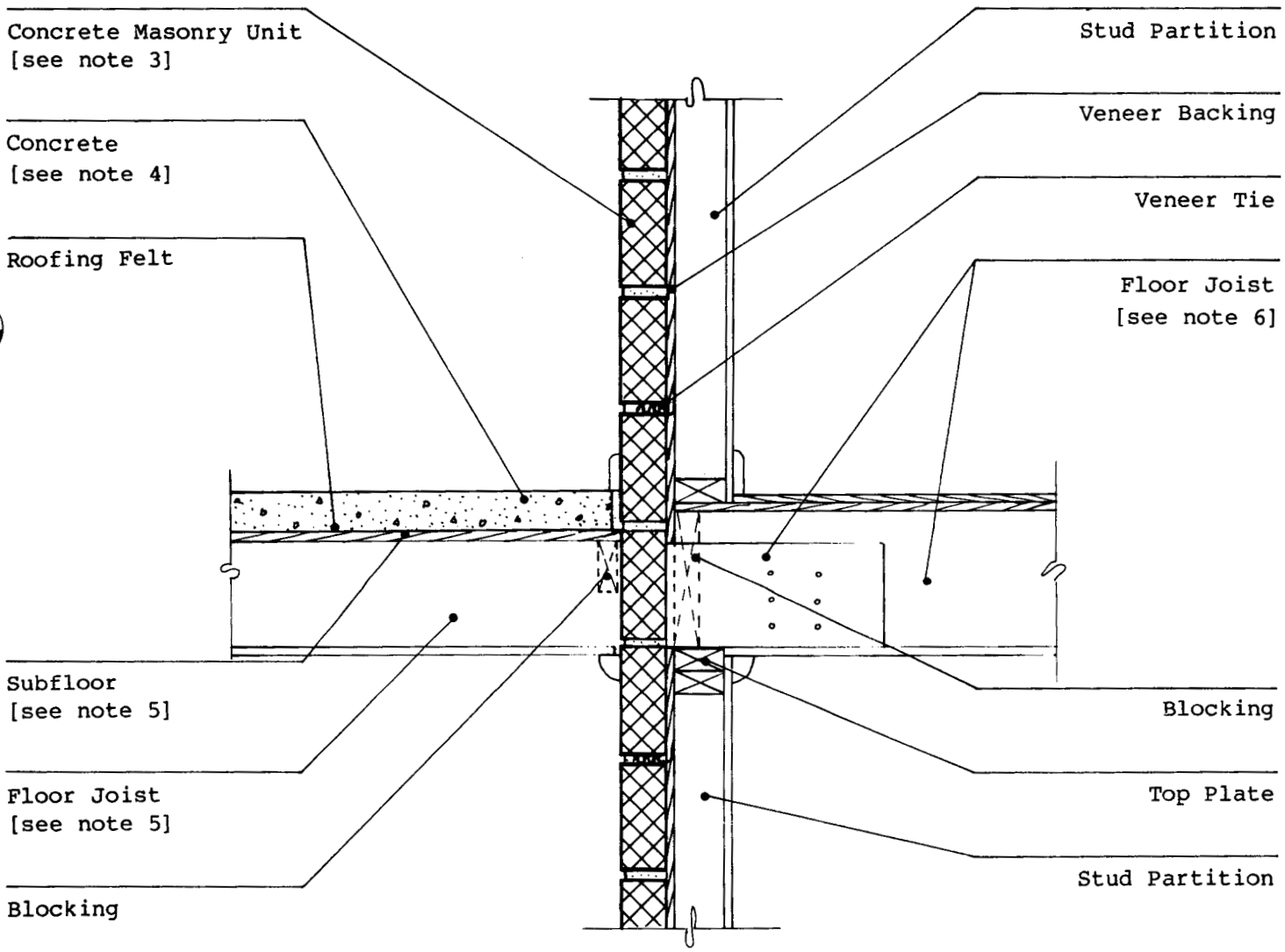


[1] CMU veneer must be continuous. Floor joists are framed through veneer.
[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.
[3] Interior CMU veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1120.
[4] For information on CMU pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1172.
[5] Consideration must be given to the additional weight of pavers. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.
[6] Joists are lapped and nailed together and bear on the double plate of the stud partition below. The joists are unequal in depth to maintain the floor level.

Direct Gain
CMU Veneer Interior Wall
Concrete/Wood Upper Floor

3.1408

Detail



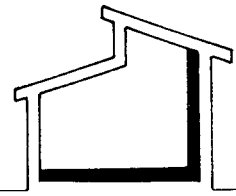
Construction Notes

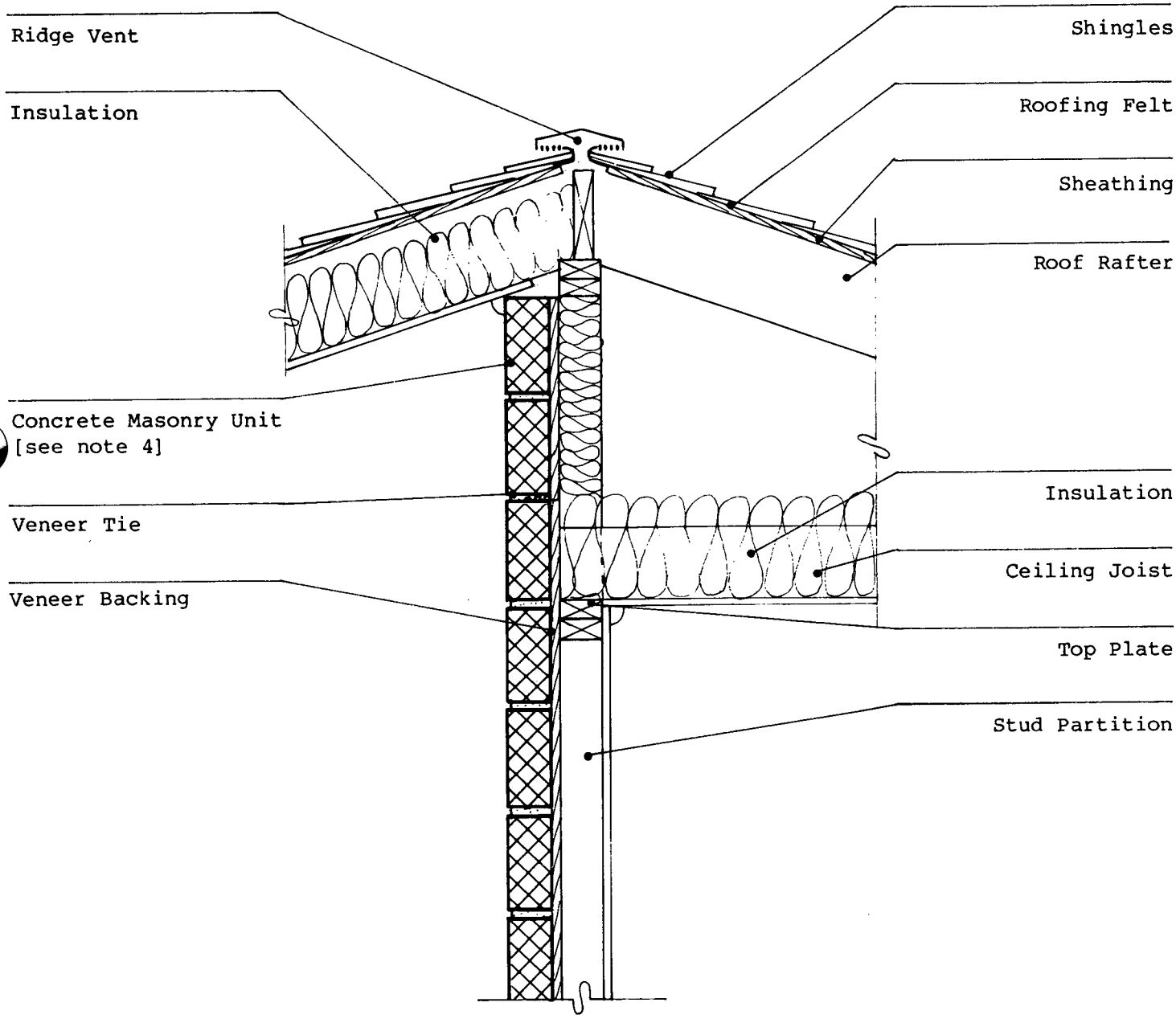
[1] CMU veneer must be continuous. Floor joists are framed through veneer.
[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.
[3] Interior CMU veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1120.
[4] For information on Concrete used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1176.
[5] Consideration must be given to the additional weight of Concrete. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.
[6] Joists are lapped and nailed together and bear on the double plate of the stud partition below. The joists are unequal in depth to maintain the floor level.

Direct Gain
CMU Veneer Interior Wall
Roof

3.1410

Detail





[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections.

[2] Placement of metal ties to be determined by local building codes and/or accepted practice.

[3] Insulation in ceiling must meet or exceed requirements of local building/ energy codes.

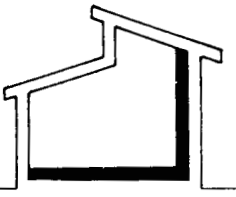
[4] Interior CMU veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1120.

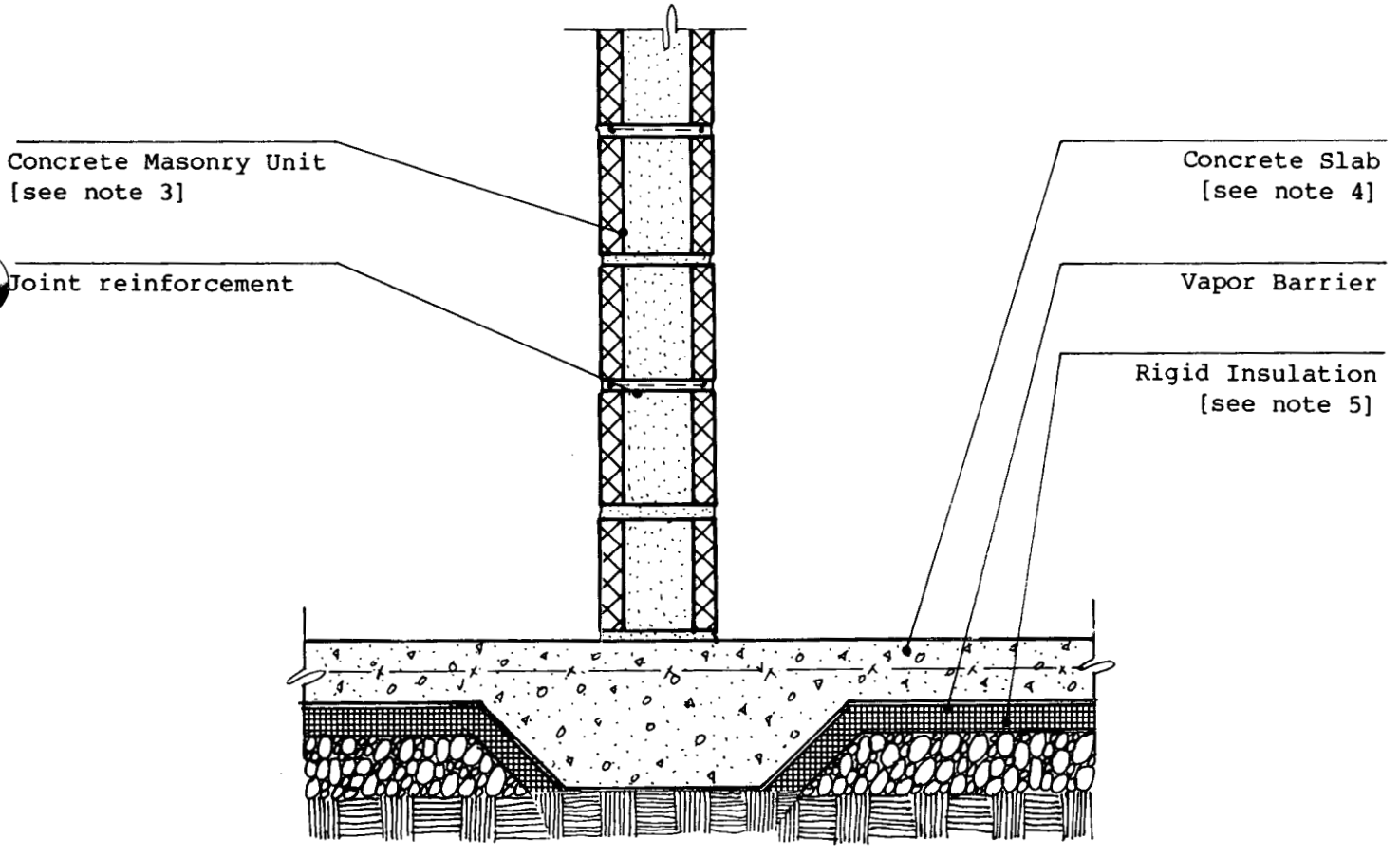
Direct Gain

CMU Interior Wall
Concrete Slab-On-Grade

3.1412

Detail





[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

[2] Placement of vertical reinforcing and horizontal joint reinforcement to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code.

[3] Concrete masonry interior partition used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.1122.

[4] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.

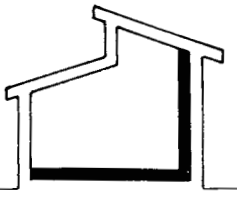
[5] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.

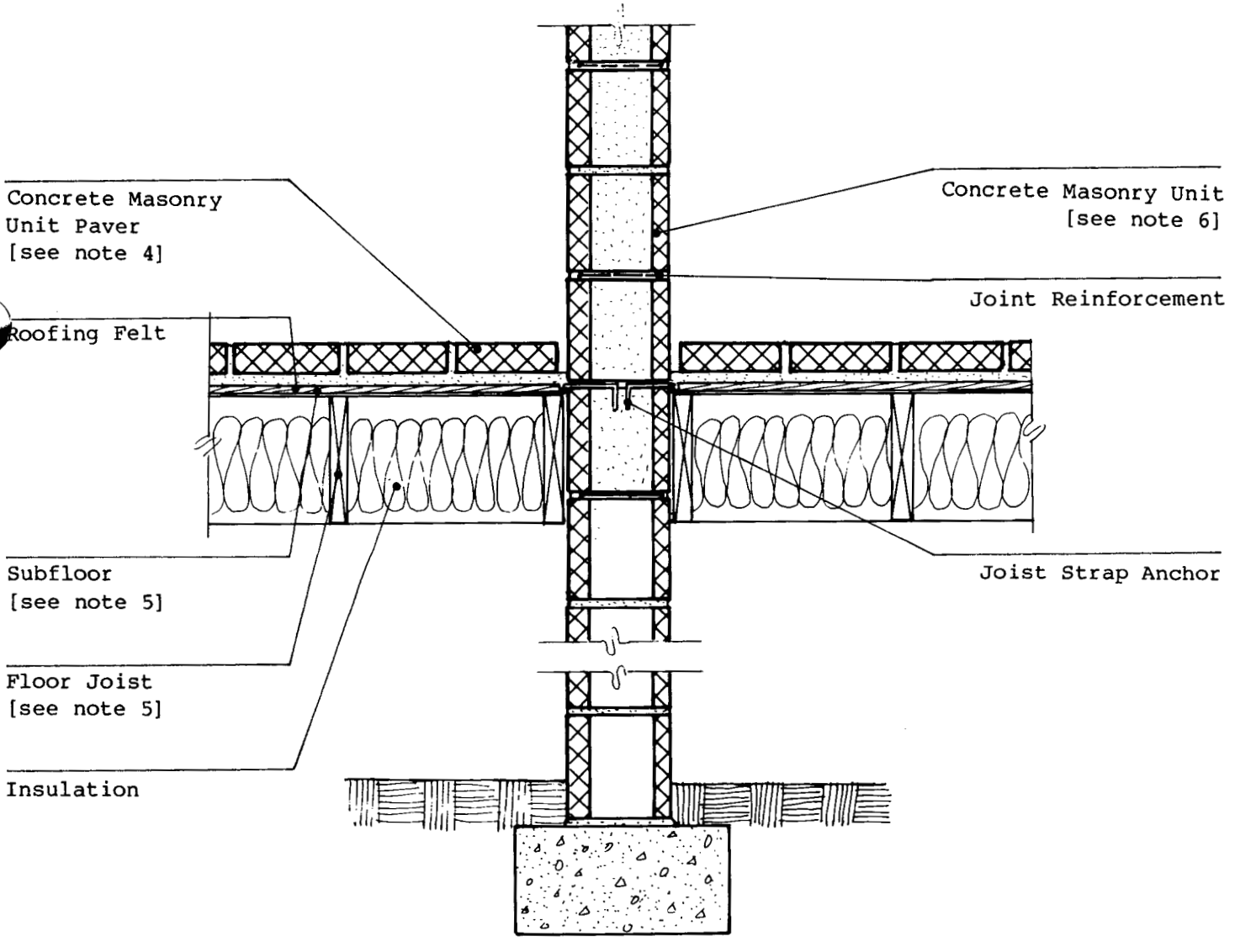
Direct Gain

CMU Interior Wall
CMU Paver/Wood First Floor

3.1414

Detail





[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

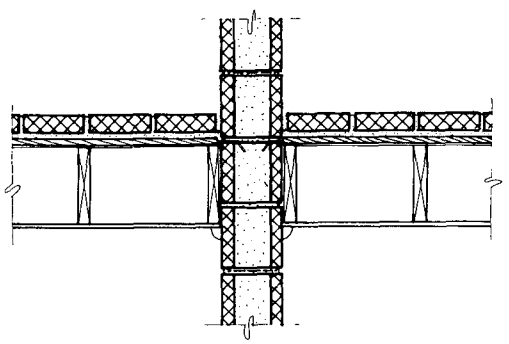
[2] Placement of reinforcing and joist strap anchors to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels in floors must meet or exceed requirements of local building/ energy codes.

[4] For information on CMU pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1172.

[5] Consideration must be given to the additional weight of pavers. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.

[6] Concrete masonry interior partition used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.1122.

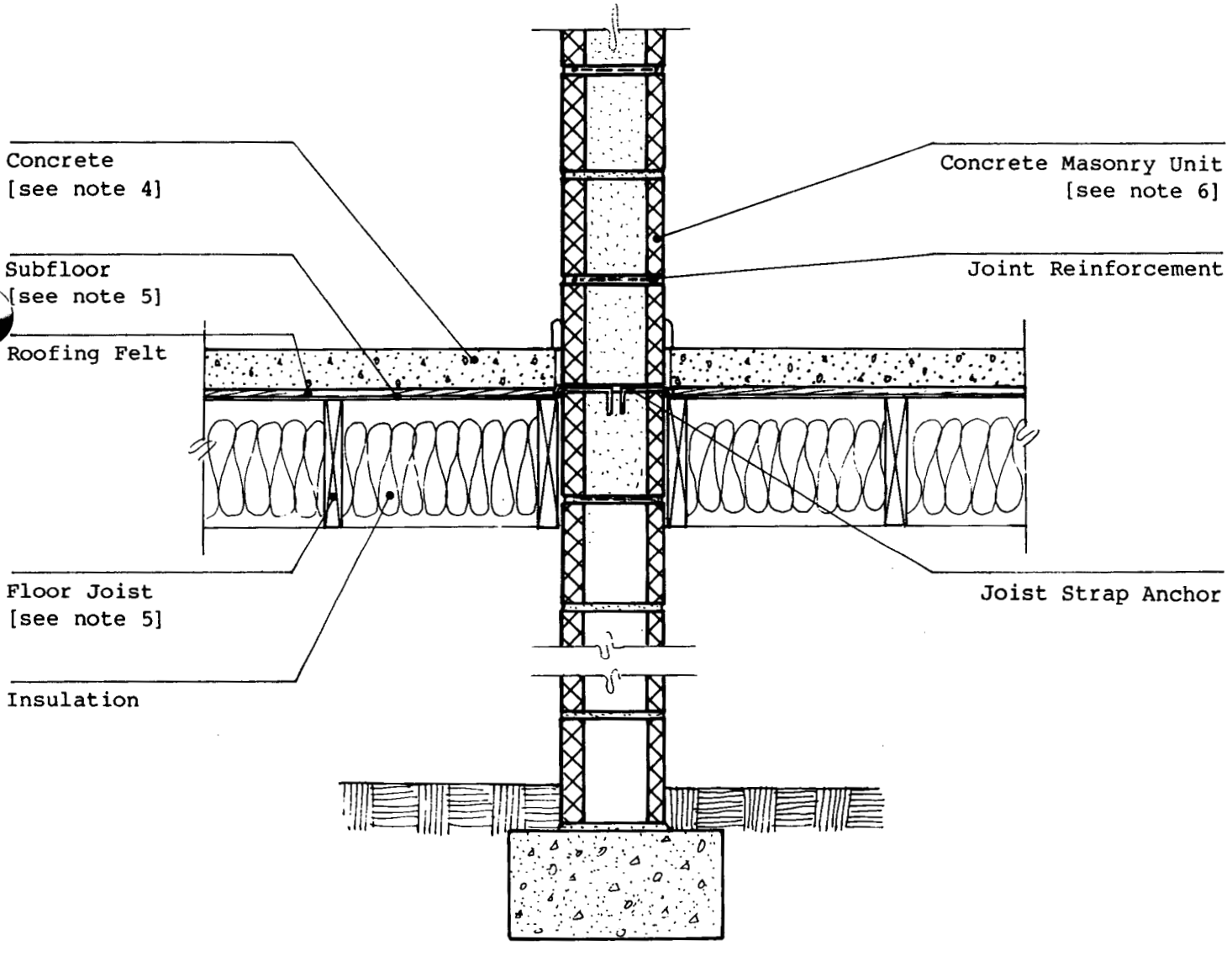


Connection at Upper Floor

Direct Gain
CMU Interior Wall
Concrete/Wood First Floor

3.1416

Detail



[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

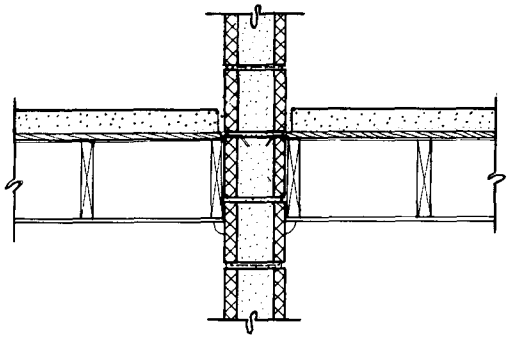
[2] Placement of reinforcing and joist strap anchors to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels in floors must meet or exceed requirements of local building/ energy codes.

[4] For information on Concrete used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1176.

[5] Consideration must be given to the additional weight of Concrete. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.

[6] Concrete masonry interior partition used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.1122.

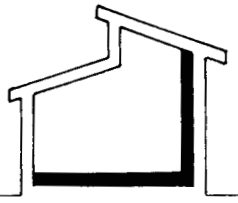


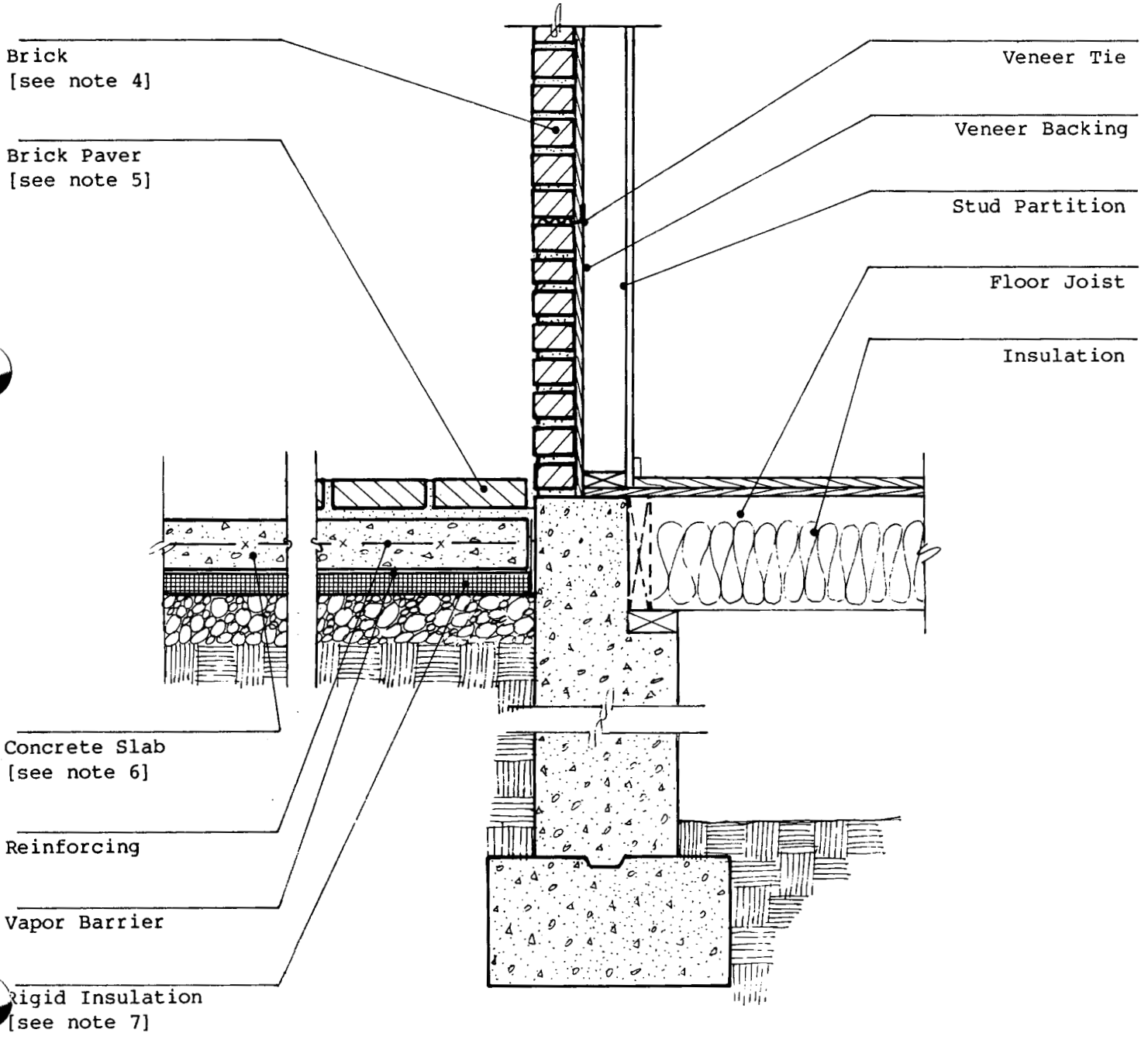
Connection at Upper Floor

Direct Gain
Brick Veneer Interior Wall
Brick Paver/Slab-On-Grade

3.1418

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

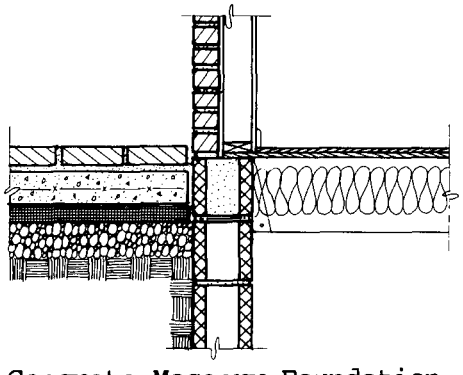
[3] Insulation levels in floors must meet or exceed requirements of local building/energy codes.

[4] Interior Brick veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1124.

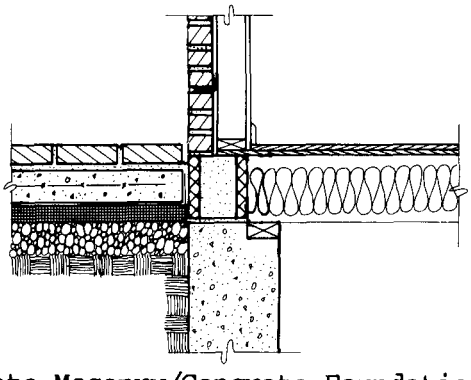
[5] For information on Brick pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1178.

[6] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.

[7] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.



Concrete Masonry Foundation



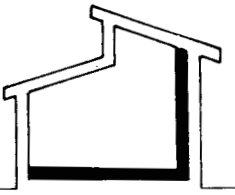
Concrete Masonry/Concrete Foundation

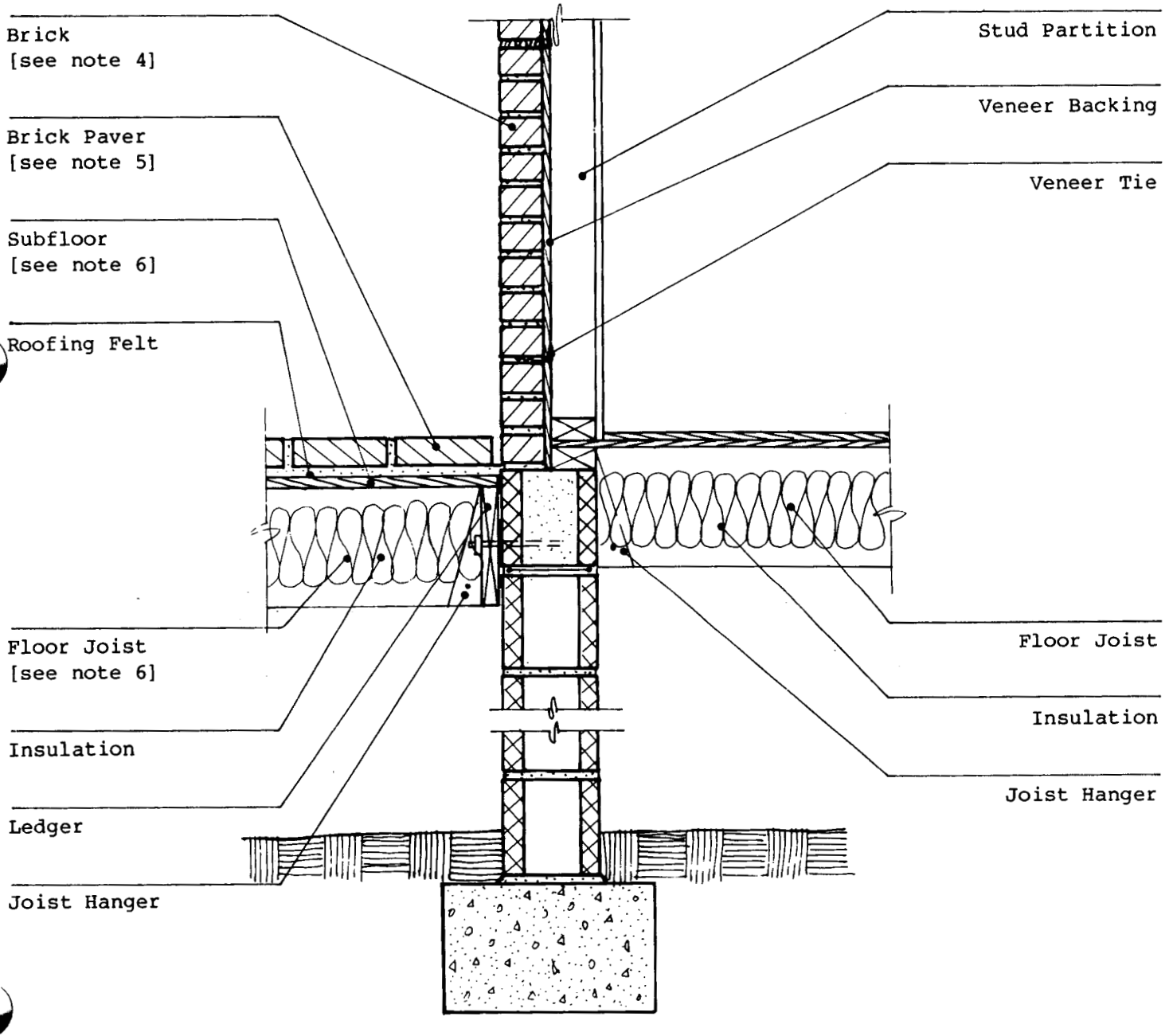
Direct Gain

Brick Veneer Interior Wall
Brick Paver/Wood First Floor

3.1420

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

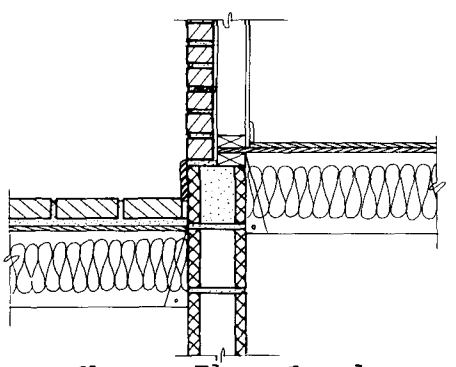
[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels in floors must meet or exceed requirements of local building/ energy codes.

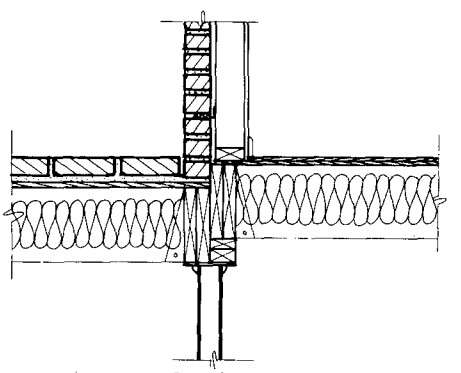
[4] Interior Brick veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1124.

[5] For information on Brick pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1180.

[6] Consideration must be given to the additional weight of pavers. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.



Uneven Floor Levels



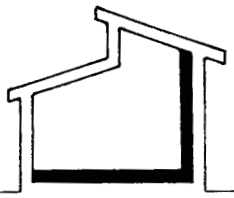
Post and Girder Support

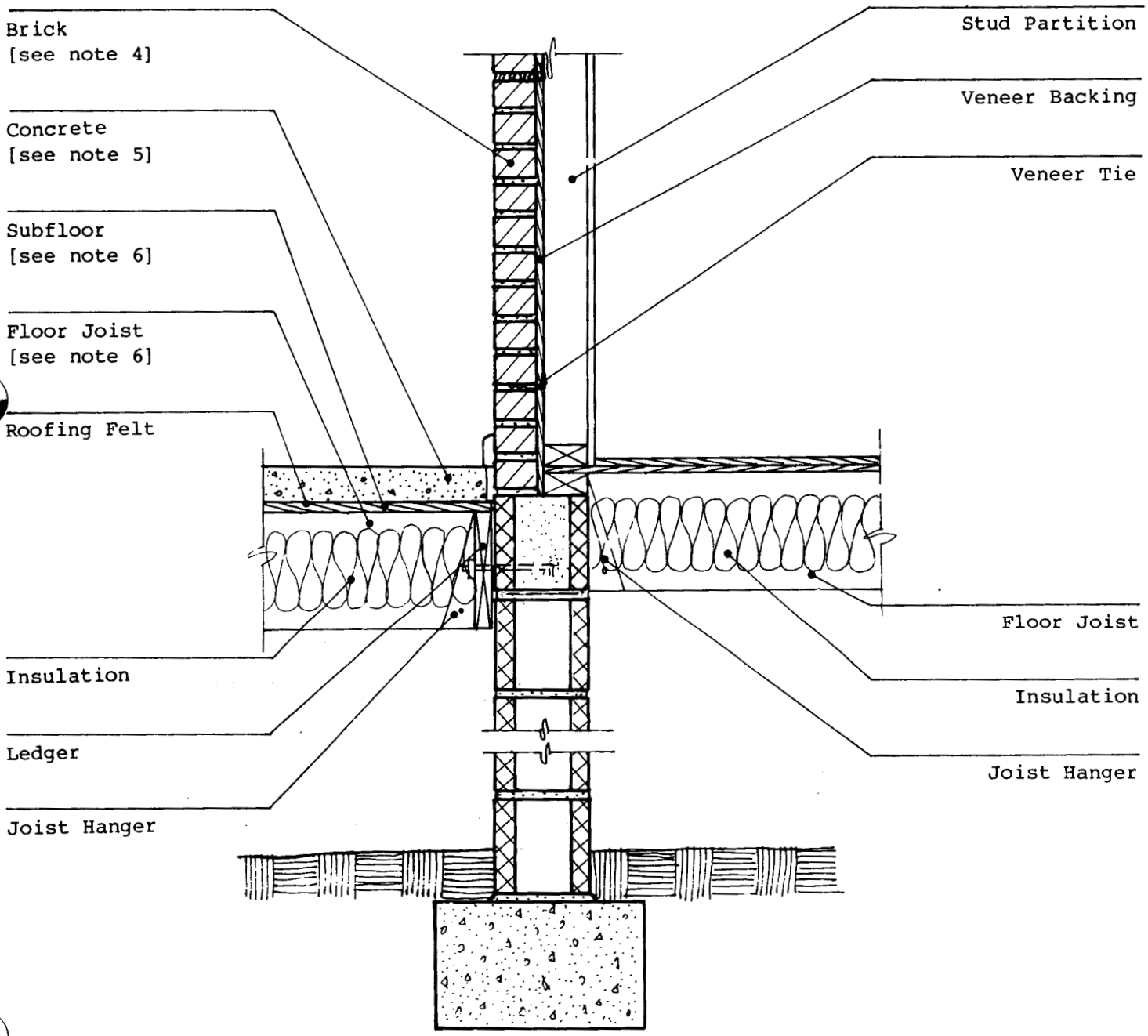
Direct Gain

Brick Veneer Interior Wall
Concrete/Wood First Floor

3.1422

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

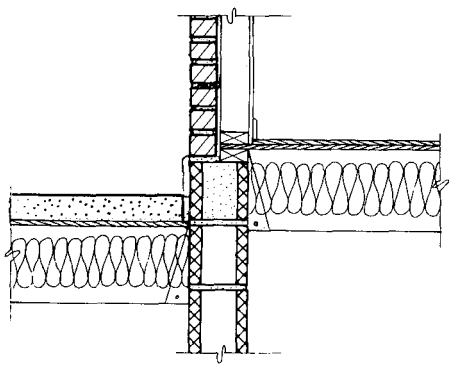
[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels in floors must meet or exceed requirements of local building/ energy codes.

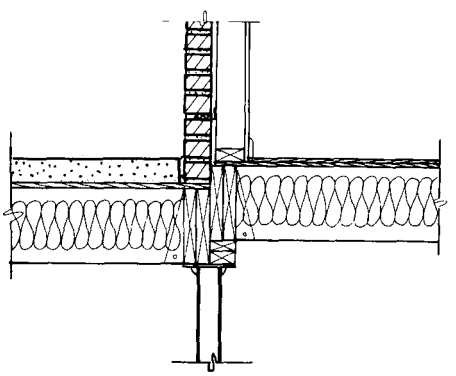
[4] Interior Brick veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1124.

[5] For information on Concrete used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1176.

[6] Consideration must be given to the additional weight of Concrete. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.



Uneven Floor Levels

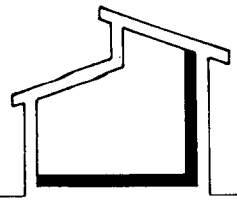


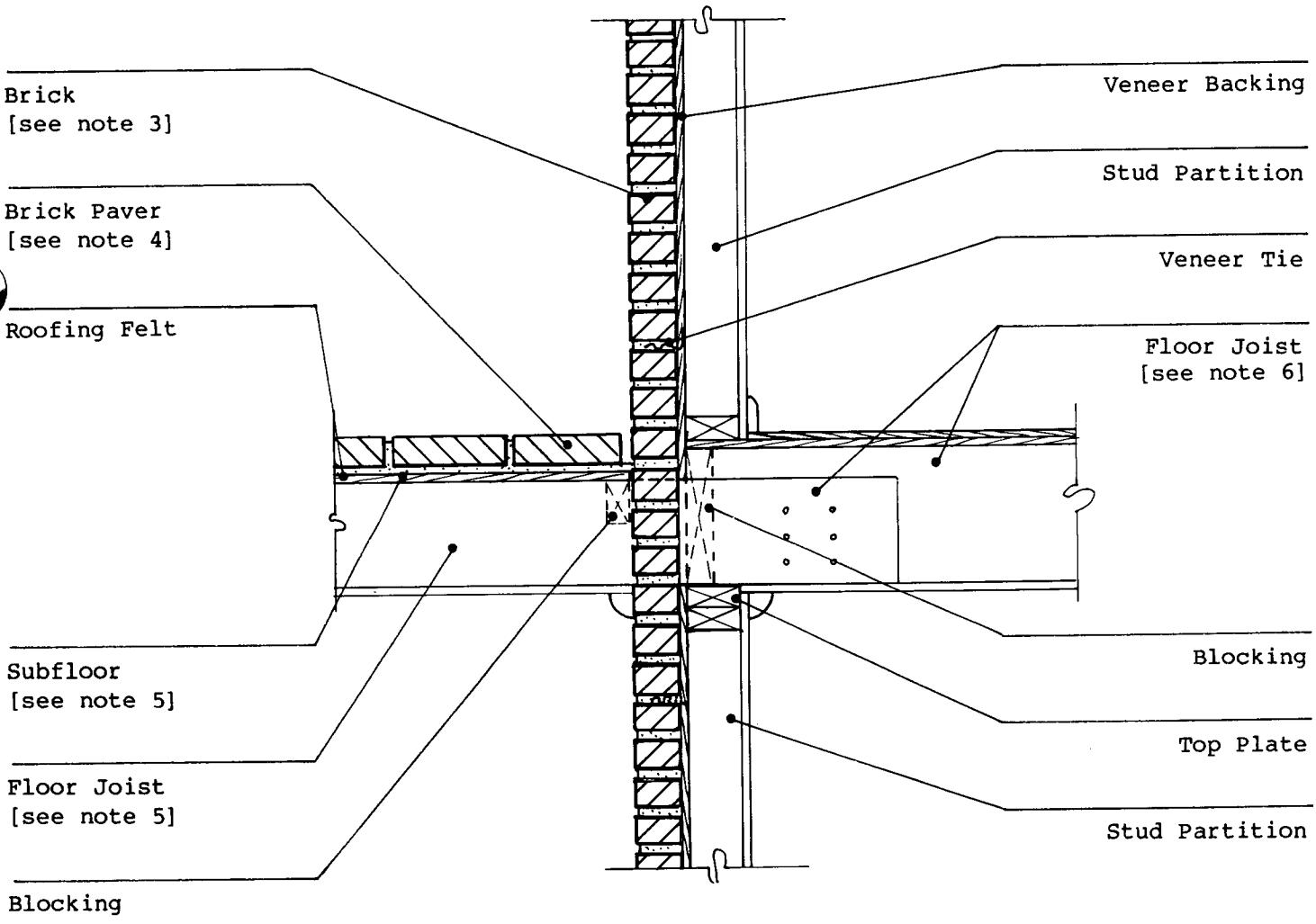
Post and Girder Support

Direct Gain

Brick Veneer Interior Wall
Brick Paver/Wood Upper Floor

Detail



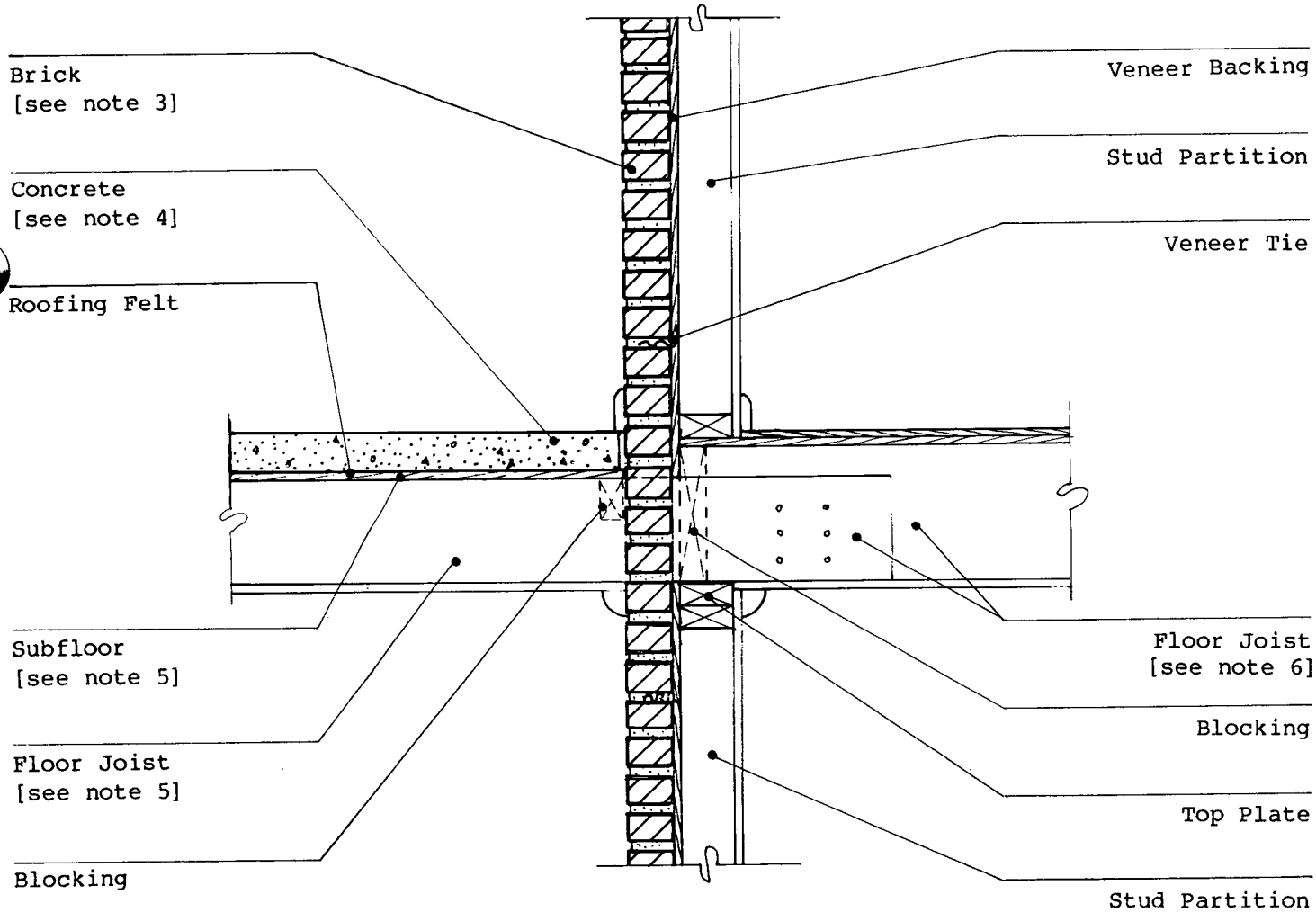


[1] Brick veneer must be continuous. Floor joists are framed through veneer.
[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.
[3] Interior Brick veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1124.
[4] For information on Brick pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1180.
[5] Consideration must be given to the additional weight of pavers. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.
[6] Joists are lapped and nailed together and bear on the double plate of the stud partition below. The joists are unequal in depth to maintain the floor level.

Direct Gain
Brick Veneer Interior Wall
Concrete/Wood Upper Floor

3.1426

Detail

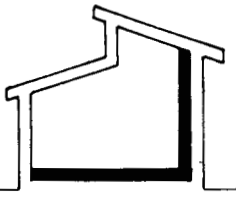


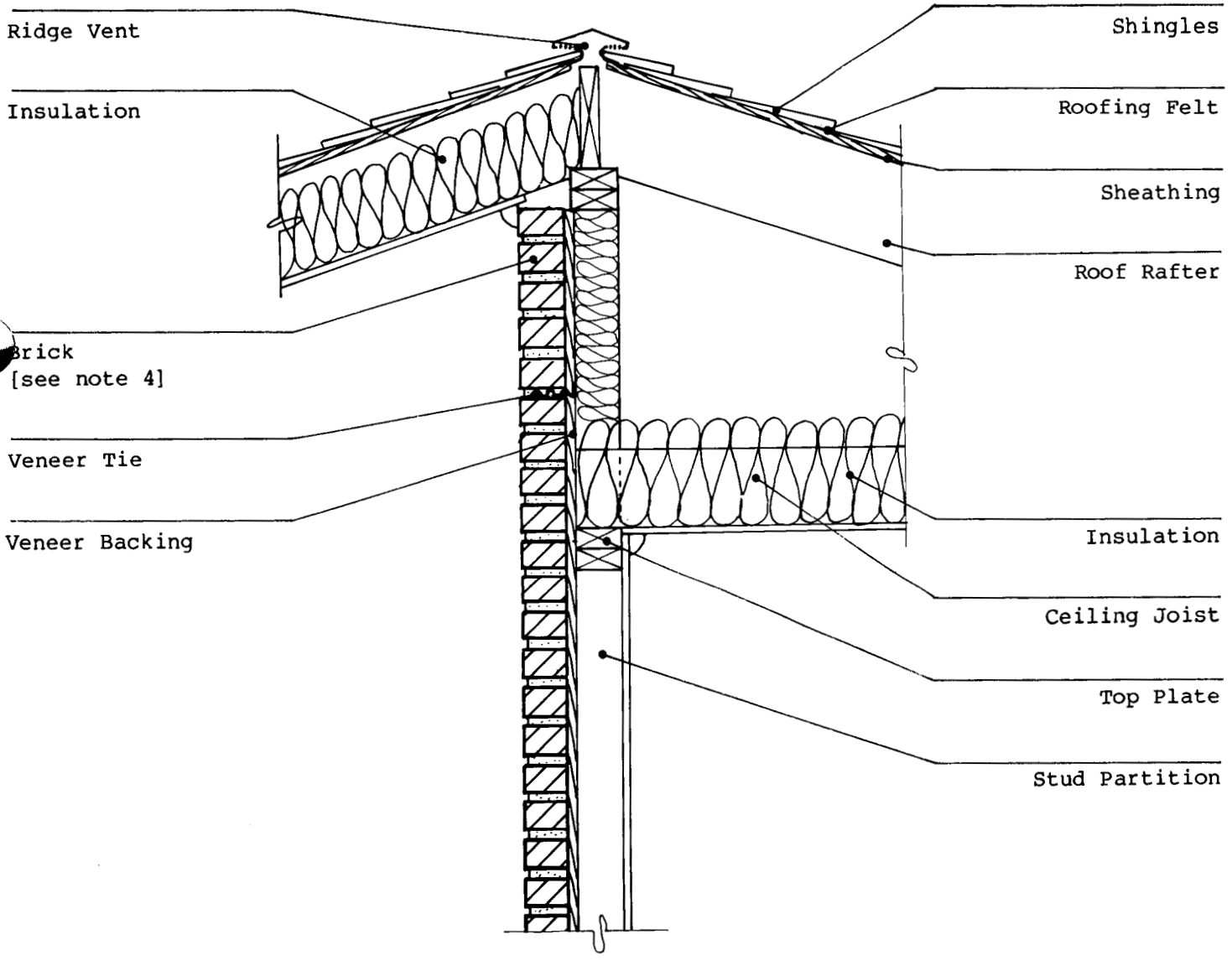
[1] Brick veneer must be continuous. Floor joists are framed through veneer.
[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.
[3] Interior Brick veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1124.
[4] For information on Concrete used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1176.
[5] Consideration must be given to the additional weight of Concrete. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.
[6] Joists are lapped and nailed together and bear on the double plate of the stud partition below. The joists are unequal in depth to maintain the floor level.

Direct Gain
Brick Veneer Interior Wall
Roof

3.1428

Detail





Construction Notes

[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections.

[2] Placement of metal ties to be determined by local building codes and/or accepted practice.

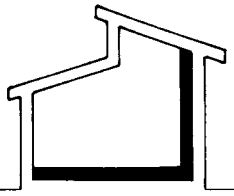
[3] Insulation in ceiling must meet or exceed requirements of local building/ energy codes.

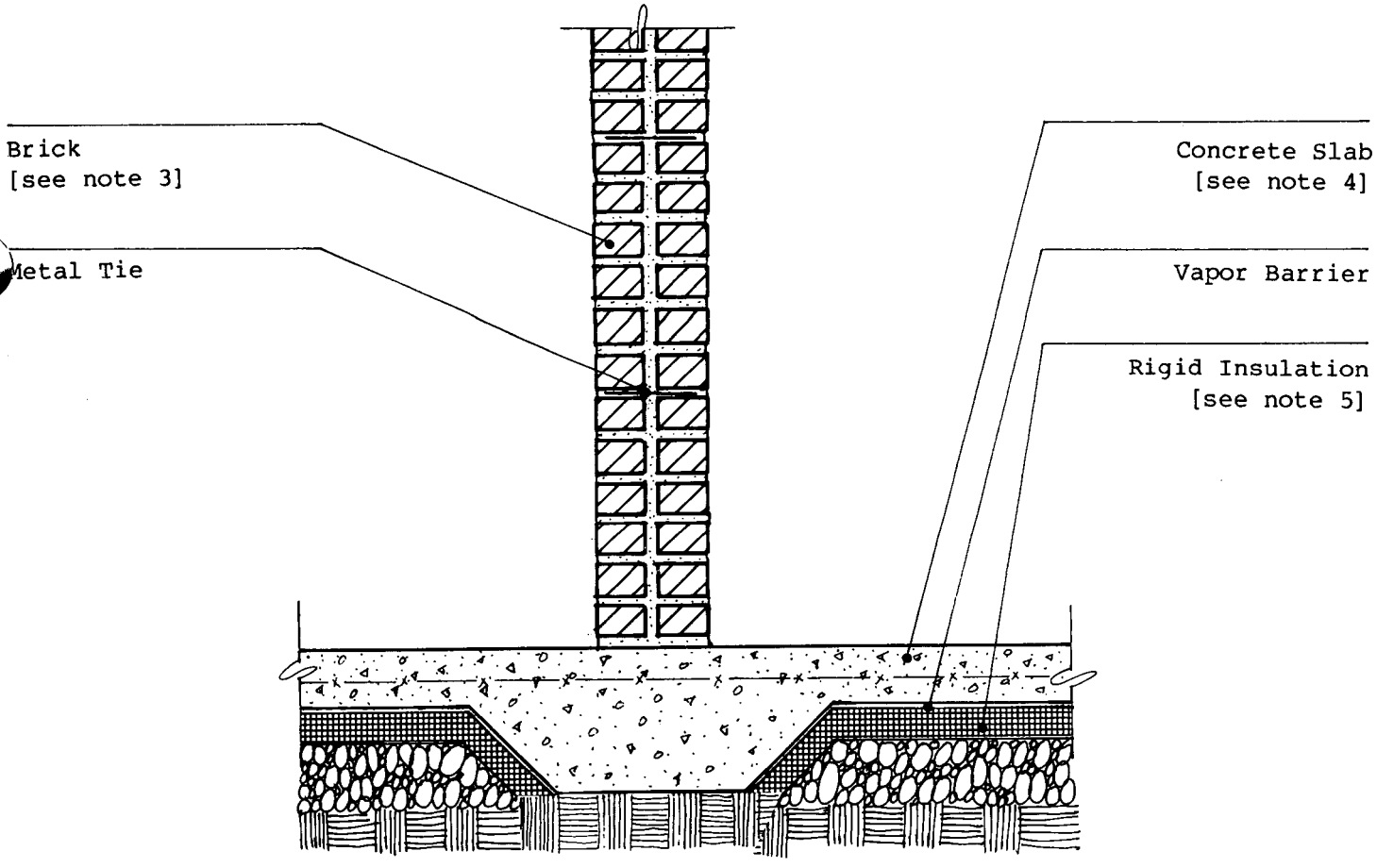
[4] Interior Brick veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1124.

Direct Gain
Solid Brick Interior Wall
Concrete Slab-On-Grade

3.1430

Detail





[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code.

[3] Solid Brick interior partition used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.1126.

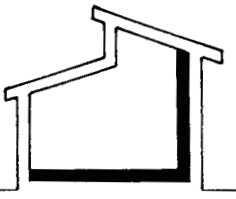
[4] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.

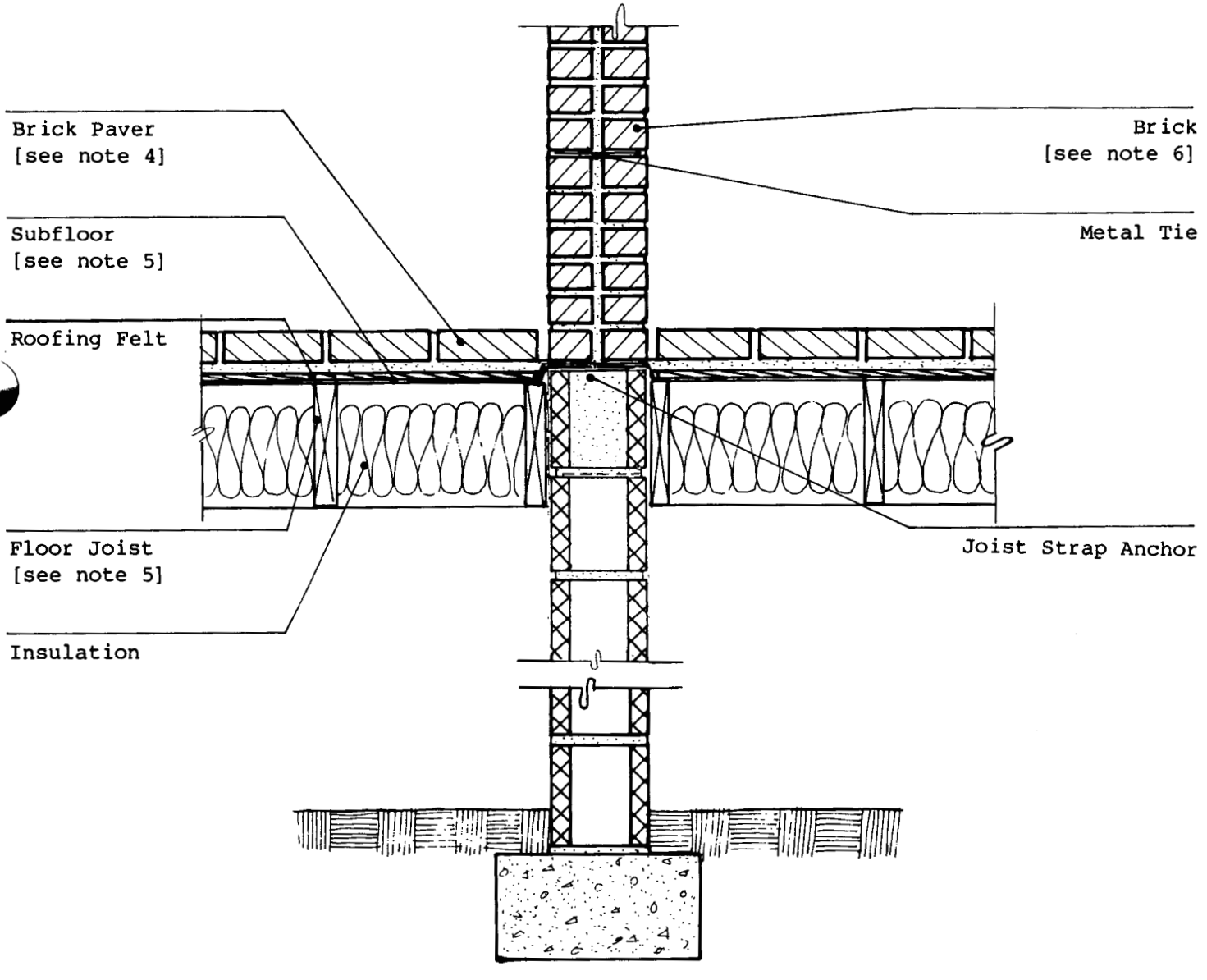
[5] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.

Direct Gain
Solid Brick Interior Wall
Brick Paver/Wood First Floor

3.1432

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

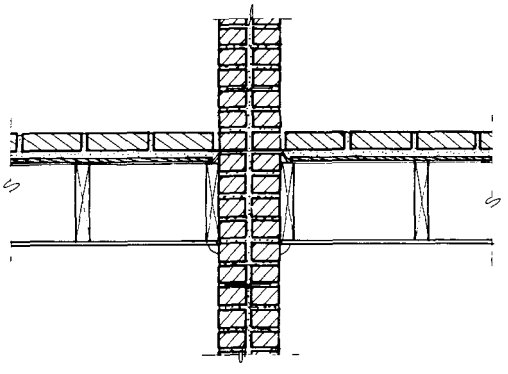
[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels in floors must meet or exceed requirements of local building/ energy codes.

[4] For information on Brick pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1180.

[5] Consideration must be given to the additional weight of pavers. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.

[6] Solid Brick interior partition used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.1126.

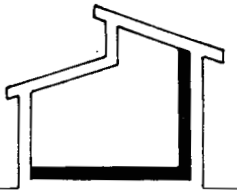


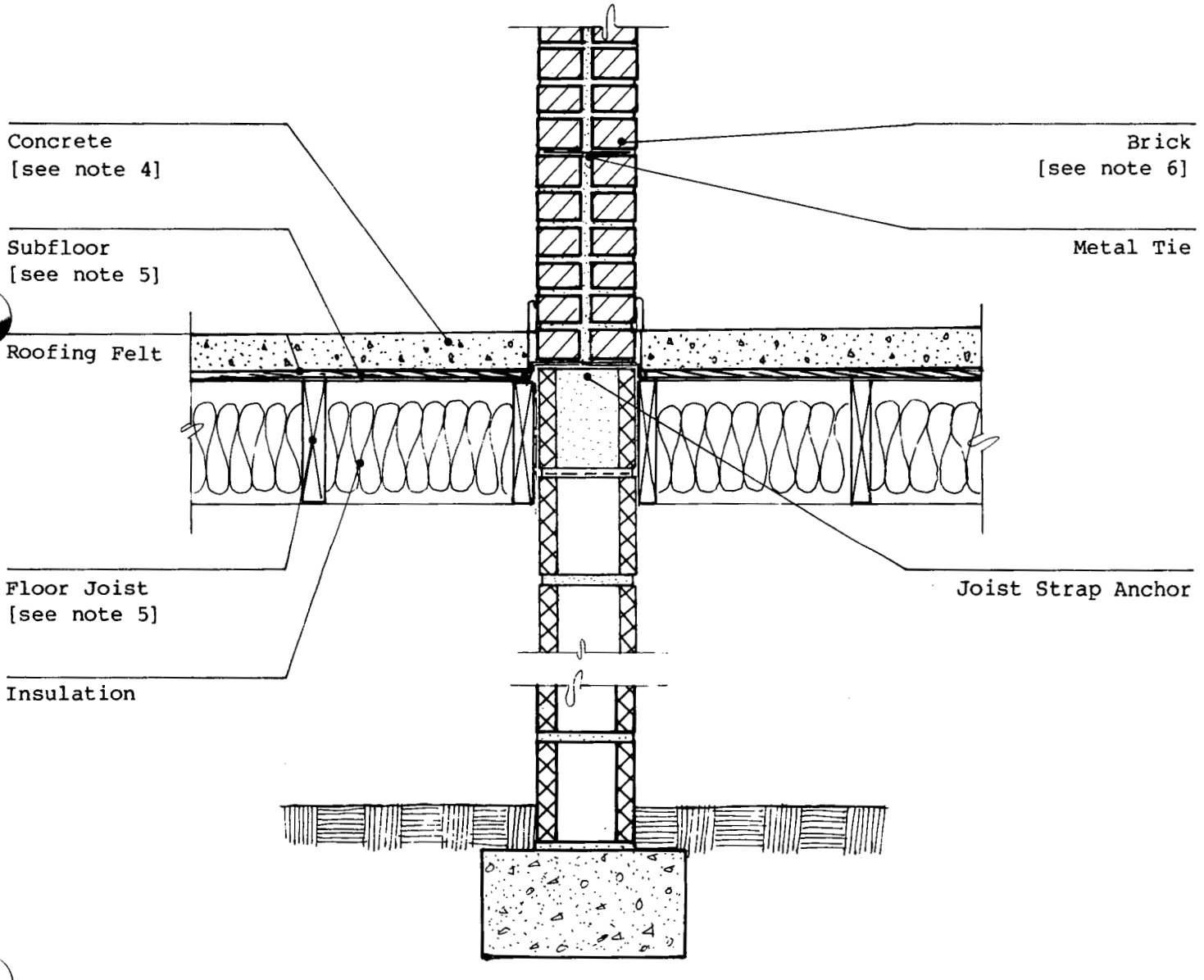
Connection at Upper Floor

Direct Gain
Solid Brick Interior Wall
Concrete/Wood First Floor

3.1434

Detail





[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

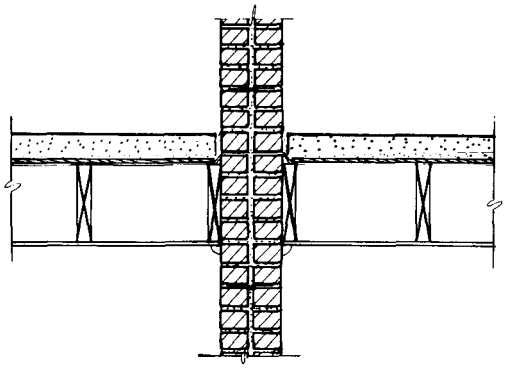
[2] Placement of reinforcing, metal ties and joist strap anchors to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels in floors must meet or exceed requirements of local building/ energy codes.

[4] For information on Concrete used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1176.

[5] Consideration must be given to the additional weight of Concrete. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.

[6] Solid Brick interior partition used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.1126.

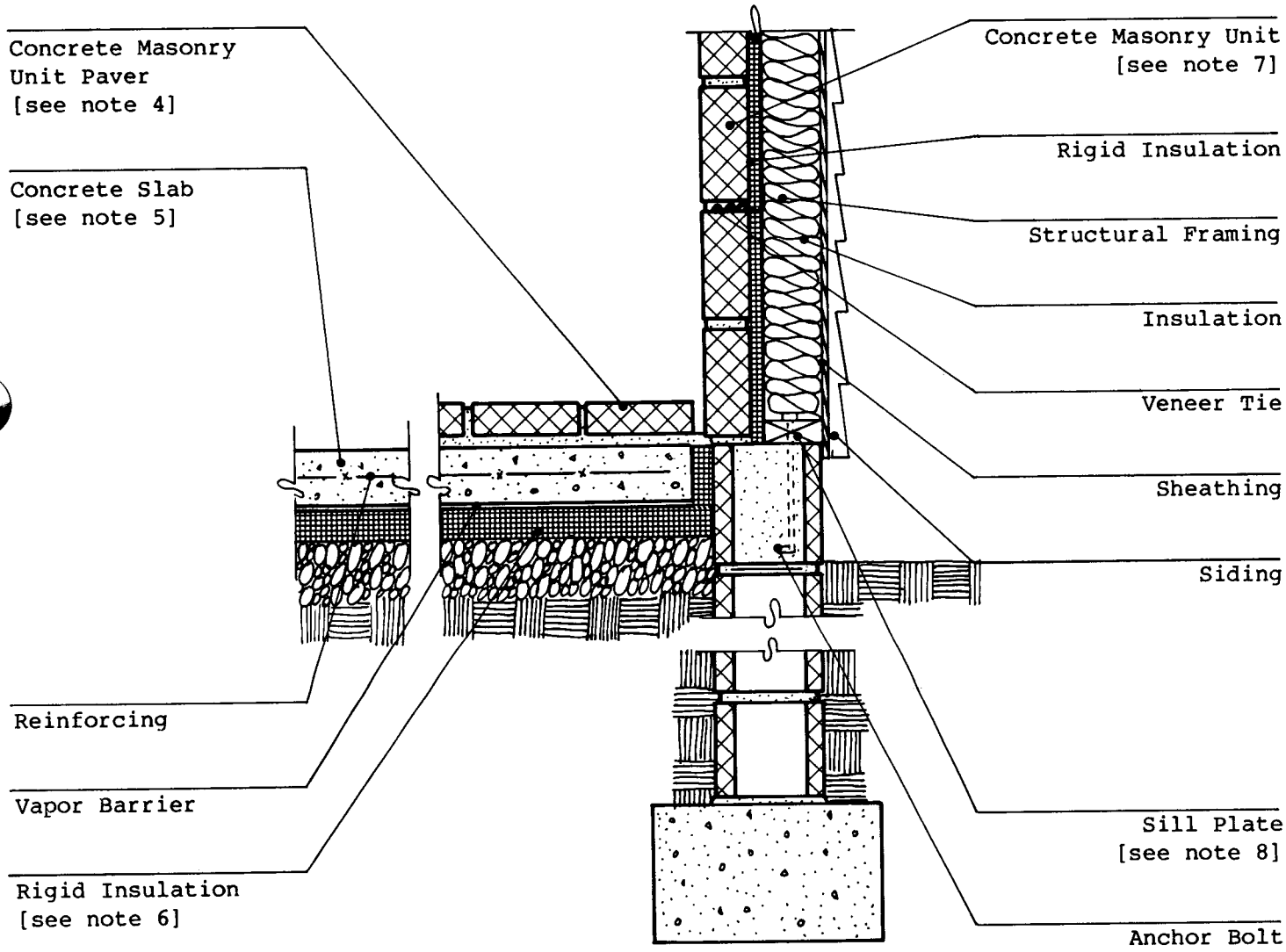


Connection at Upper Floor

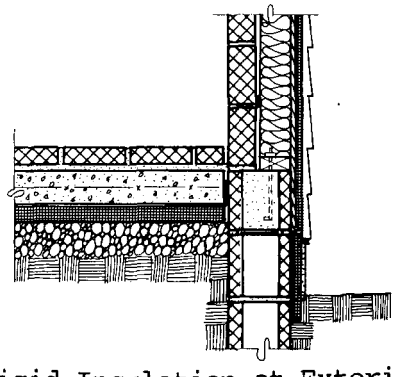
Direct Gain

CMU Veneer Exterior Wall
CMU Paver/Slab-On-Grade

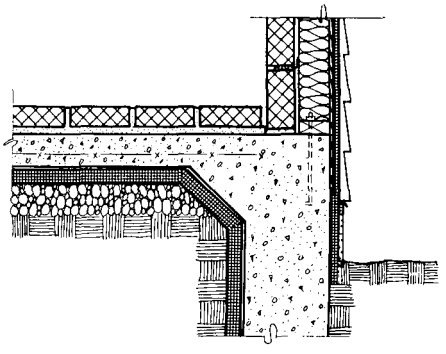
Detail



[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.
[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.
[3] Insulation levels in floors and walls must meet or exceed requirements of local building/energy codes.
[4] For information on CMU pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1170.
[5] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.
[6] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.
[7] Interior CMU veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1140.
[8] Continuous sill sealer is recommended to provide protection against infiltration.



Rigid Insulation at Exterior

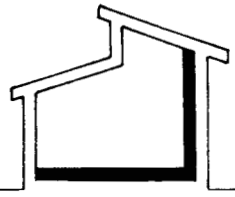


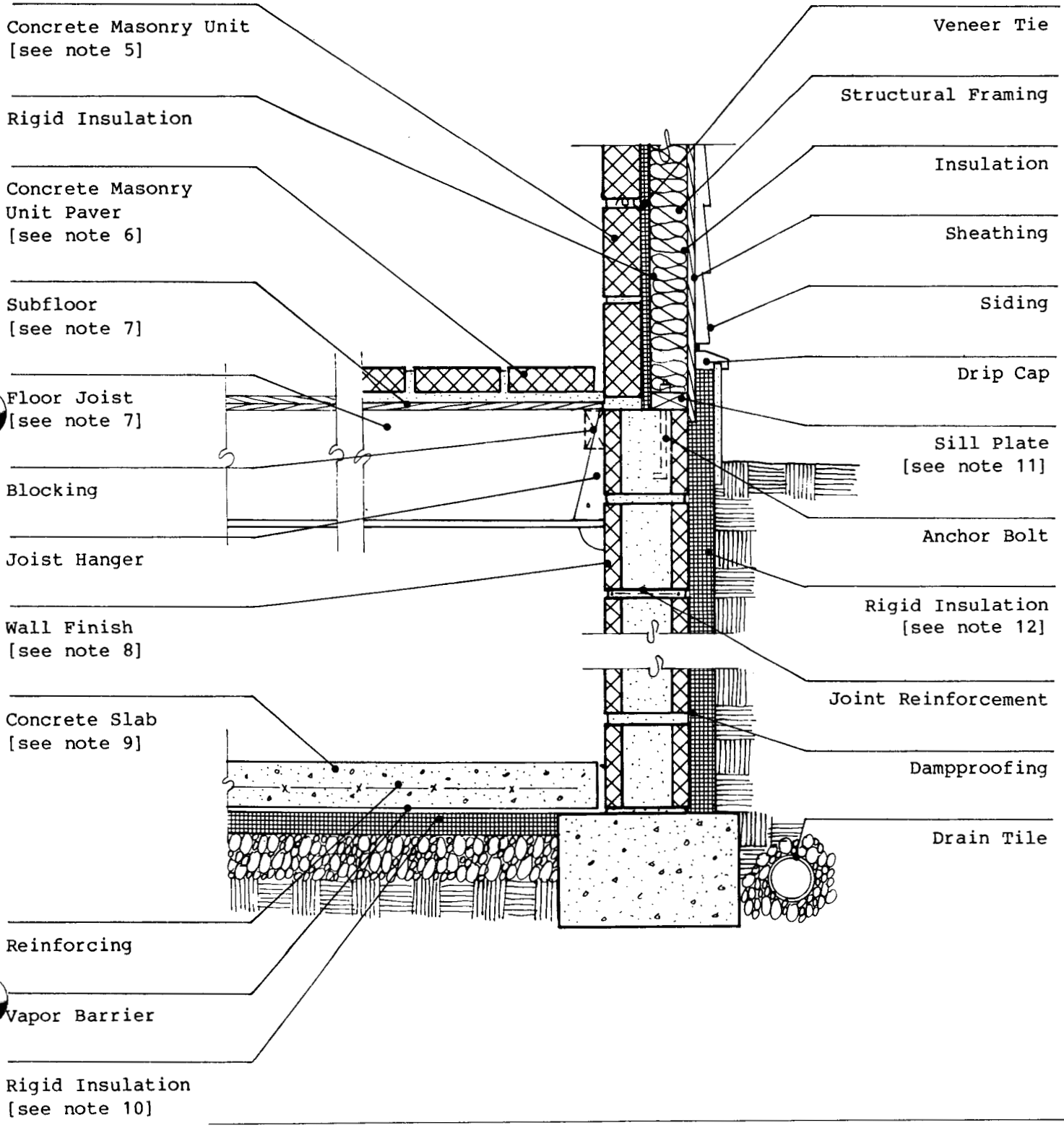
Concrete Foundation

Direct Gain

CMU Veneer Exterior Wall
CMU Paver/Wood First Floor

Detail





[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels in floors and walls must meet or exceed requirements of local building/energy codes.

[4] Insulation may be placed between floor joists over crawl space or unheated basement instead of on foundation/basement walls or under basement slab.

[5] Interior CMU veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1140.

[6] For information on CMU pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1172.

[7] Consideration must be given to the additional weight of pavers. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.

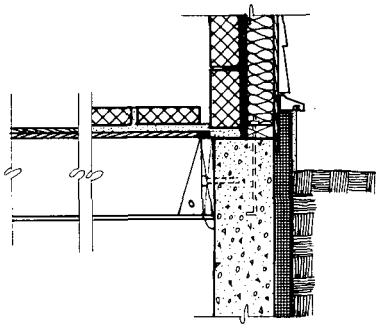
[8] Below grade wall may be used for Direct Gain storage. For information on interior finishes, see Key Pages 3.1142 and 3.1146.

[9] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.

[10] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.

[11] Continuous sill sealer is recommended to provide protection against infiltration.

[12] Insulation must be protected where exposed above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used, allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

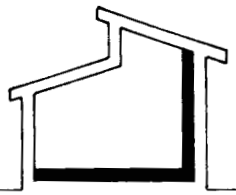


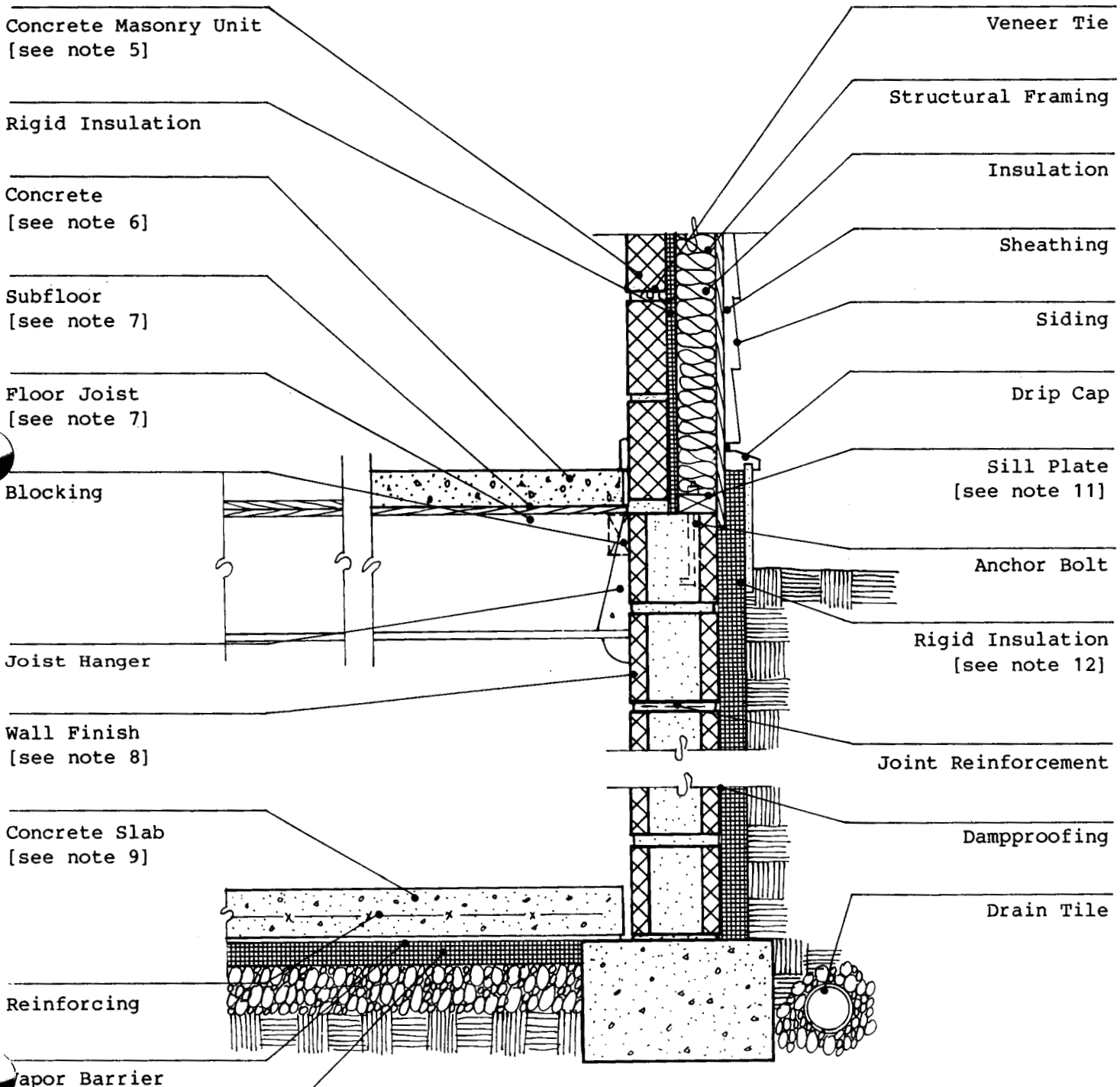
Concrete Basement Wall

Direct Gain
CMU Veneer Exterior Wall Concrete/Wood First Floor

3.1440

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels in floors and walls must meet or exceed requirements of local building/energy codes.

[4] Insulation may be placed between floor joists over crawl space or unheated basement instead of on foundation/basement walls or under basement slab.

[5] Interior CMU veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1140.

[6] For information on Concrete used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1176.

[7] Consideration must be given to the additional weight of Concrete. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.

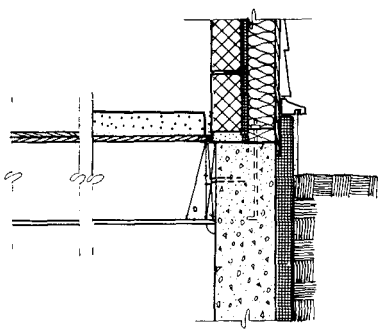
[8] Below grade wall may be used for Direct Gain storage. For information on interior finishes, see Key Pages 3.1142 and 3.1146.

[9] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.

[10] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.

[11] Continuous sill sealer is recommended to provide protection against infiltration.

[12] Insulation must be protected where exposed above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used, allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

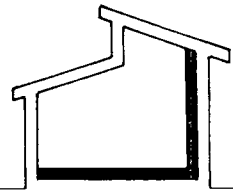


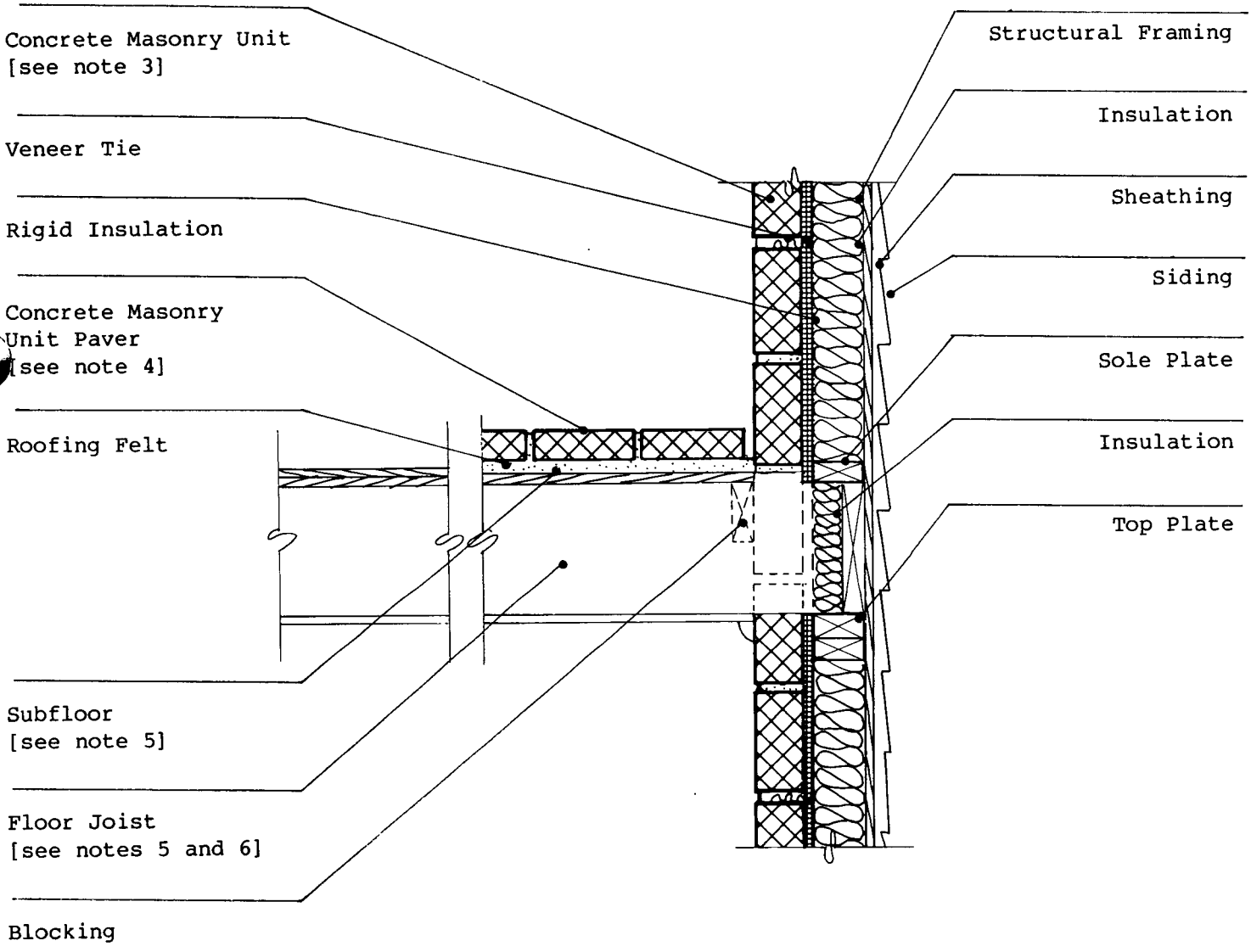
Concrete Basement Wall

Direct Gain

CMU Veneer Exterior Wall
CMU Paver/Wood Upper Floor

Detail





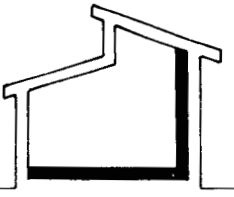
[1] Insulation levels in walls must meet or exceed requirements of local building/ energy codes.
[2] Placement of metal ties to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.
[3] Interior CMU veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1140.
[4] For information on CMU pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1172.
[5] Consideration must be given to the additional weight of pavers. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.
[6] CMU veneer wall must be continuous. Joists are framed through veneer into structural framing.

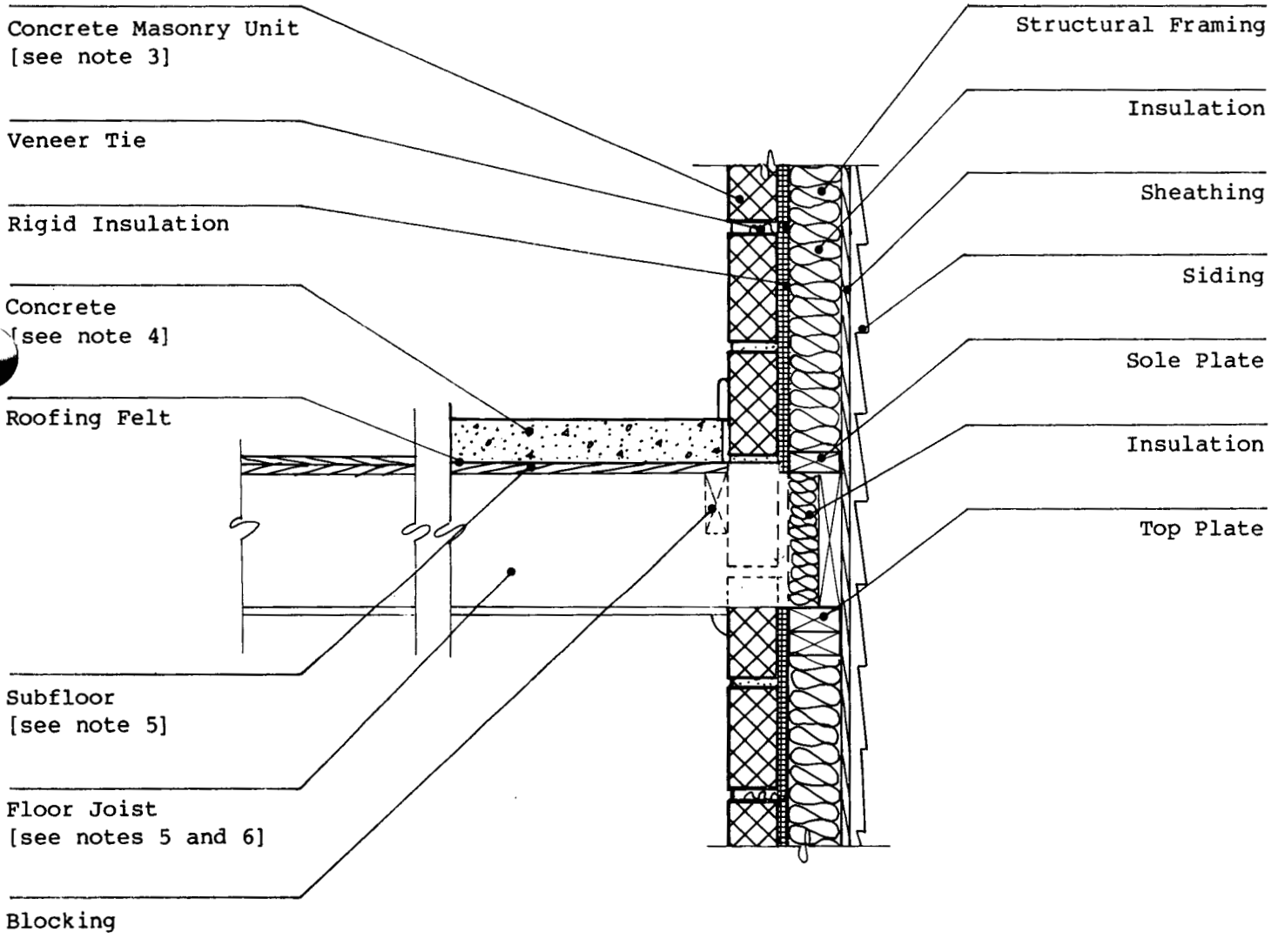
Direct Gain

CMU Veneer Exterior Wall
Concrete/Wood Upper Floor

3.1444

Detail





Construction Notes

[1] Insulation levels in walls must meet or exceed requirements of local building/ energy codes.

[2] Placement of metal ties to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Interior CMU veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1140.

[4] For information on Concrete used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1176.

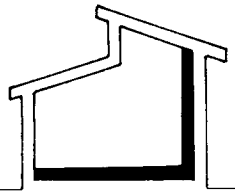
[5] Consideration must be given to the additional weight of Concrete. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.

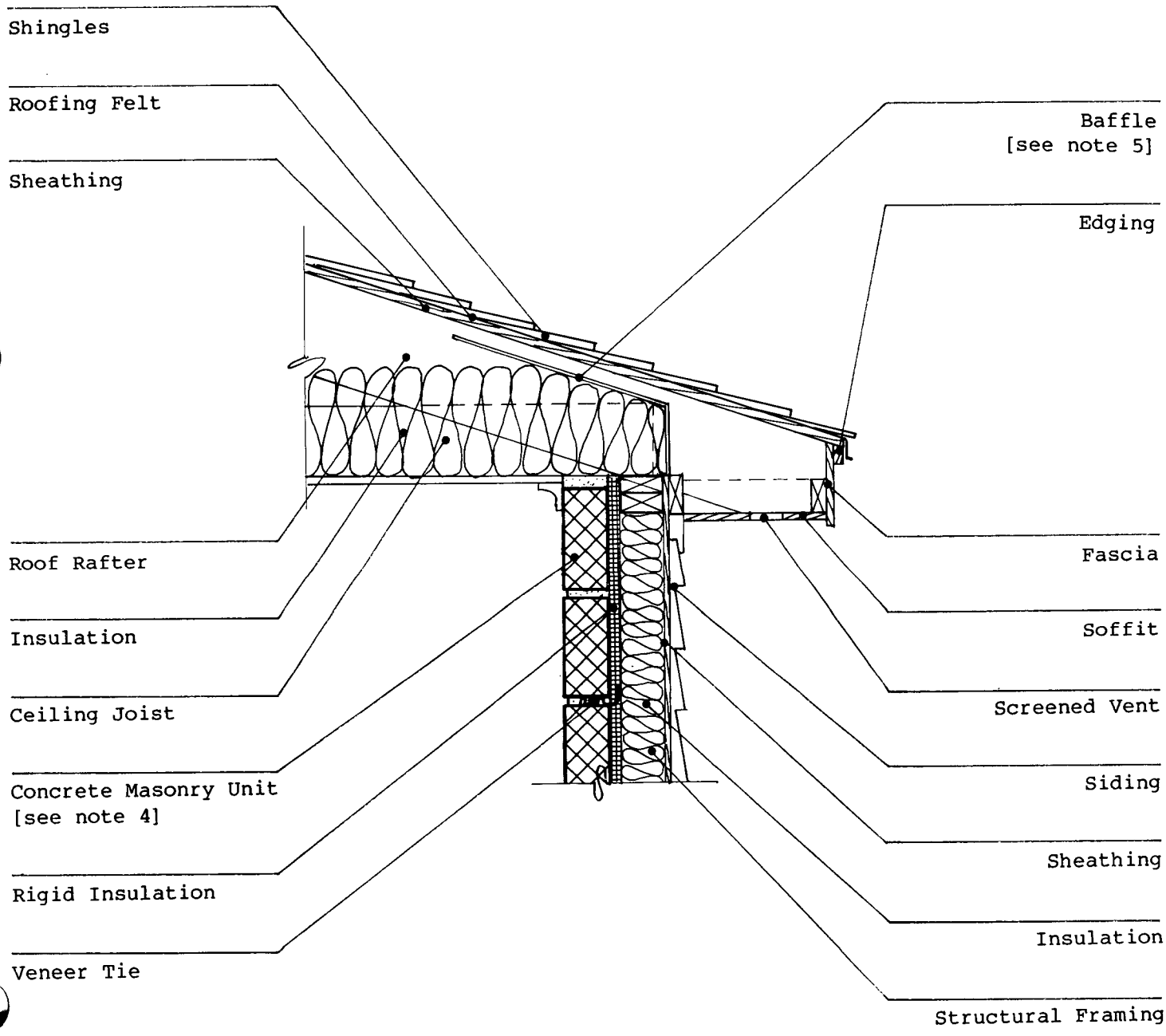
[6] CMU veneer wall must be continuous. Joists are framed through veneer into structural framing.

Direct Gain
CMU Veneer Exterior Wall
Roof

3.1446

Detail





Construction Notes

[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof/wall connections, especially in seismic and/or high wind areas.

[2] Insulation levels in ceiling and walls must meet or exceed requirements of local building/energy codes.

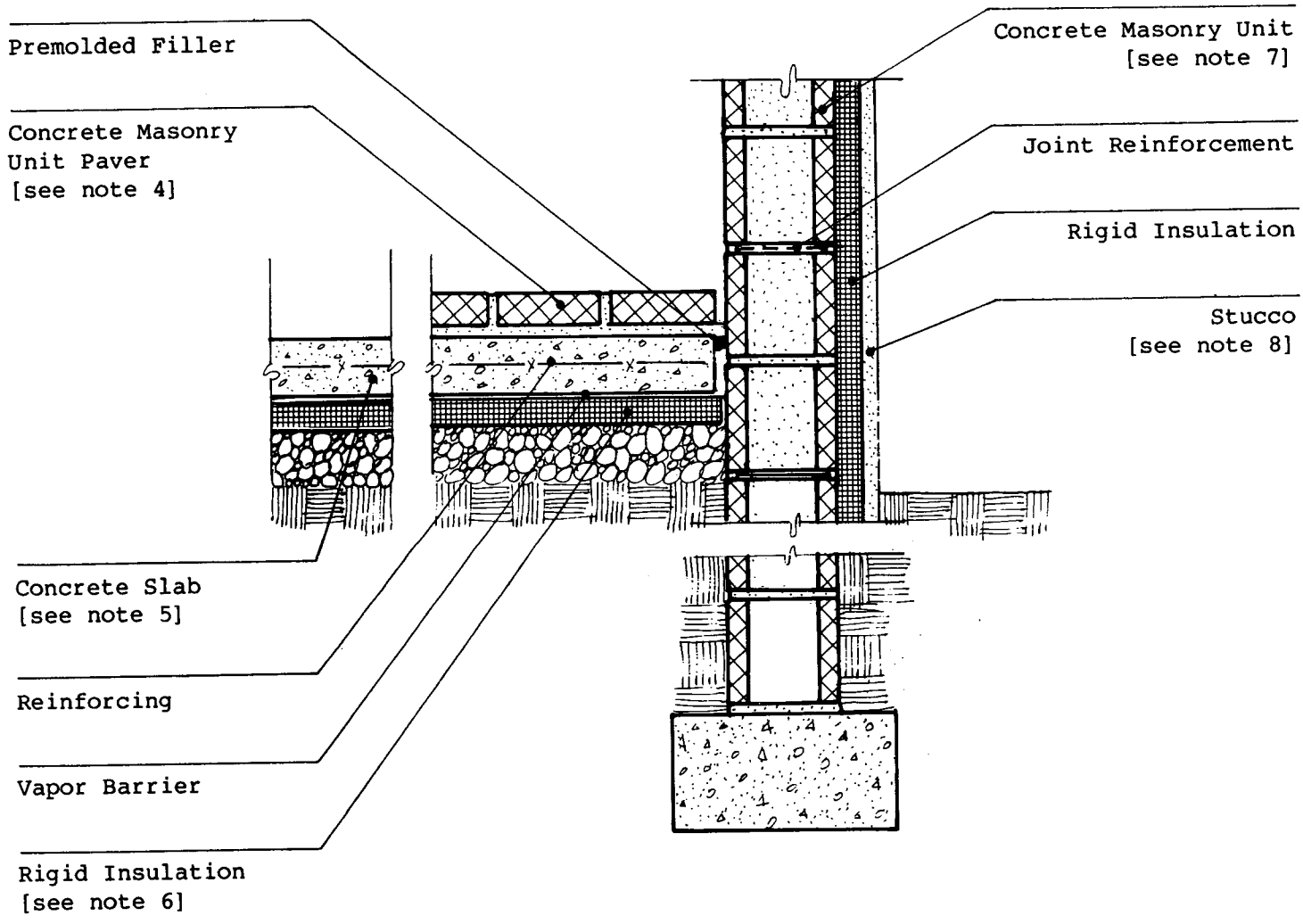
[3] Provide gutters and downspouts as required.

[4] Interior CMU veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1140.

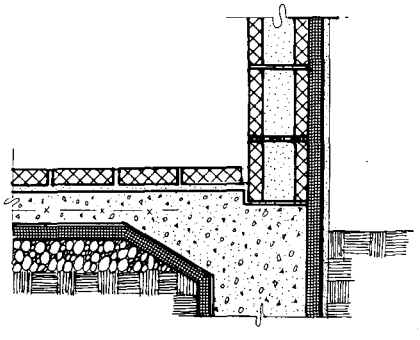
[5] Provide baffles where necessary to maintain 1 inch minimum airspace for venting attic.

Direct Gain
CMU Exterior Wall
CMU Paver/Slab-On-Grade

Detail



[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.
[2] Placement of vertical reinforcing and horizontal joint reinforcement to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.
[3] Insulation levels in floors and walls must meet or exceed requirements of local building/energy codes.
[4] For information on CMU pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1170.
[5] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.
[6] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.
[7] Single wythe CMU used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics see Key Page 3.1142.
[8] Cement plaster (stucco) finish applied on wire lath over exterior insulation. Wire must be mechanically fastened to insulation. Consult insulation manufacturer for recommended installation procedures.

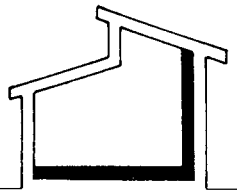


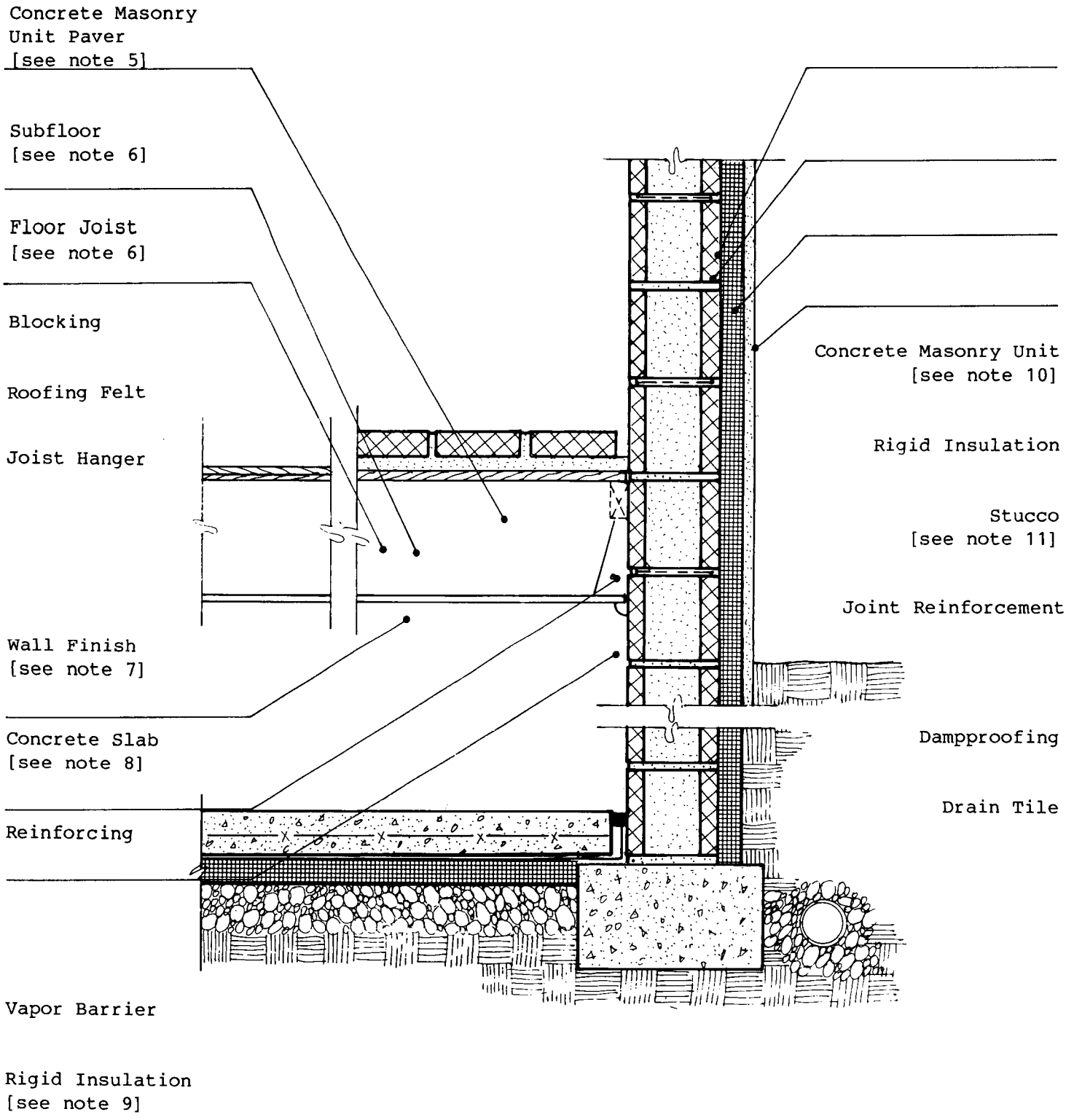
Concrete Foundation

Direct Gain
CMU Exterior Wall
CMU Paver/Wood First Floor

3.1450

Detail





[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

[2] Placement of vertical reinforcing and horizontal joint reinforcement to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels in floors and walls must meet or exceed requirements of local building/energy codes.

[4] Insulation may be placed between floor joists over crawl space or unheated basement instead of on foundation/basement walls or under basement slab.

[5] For information on CMU pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1172.

[6] Consideration must be given to the additional weight of pavers. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.

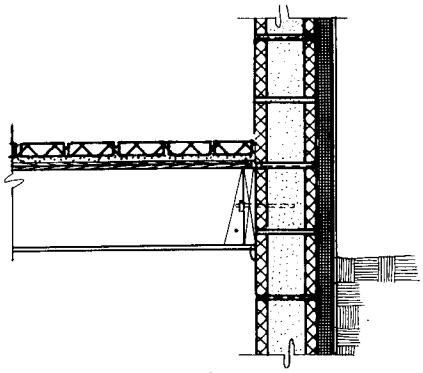
[7] Below grade wall may be used for Direct Gain storage. For information on interior finishes, see Key Pages 3.1142 and 3.1146.

[8] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.

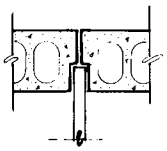
[9] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.

[10] Single wythe CMU used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics see Key Page 3.1142.

[11] Cement plaster (stucco) finish applied on wire lath over exterior insulation. Wire must be mechanically fastened to insulation. Consult insulation manufacturer for recommended installation procedures.



Floor Joist Ledger

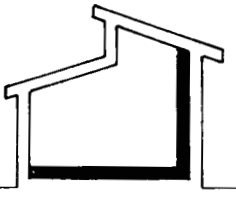


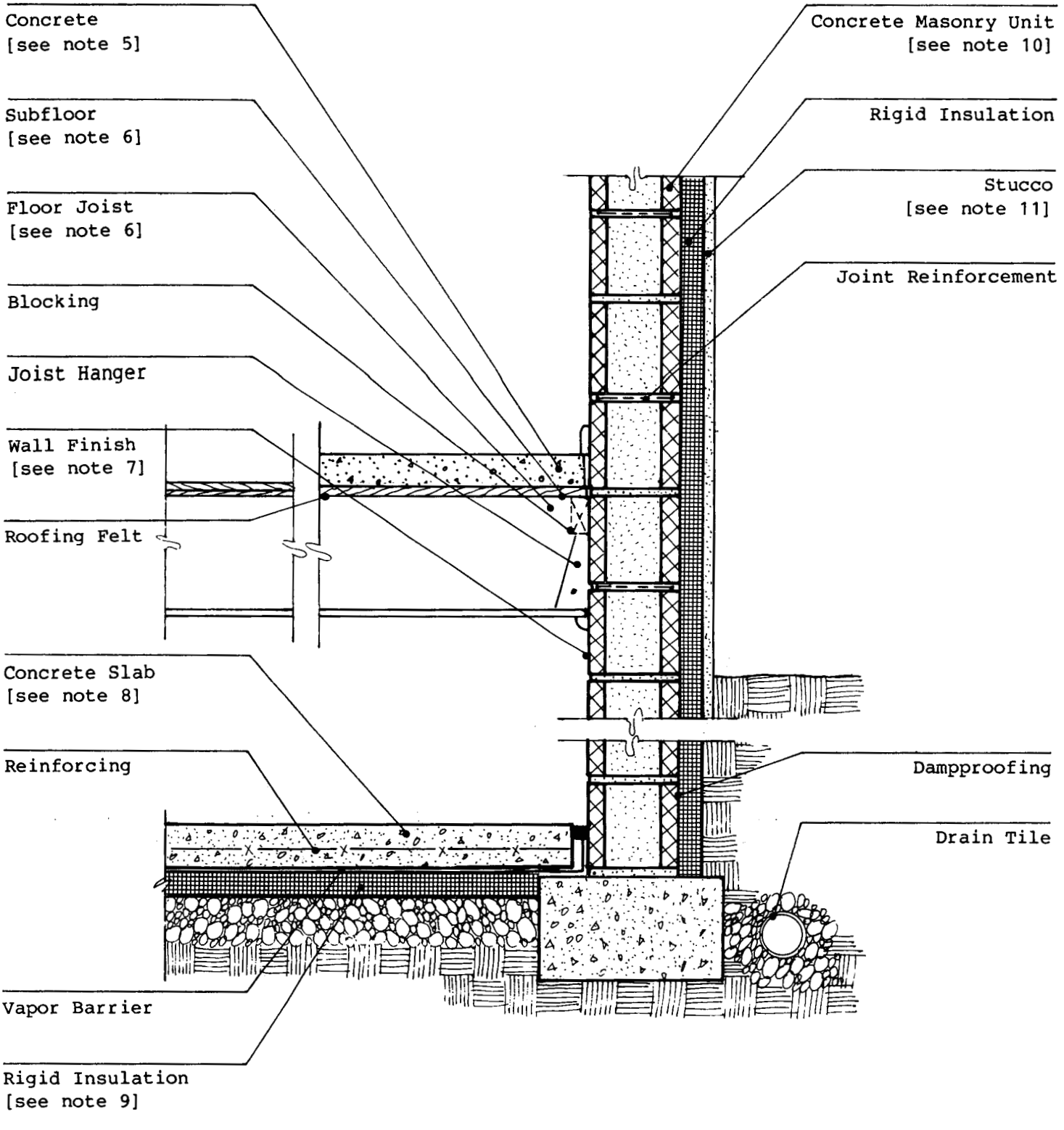
Special CMU for Joist Pocket (Plan View)

Direct Gain
CMU Exterior Wall
Concrete/Wood First Floor

3.1452

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

[2] Placement of vertical reinforcing and horizontal joint reinforcement to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels in floors and walls must meet or exceed requirements of local building/energy codes.

[4] Insulation may be placed between floor joists over crawl space or unheated basement instead of on foundation/basement walls or under basement slab.

[5] For information on Concrete used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1176.

[6] Consideration must be given to the additional weight of Concrete. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.

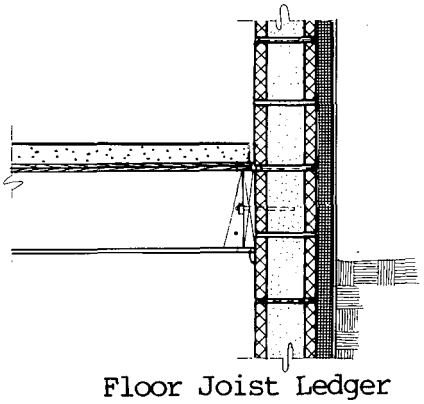
[7] Below grade wall may be used for Direct Gain storage. For information on interior finishes, see Key Pages 3.1142 and 3.1146.

[8] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.

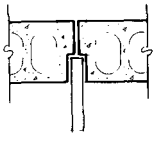
[9] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.

[10] Single wythe CMU used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics see Key Page 3.1142.

[11] Cement plaster (stucco) finish applied on wire lath over exterior insulation. Wire must be mechanically fastened to insulation. Consult insulation manufacturer for recommended installation procedures.



Floor Joist Ledger

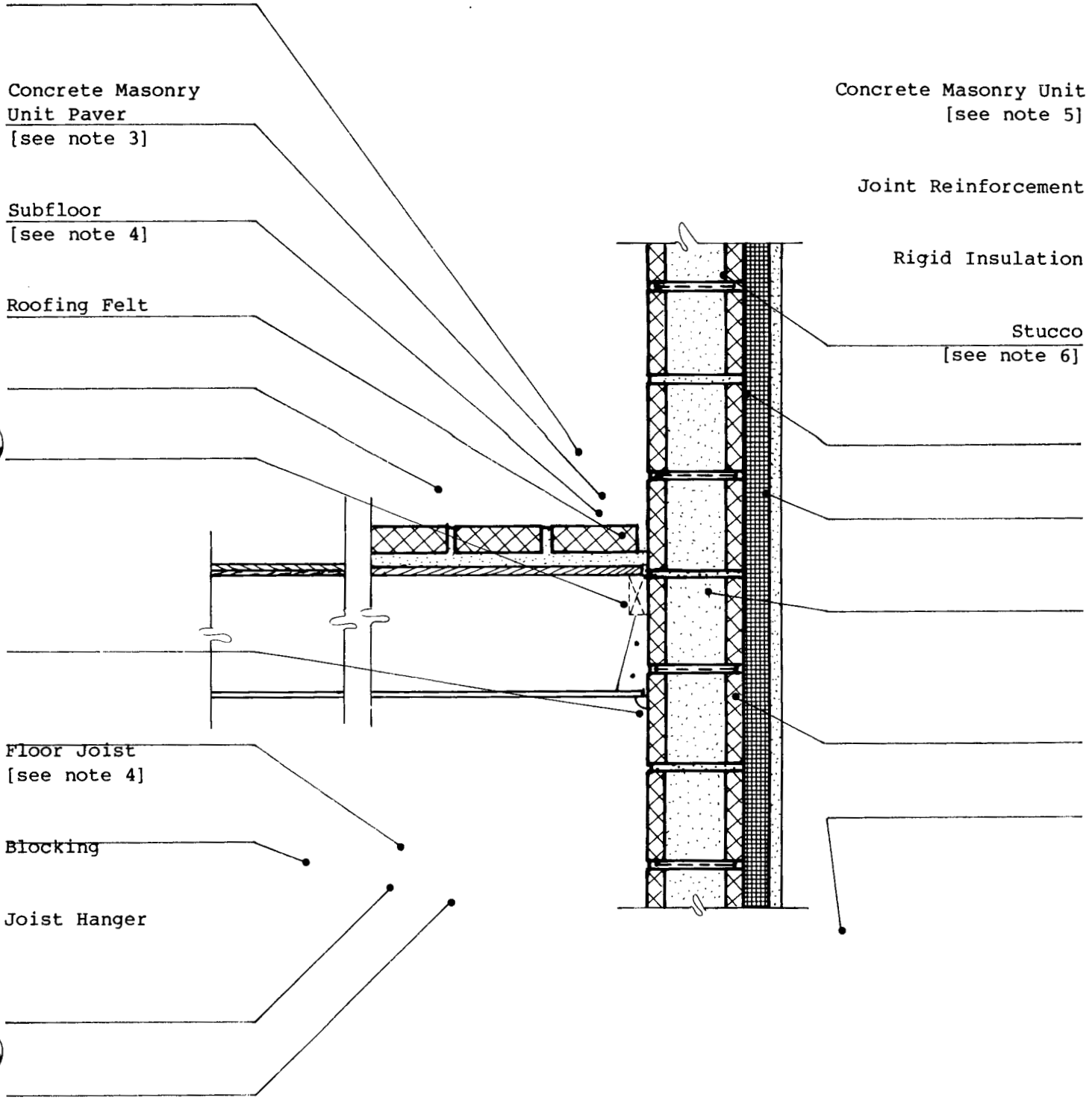


Special CMU for Joist Pocket (Plan View)

Direct Gain
CMU Exterior Wall
CMU Paver/Wood Upper Floor

3.1454

Detail



Construction Notes

[1] Insulation levels in walls must meet or exceed requirements of local building/ energy codes.

[2] Placement of vertical reinforcing and horizontal joint reinforcement to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] For information on CMU pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1172.

[4] Consideration must be given to the additional weight of pavers. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.

[5] Single wythe CMU used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics see Key Page 3.1142.

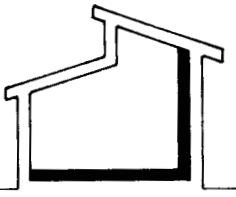
[6] Cement plaster (stucco) finish applied on wire lath over exterior insulation. Wire must be mechanically fastened to insulation. Consult insulation manufacturer for recommended installation procedures.

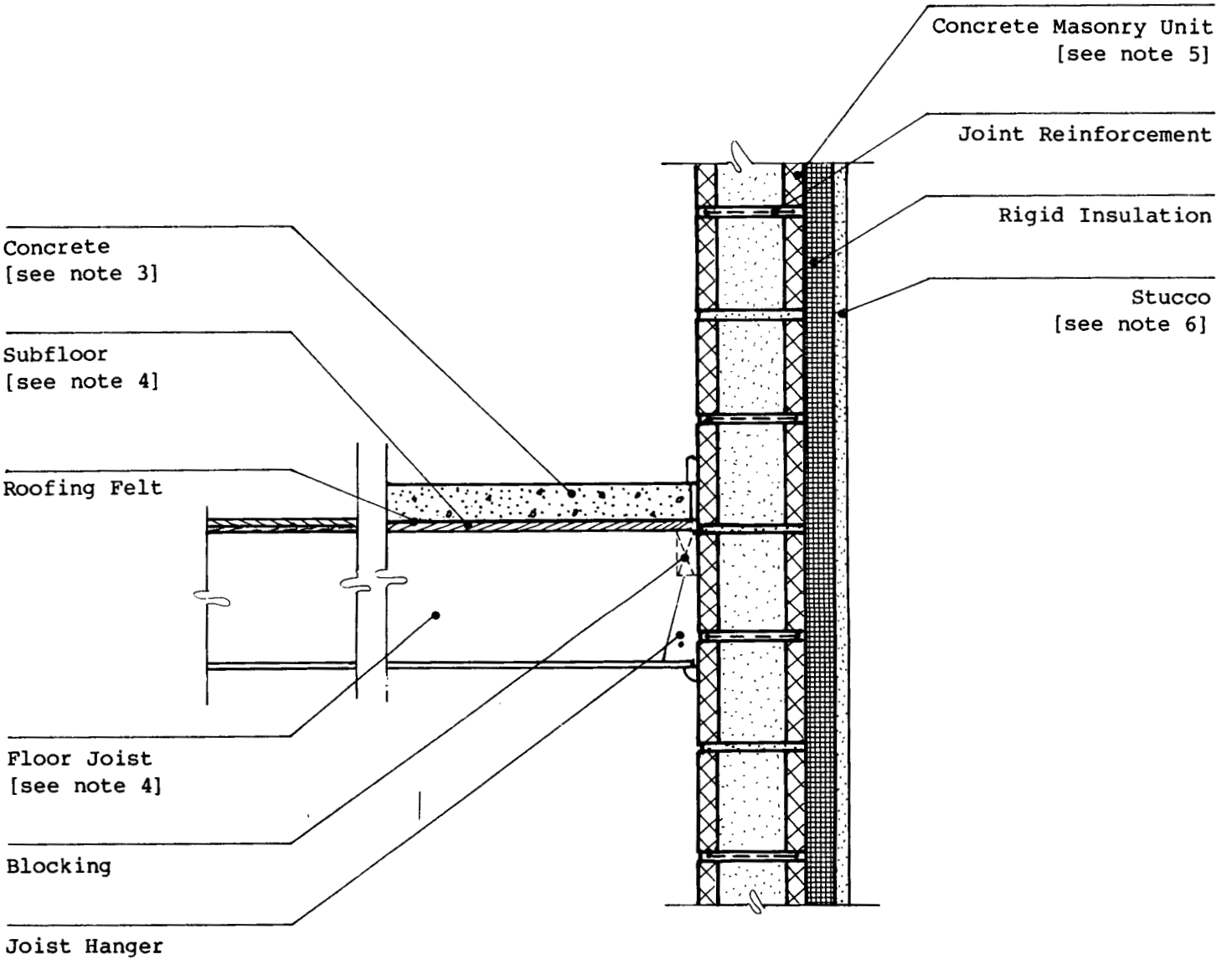
Direct Gain

CMU Exterior Wall
Concrete/Wood Upper Floor

3.1456

Detail





Construction Notes

[1] Insulation levels in walls must meet or exceed requirements of local building/ energy codes.

[2] Placement of vertical reinforcing and horizontal joint reinforcement to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] For information on Concrete used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1176.

[4] Consideration must be given to the additional weight of Concrete. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.

[5] Single wythe CMU used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics see Key Page 3.1142.

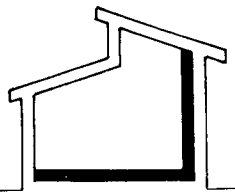
[6] Cement plaster (stucco) finish applied on wire lath over exterior insulation. Wire must be mechanically fastened to insulation. Consult insulation manufacturer for recommended installation procedures.

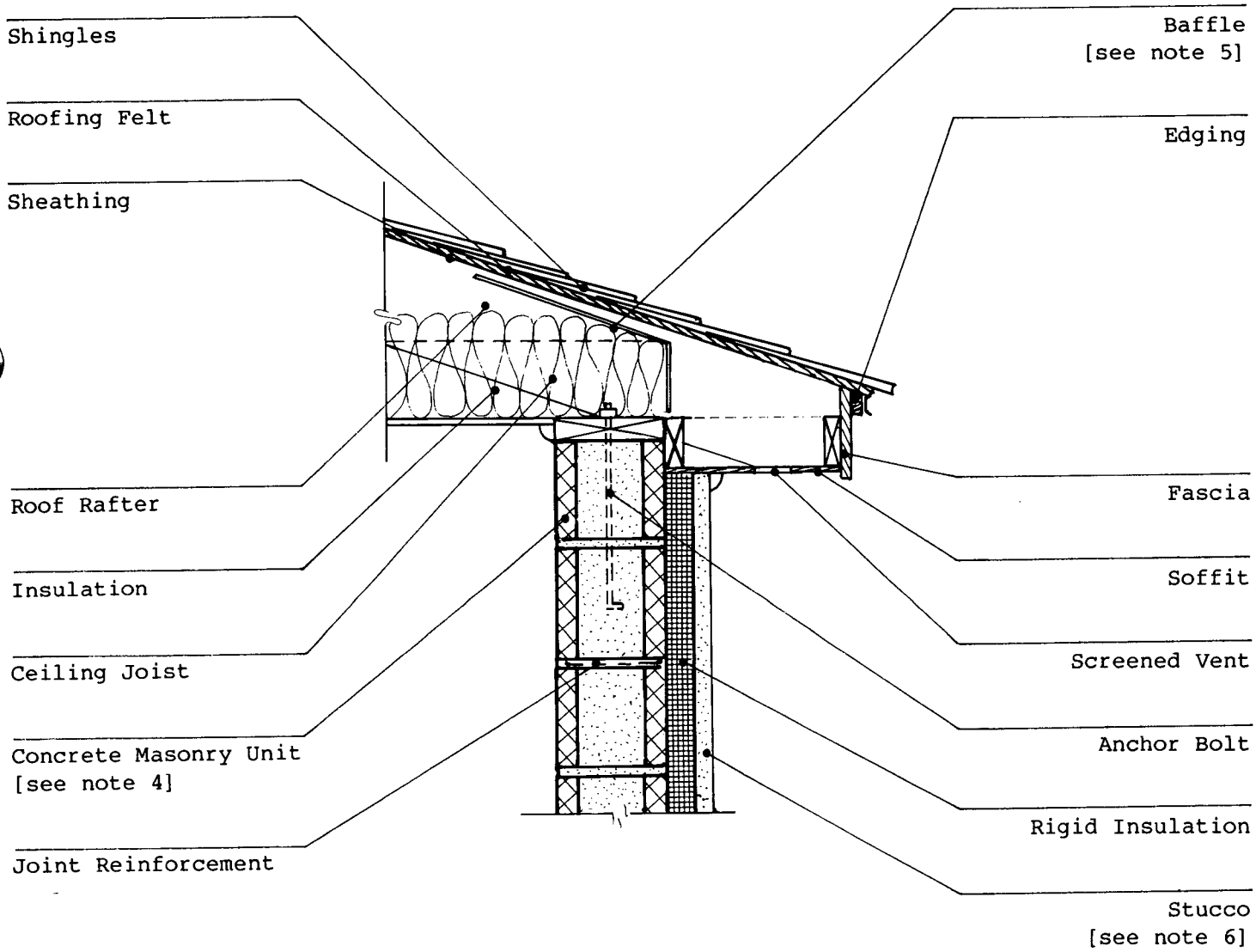
Direct Gain

CMU Exterior Wall
Roof

3.1458

Detail





Construction Notes

[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof/wall connections, especially in seismic and/or high wind areas.

[2] Insulation levels in ceiling and walls must meet or exceed requirements of local building/energy codes.

[3] Provide gutters and downspouts as required.

[4] Single wythe CMU used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics see Key Page 3.1142.

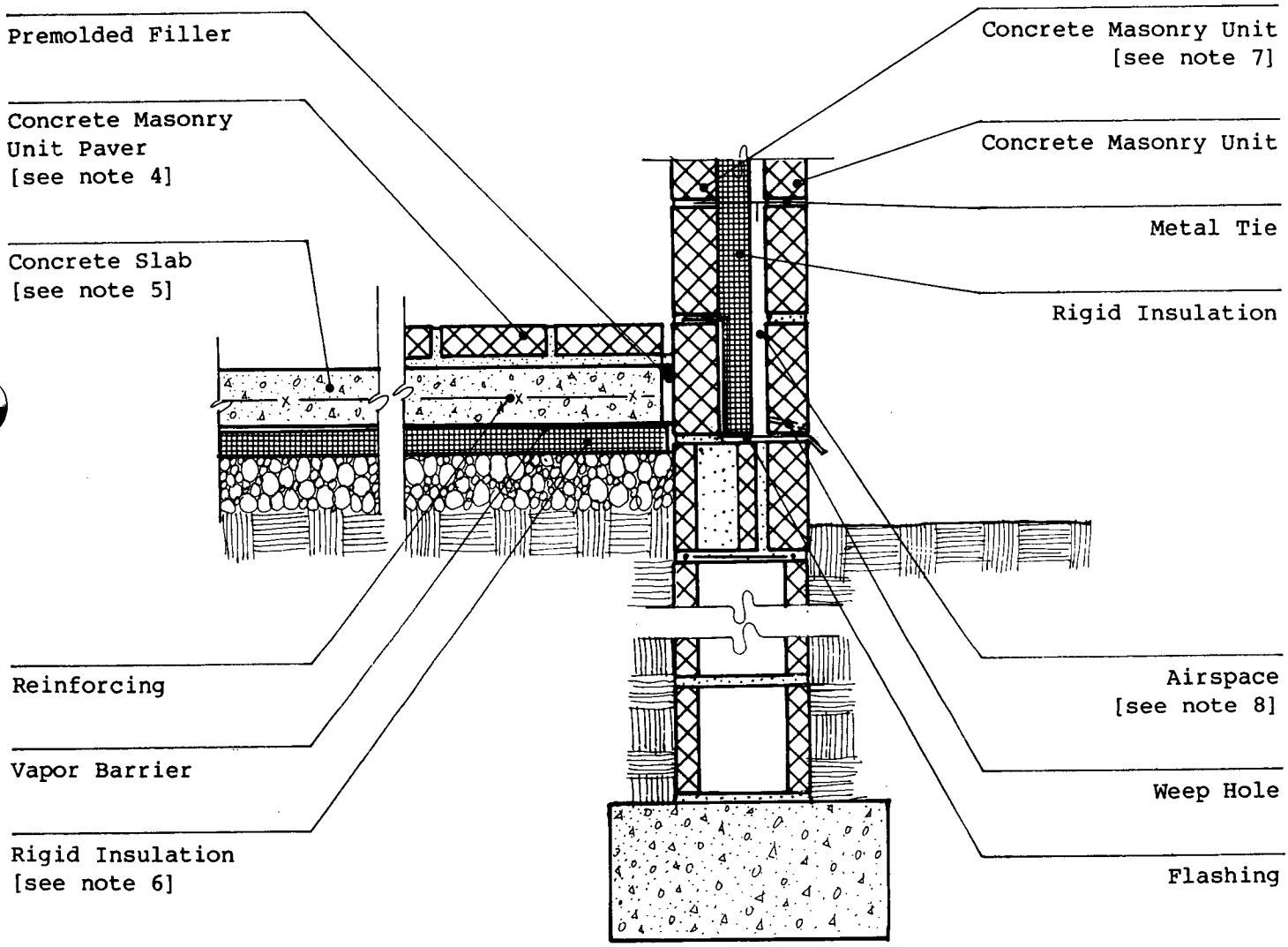
[5] Provide baffles where necessary to maintain 1 inch minimum airspace for venting attic.

[6] Cement plaster (stucco) finish applied on wire lath over exterior insulation. Wire must be mechanically fastened to insulation. Consult insulation manufacturer for recommended installation procedures.

Direct Gain

CMU Cavity Exterior Wall
CMU Paver/Slab-On-Grade

Detail



[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels in floors and walls must meet or exceed requirements of local building/energy codes.

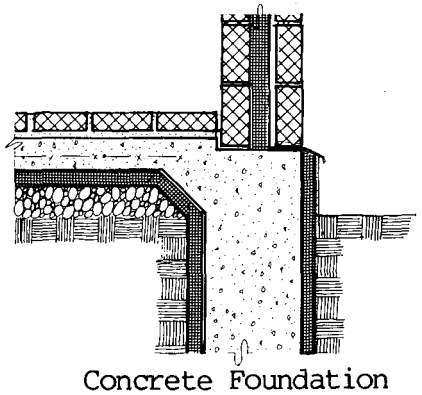
[4] For information on CMU pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1170.

[5] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.

[6] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.

[7] Interior wythe of cavity wall used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.1144.

[8] Width of cavity may vary depending upon the amount of insulation required. A 1 inch minimum airspace must be provided where rigid insulation is used. For further information see Key Page 3.1144.

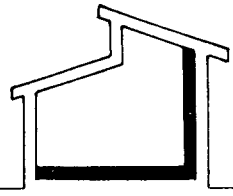


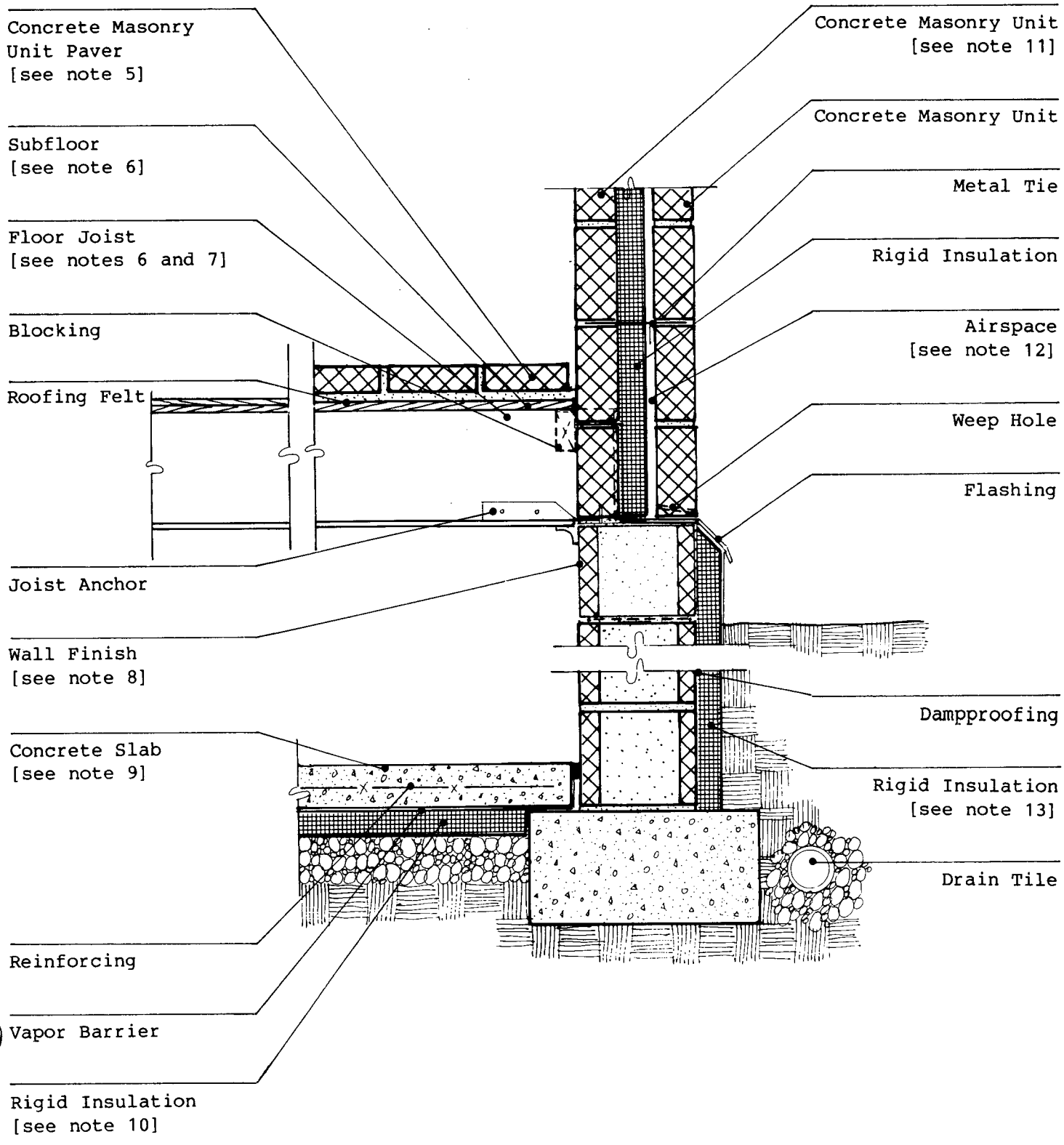
Concrete Foundation

Direct Gain

CMU Cavity Exterior Wall
CMU Paver/Wood First Floor

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels in floors and walls must meet or exceed requirements of local building/energy codes.

[4] Insulation may be placed between floor joists over crawl space or unheated basement instead of on foundation/basement walls or under basement slab.

[5] For information on CMU pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1172.

[6] Consideration must be given to the additional weight of pavers. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.

[7] Floor joists must bear on solid masonry not less than 4 inch thick. Fire-cut joists as required.

[8] Below grade wall may be used for Direct Gain storage. For information on interior finishes, see Key Pages 3.1142 and 3.1146.

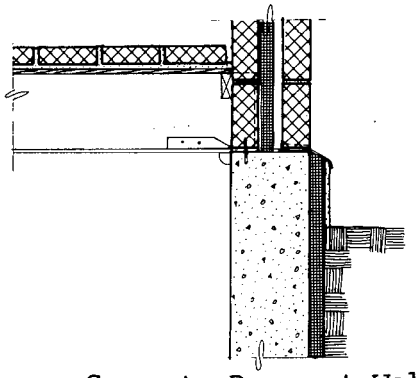
[9] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.

[10] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.

[11] Interior wythe of cavity wall used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.1144.

[12] Width of cavity may vary depending upon the amount of insulation required. A 1 inch minimum airspace must be provided where rigid insulation is used. For further information see Key Page 3.1144.

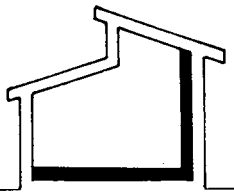
[13] Insulation must be protected where exposed above grade. Cement plaster over wire lath or other methods may be employed.

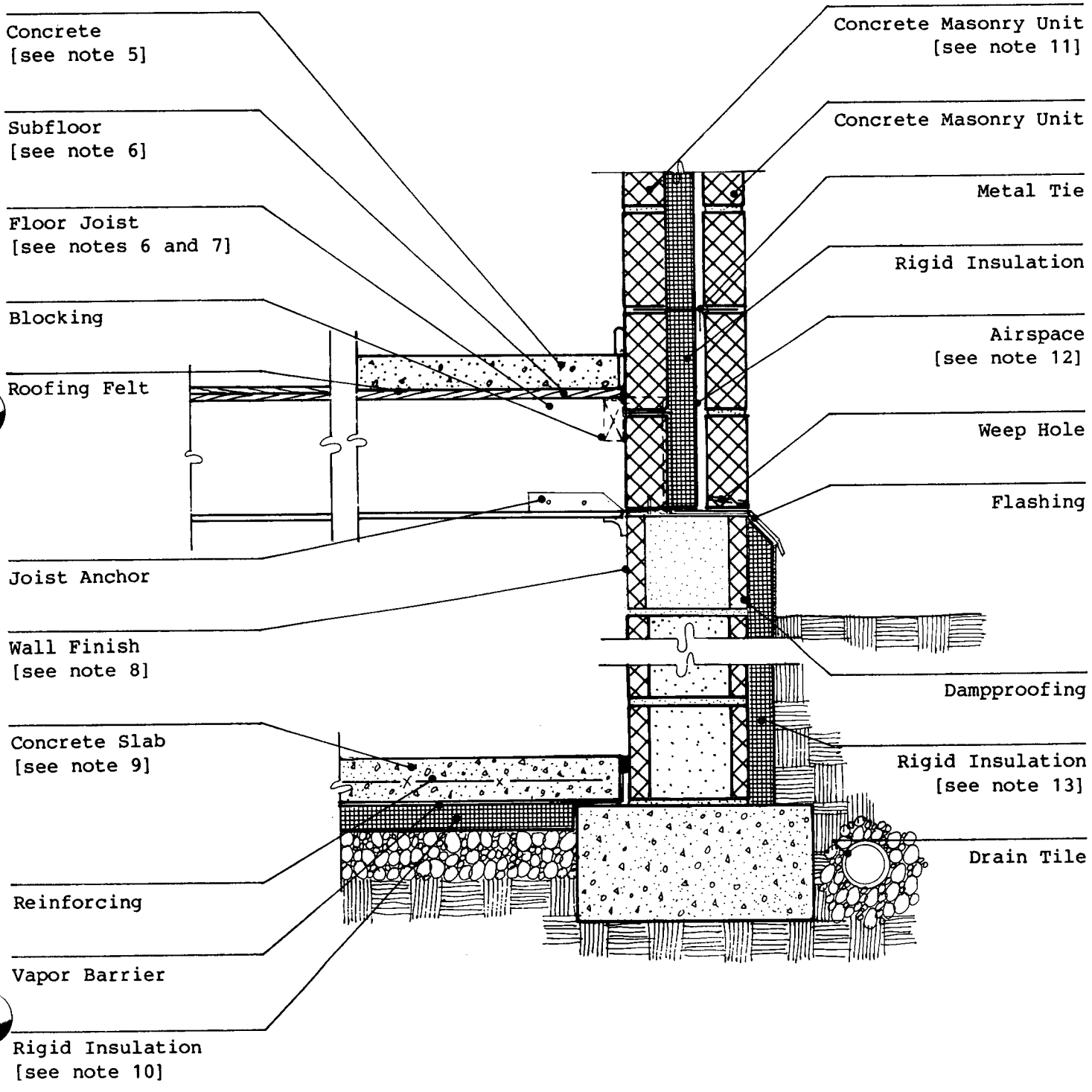


Concrete Basement Wall

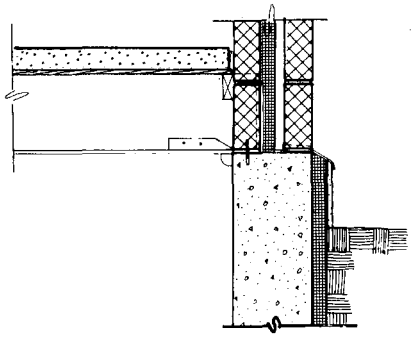
Direct Gain
CMU Cavity Exterior Wall
Concrete/Wood First Floor

Detail





[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.
[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.
[3] Insulation levels in floors and walls must meet or exceed requirements of local building/energy codes.
[4] Insulation may be placed between floor joists over crawl space or unheated basement instead of on foundation/basement walls or under basement slab.
[5] For information on Concrete used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1176.
[6] Consideration must be given to the additional weight of Concrete. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.
[7] Floor joists must bear on solid masonry not less than 4 inch thick. Fire-cut joists as required.
[8]. Below grade wall may be used for Direct Gain storage. For information on interior finishes, see Key Pages 3.1142 and 3.1146.
[9] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.
[10] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.
[11] Interior wythe of cavity wall used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.1144.
[12] Width of cavity may vary depending upon the amount of insulation required. A 1 inch minimum airspace must be provided where rigid insulation is used. For further information see Key Page 3.1144.
[13] Insulation must be protected where exposed above grade. Cement plaster over wire lath or other methods may be employed.

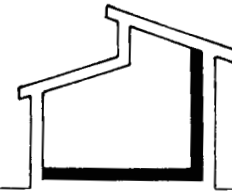


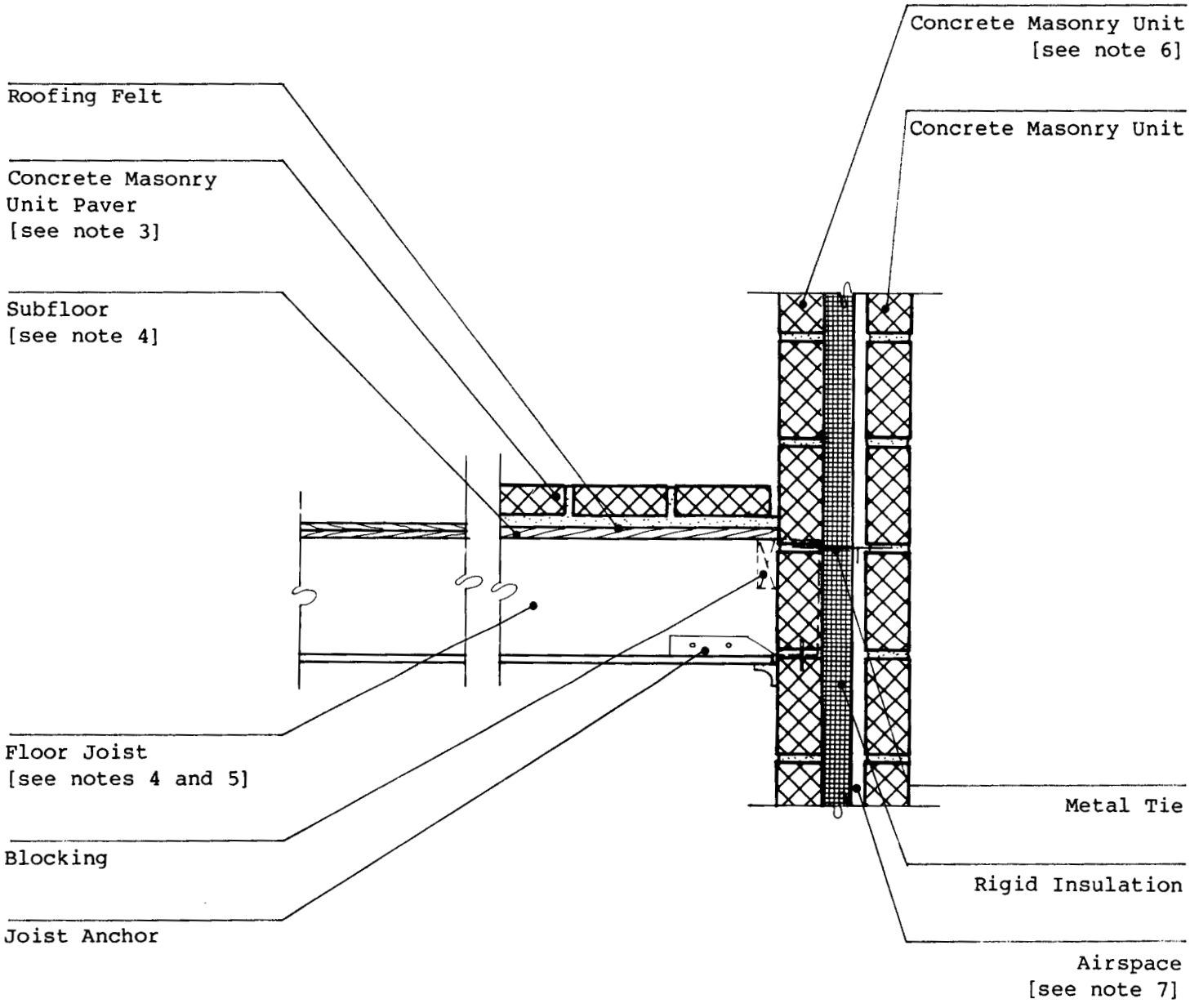
Concrete Basement Wall

Direct Gain

CMU Cavity Exterior Wall
CMU Paver/Wood Upper Floor

Detail





Construction Notes

[1] Insulation levels in walls must meet or exceed requirements of local building/ energy codes.

[2] Placement of reinforcing, metal ties and joist anchors to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] For information on CMU pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1172.

[4] Consideration must be given to the additional weight of pavers. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.

[5] Floor joists must bear on solid masonry not less than 4 inch thick. Fire-cut joists as required.

[6] Interior wythe of cavity wall used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.1144.

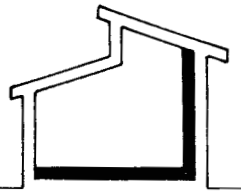
[7] Width of cavity may vary depending upon the amount of insulation required. A 1 inch minimum airspace must be provided where rigid insulation is used. For further information see Key Page 3.1144.

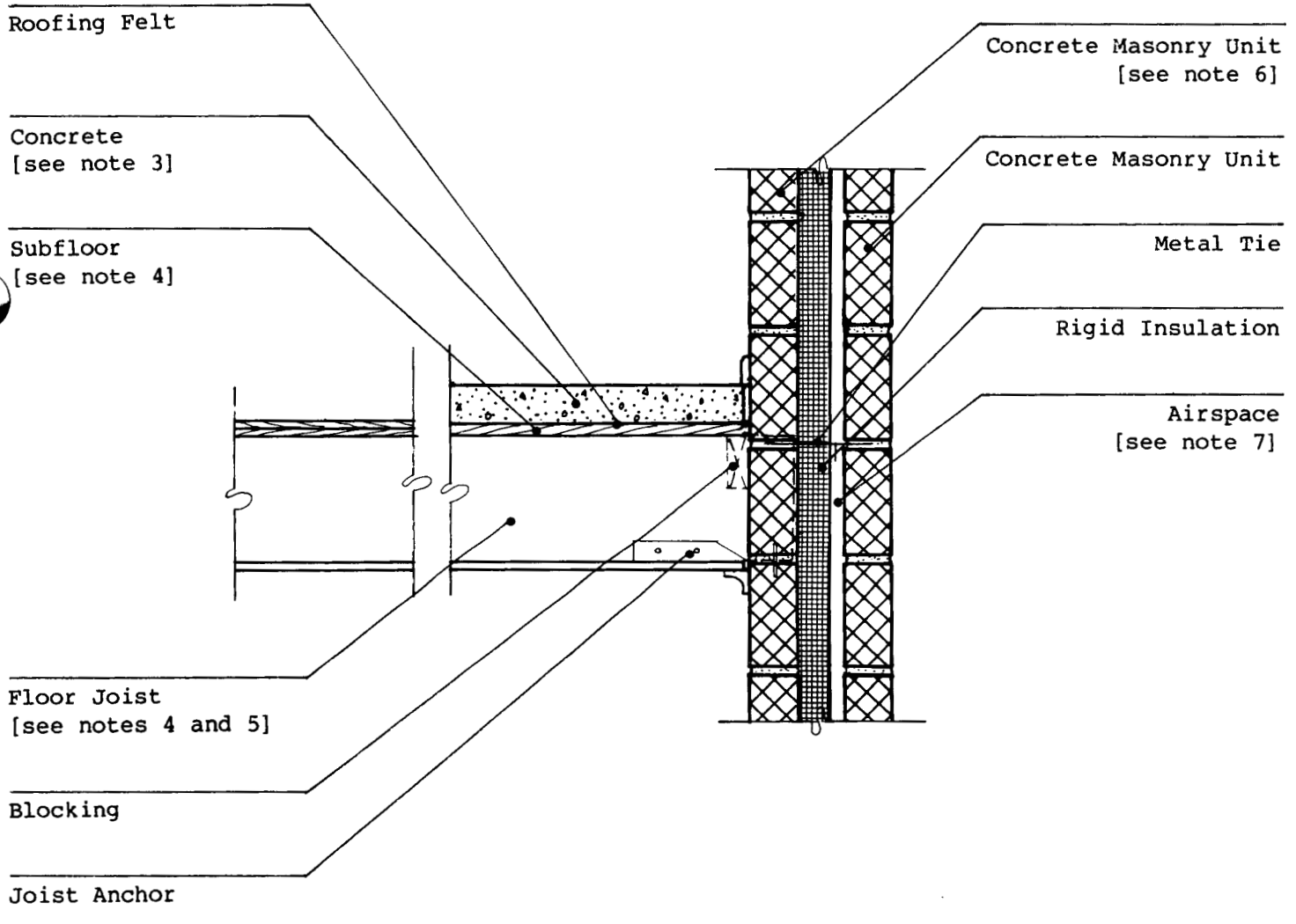
Direct Gain

CMU Cavity Exterior Wall
Concrete/Wood Upper Floor

3.1468

Detail





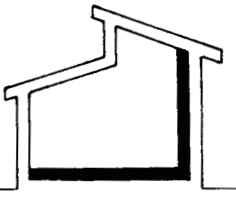
[1] Insulation levels in walls must meet or exceed requirements of local building/ energy codes.
[2] Placement of reinforcing, metal ties and joist anchors to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.
[3] For information on Concrete used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1176.
[4] Consideration must be given to the additional weight of Concrete. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.
[5] Floor joists must bear on solid masonry not less than 4 inch thick. Fire-cut joists as required.
[6] Interior wythe of cavity wall used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.1144.
[7] Width of cavity may vary depending upon the amount of insulation required. A 1 inch minimum airspace must be provided where rigid insulation is used. For further information see Key Page 3.1144.

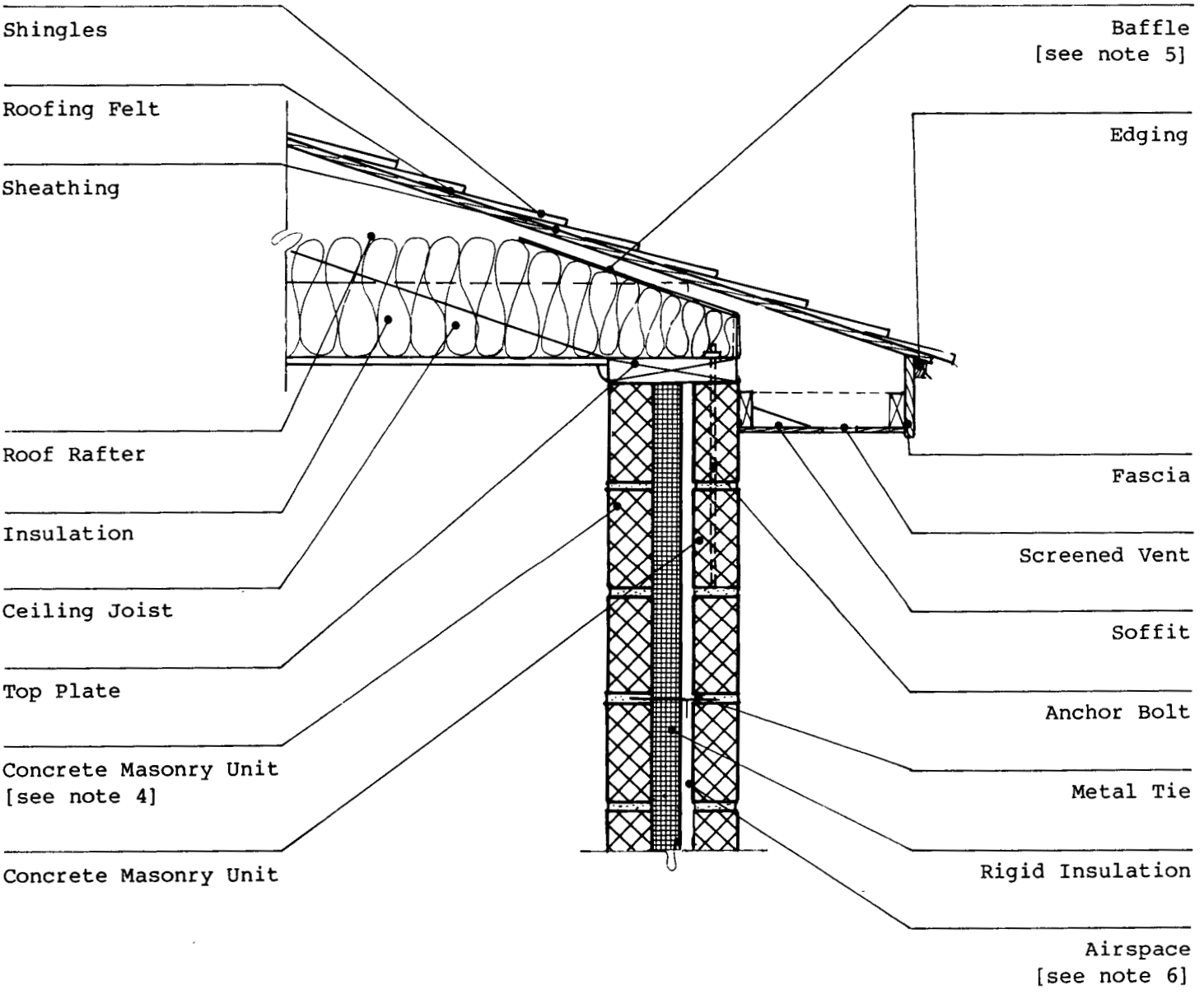
Direct Gain

CMU Cavity Exterior Wall
Roof

3.1470

Detail





Construction Notes

[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof/wall connections, especially in seismic and/or high wind areas.

[2] Insulation levels in ceiling and walls must meet or exceed requirements of local building/energy codes.

[3] Provide gutters and downspouts as required.

[4] Interior wythe of cavity wall used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.1144.

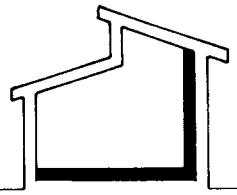
[5] Provide baffles where necessary to maintain 1 inch minimum airspace for venting attic.

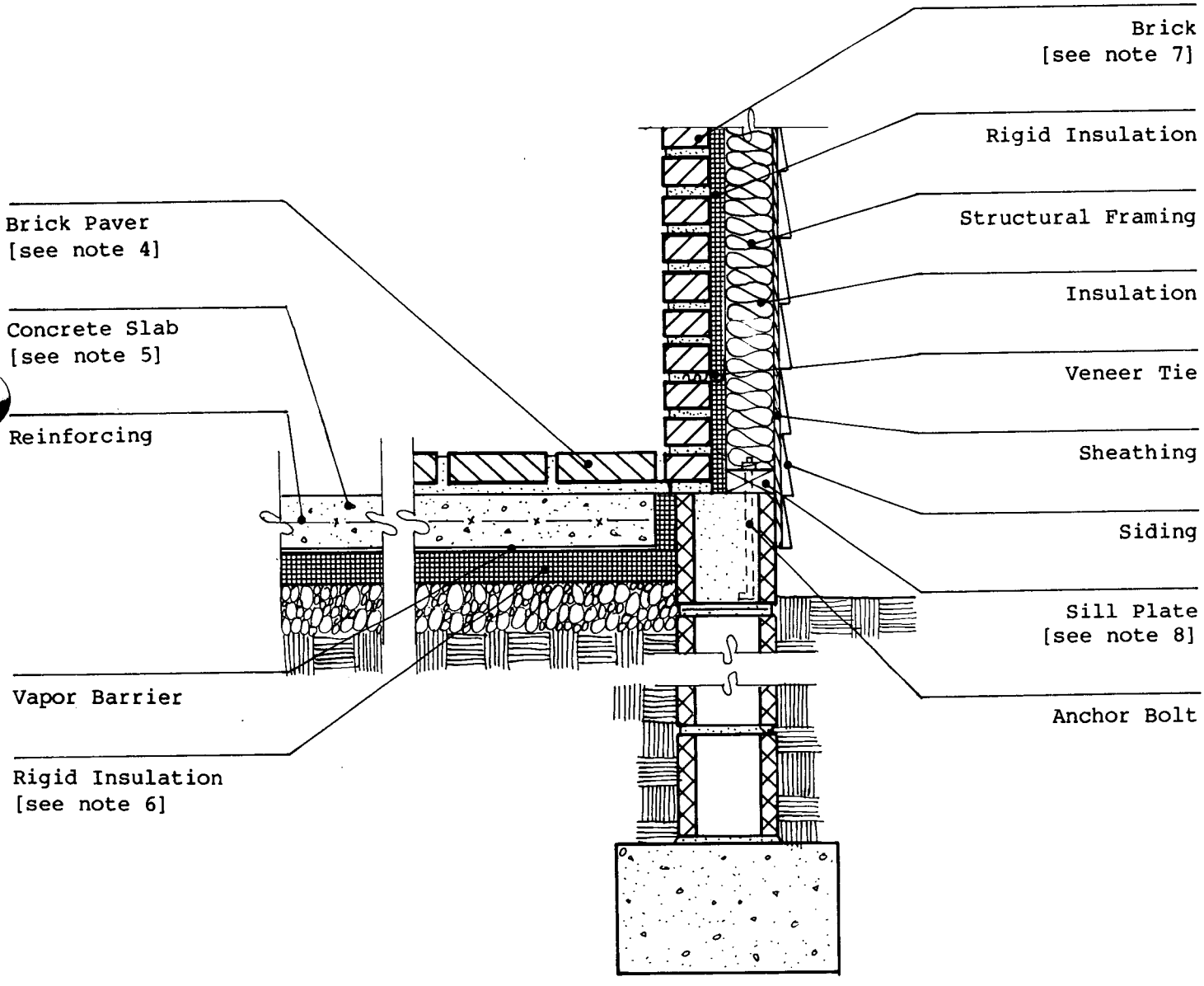
[6] Width of cavity may vary depending upon the amount of insulation required. A 1 inch minimum airspace must be provided where rigid insulation is used. For further information see Key Page 3.1144.

Direct Gain
Brick Veneer Exterior Wall
Brick Paver/Slab-On-Grade

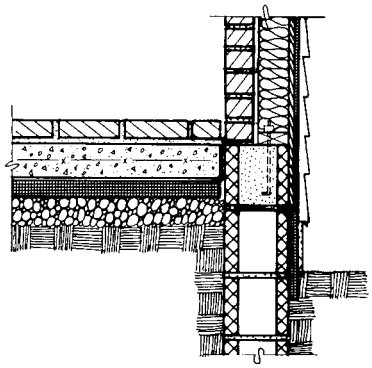
3.1472

Detail

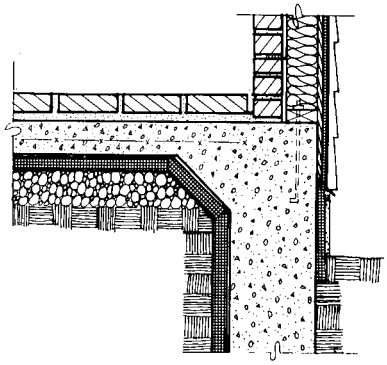




[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.
[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.
[3] Insulation levels in floors and walls must meet or exceed requirements of local building/energy codes.
[4] For information on Brick pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1178.
[5] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.
[6] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.
[7] Interior Brick veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1148.
[8] Continuous sill sealer is recommended to provide protection against infiltration.



Rigid Insulation at Exterior

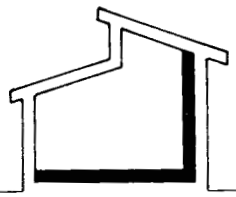


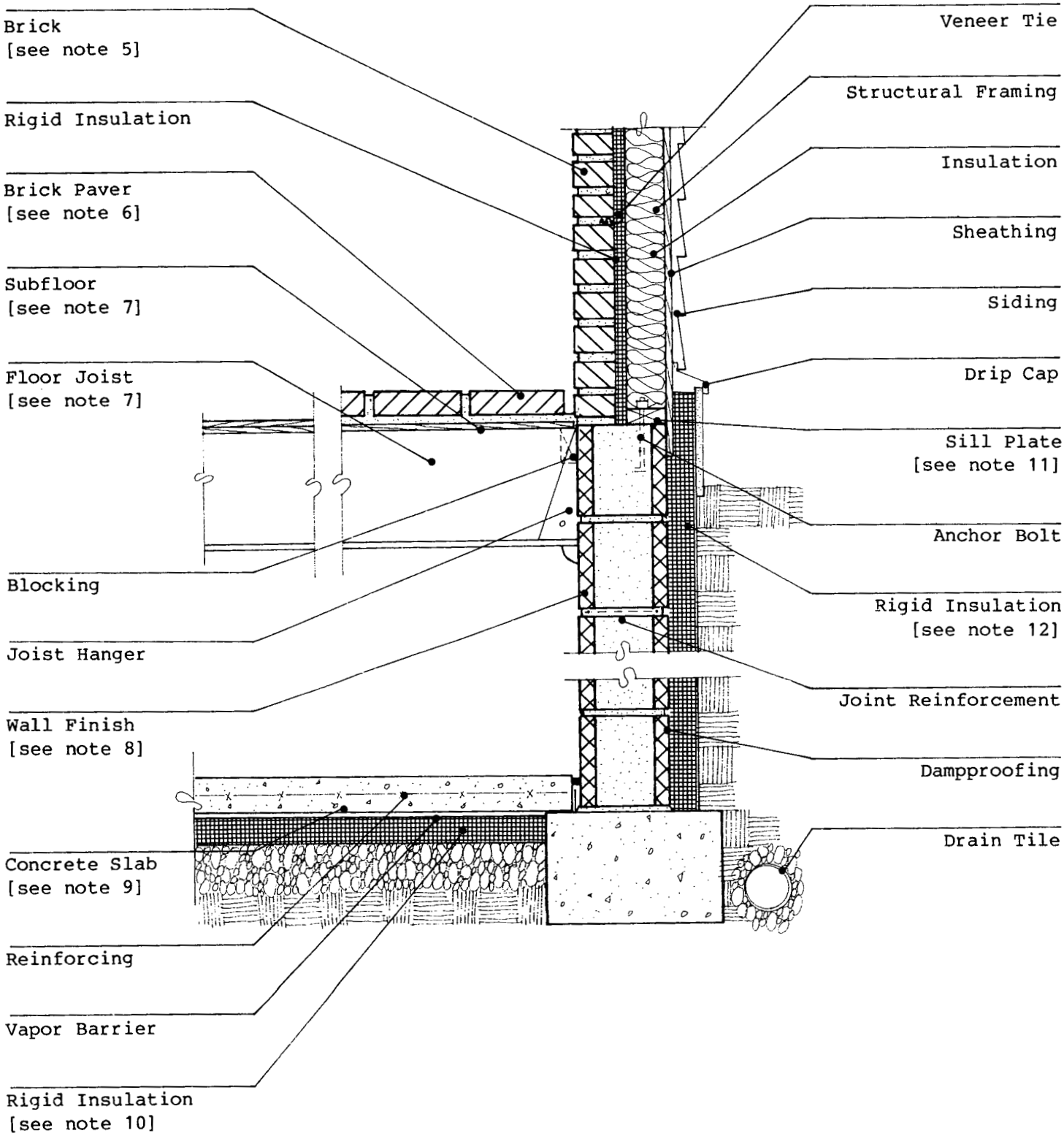
Concrete Foundation

Direct Gain

Brick Veneer Exterior Wall
Brick Paver/Wood First Floor

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels in floors and walls must meet or exceed requirements of local building/energy codes.

[4] Insulation may be placed between floor joists over crawl space or unheated basement instead of on foundation/basement walls or under basement slab.

[5] Interior Brick veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1148.

[6] For information on Brick pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1180.

[7] Consideration must be given to the additional weight of pavers. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.

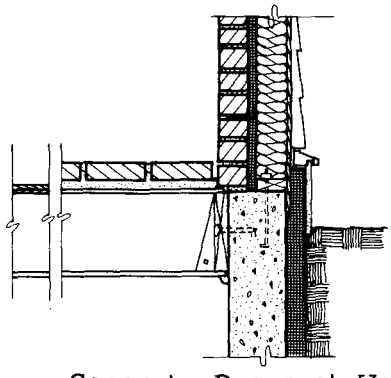
[8] Below grade wall may be used for Direct Gain storage. For information on interior finishes, see Key Pages 3.1142 and 3.1146.

[9] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.

[10] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.

[11] Continuous sill sealer is recommended to provide protection against infiltration.

[12] Insulation must be protected where exposed above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used, allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

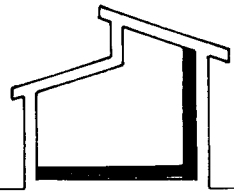


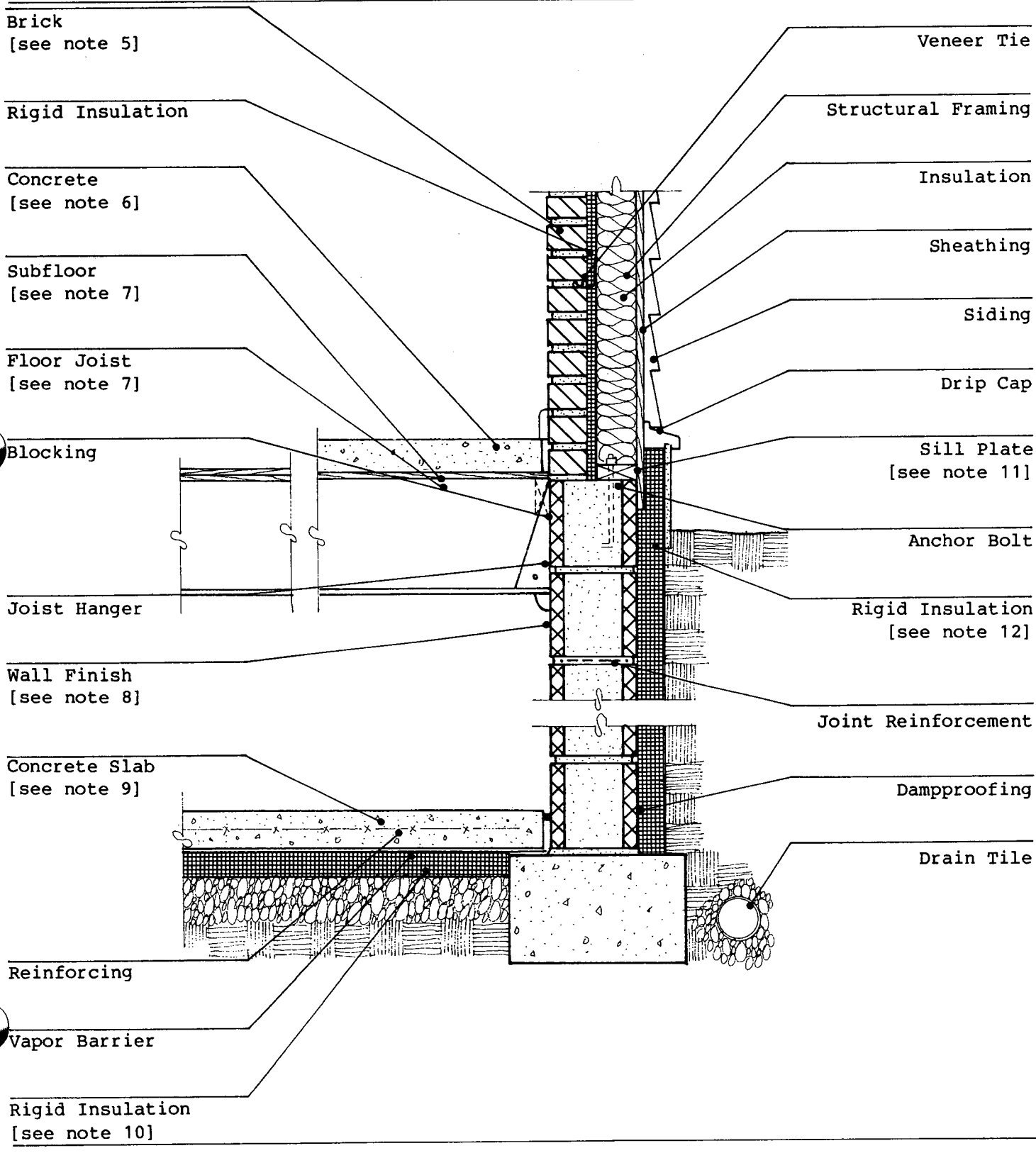
Concrete Basement Wall

Direct Gain

Brick Veneer Exterior Wall
Concrete/Wood First Floor

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels in floors and walls must meet or exceed requirements of local building/energy codes.

[4] Insulation may be placed between floor joists over crawl space or unheated basement instead of on foundation/basement walls or under basement slab.

[5] Interior Brick veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1148.

[6] For information on Concrete used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1176.

[7] Consideration must be given to the additional weight of Concrete. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.

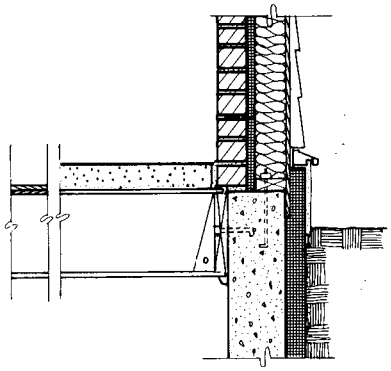
[8] Below grade wall may be used for Direct Gain storage. For information on interior finishes, see Key Pages 3.1142 and 3.1146.

[9] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.

[10] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.

[11] Continuous sill sealer is recommended to provide protection against infiltration.

[12] Insulation must be protected where exposed above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used, allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.



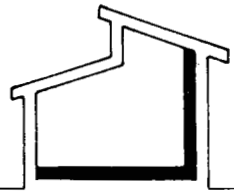
Concrete Basement Wall

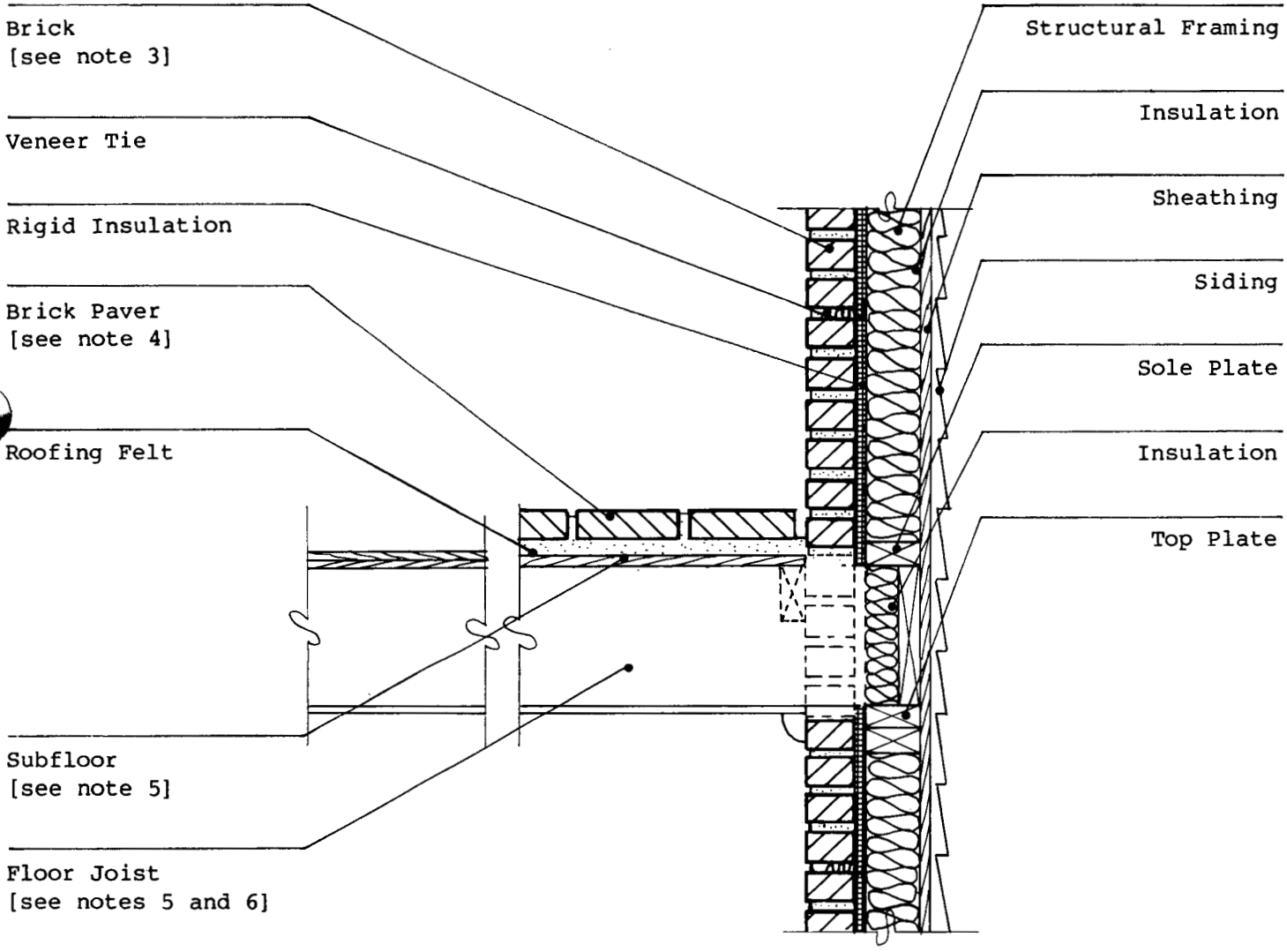
Direct Gain

Brick Veneer Exterior Wall
Brick Paver/Wood Upper Floor

3.1478

Detail





Construction Notes

[1] Insulation levels in walls must meet or exceed requirements of local building/ energy codes.

[2] Placement of metal ties to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Interior Brick veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1148.

[4] For information on Brick pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1180.

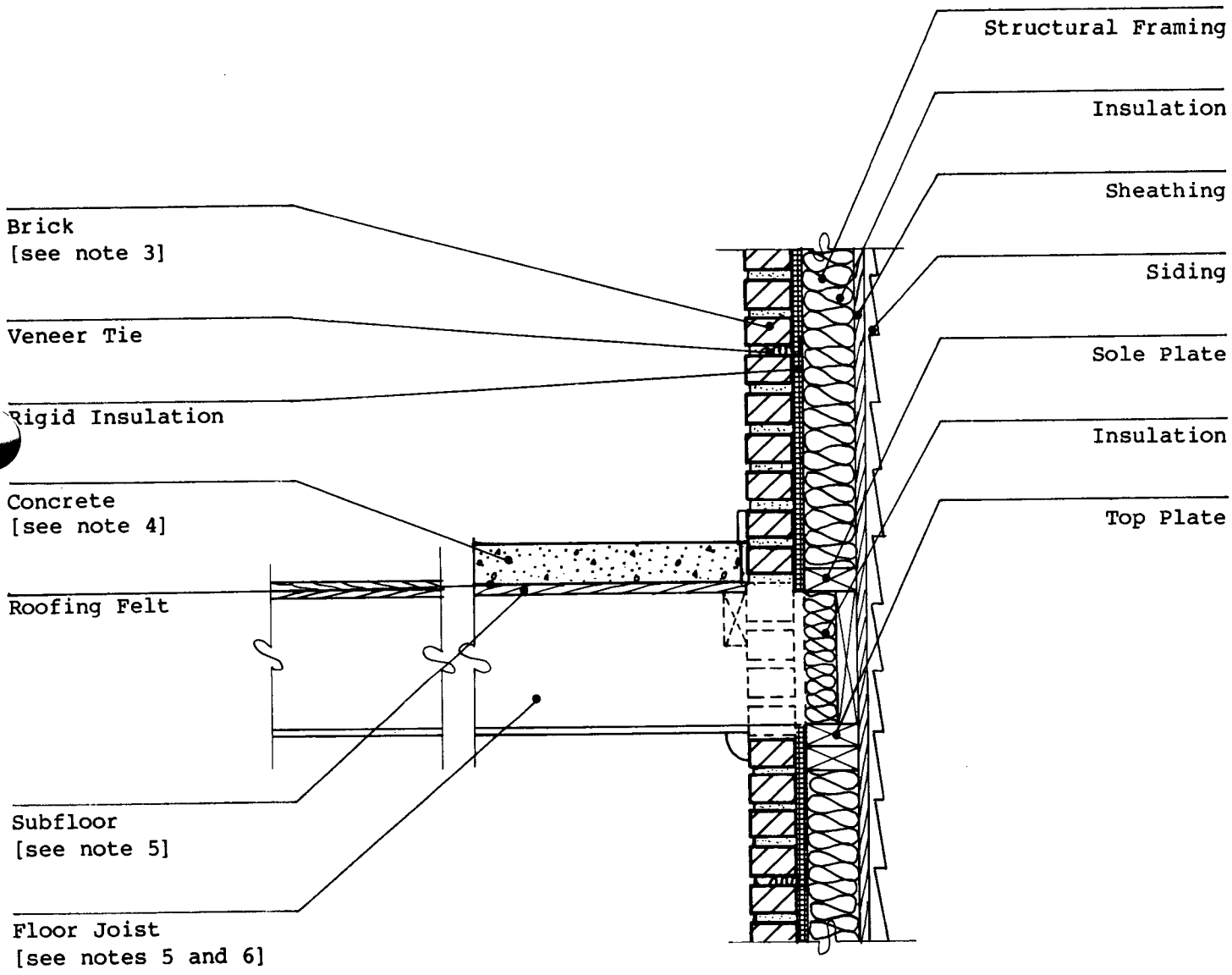
[5] Consideration must be given to the additional weight of pavers. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.

[6] Brick veneer wall must be continuous. Joists are framed through veneer into structural framing.

Direct Gain
Brick Veneer Exterior Wall
Concrete/Wood Upper Floor

3.1480

Detail



Construction Notes

[1] Insulation levels in walls must meet or exceed requirements of local building/ energy codes.

[2] Placement of metal ties to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Interior Brick veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1148.

[4] For information on Concrete used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1176.

[5] Consideration must be given to the additional weight of Concrete. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.

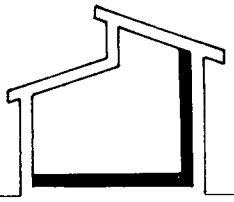
[6] Brick veneer wall must be continuous. Joists are framed through veneer into structural framing.

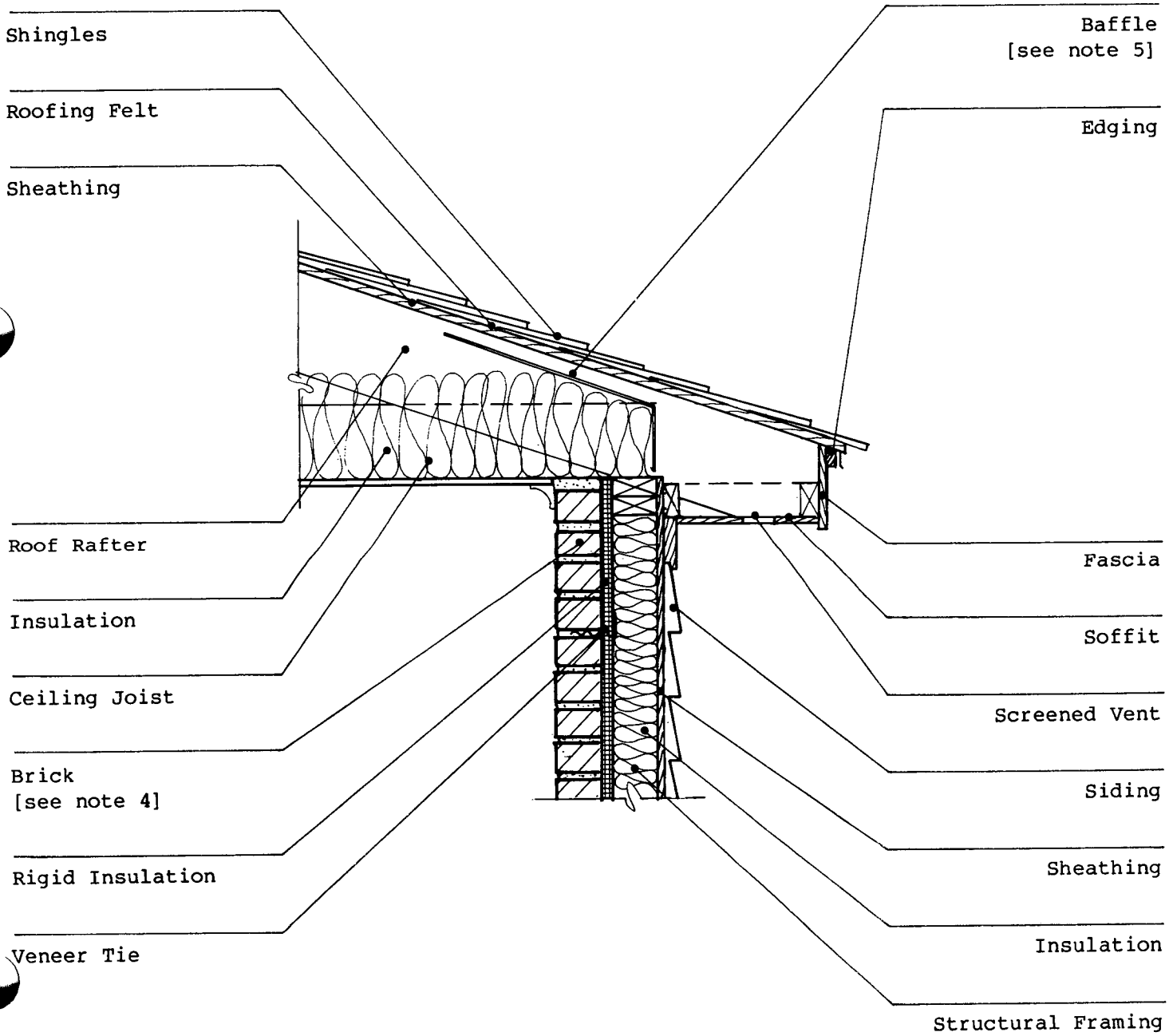
Direct Gain

Brick Veneer Exterior Wall
Roof

3.1482

Detail





Construction Notes

[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof/wall connections, especially in seismic and/or high wind areas.

[2] Insulation levels in ceiling and walls must meet or exceed requirements of local building/energy codes.

[3] Provide gutters and downspouts as required.

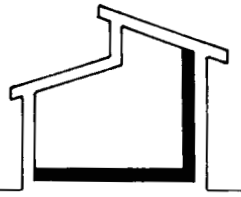
[4] Interior Brick veneer used for Direct Gain storage. For information on finishes, material variations, and thermal performance characteristics, see Key Page 3.1148.

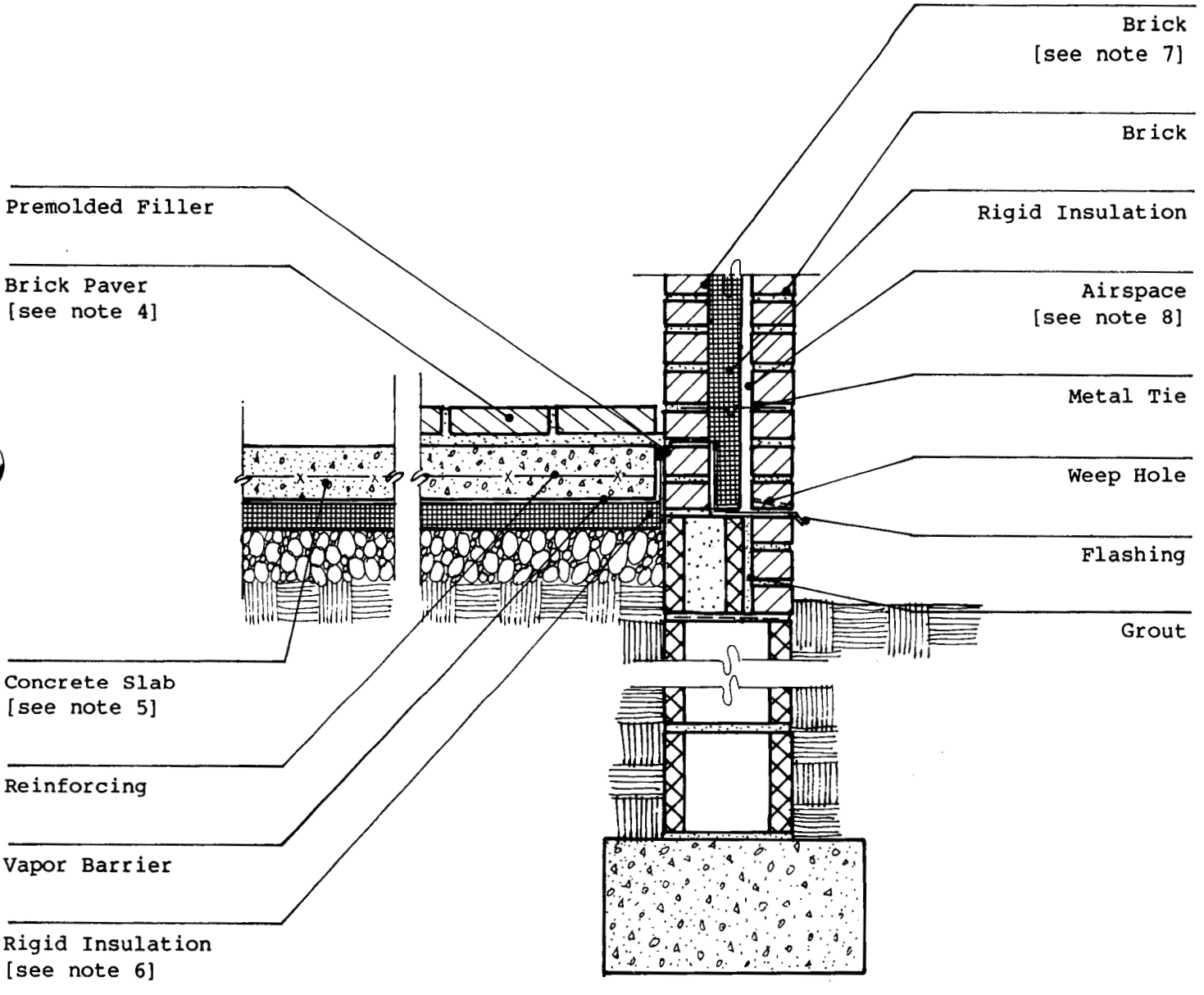
[5] Provide baffles where necessary to maintain 1 inch minimum airspace for venting attic.

Direct Gain
Brick Cavity Exterior Wall
Brick Paver/Slab-On-Grade

3.1484

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.

[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels in floors and walls must meet or exceed requirements of local building/energy codes.

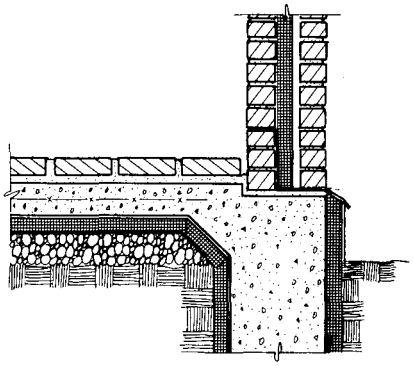
[4] For information on Brick pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1178.

[5] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.

[6] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.

[7] Interior wythe of cavity wall used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.1150.

[8] Width of cavity may vary depending upon the amount of insulation required. A 1 inch minimum airspace must be provided where rigid insulation is used. For further information see Key Page 3.1150.

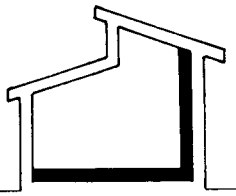


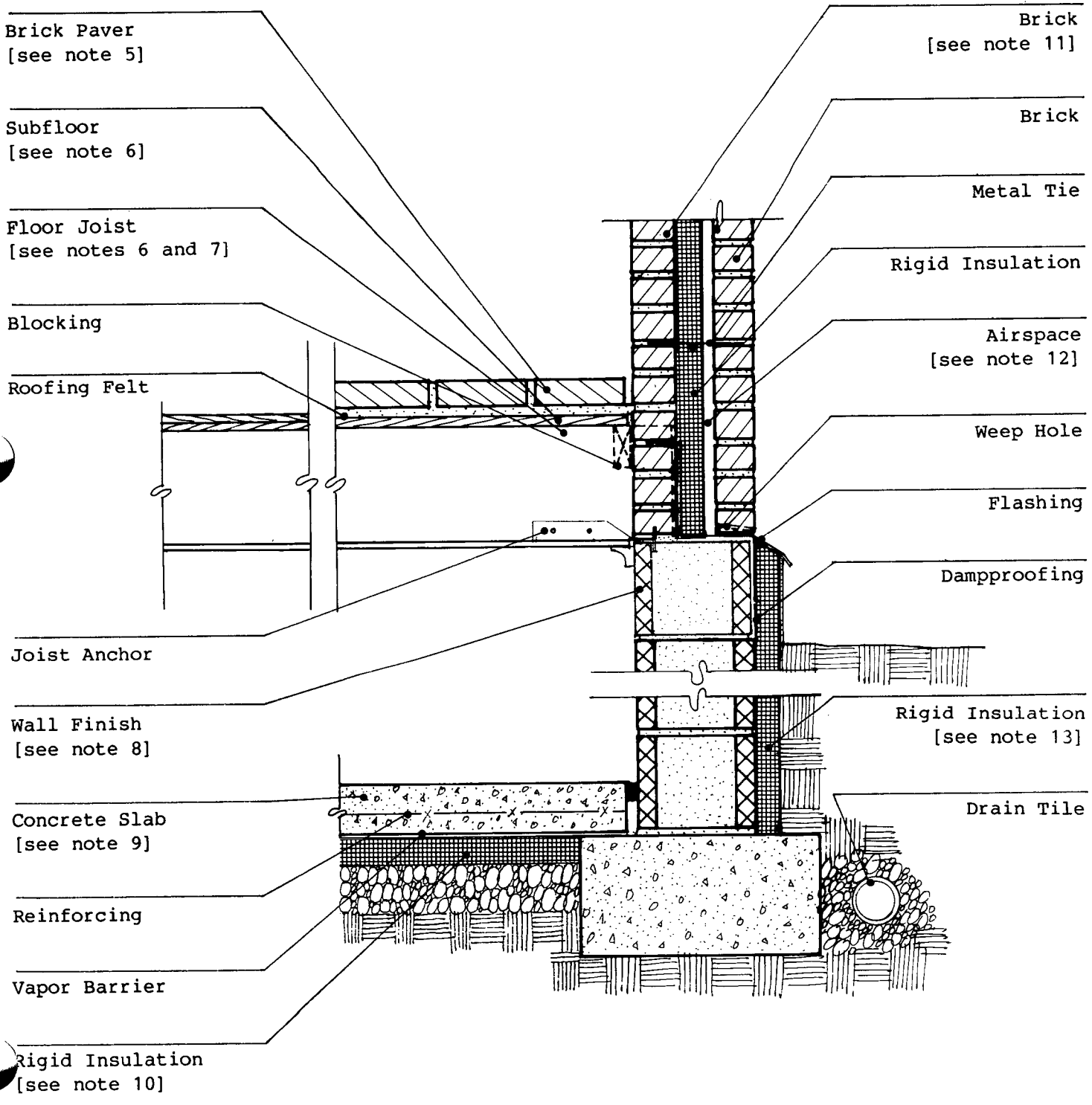
Concrete Foundation

Direct Gain

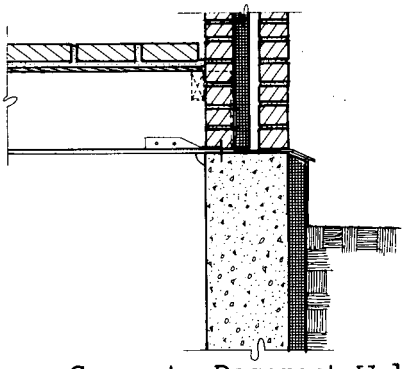
Brick Cavity Exterior Wall
Brick Paver/Wood First Floor

Detail





[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.
[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.
[3] Insulation levels in floors and walls must meet or exceed requirements of local building/energy codes.
[4] Insulation may be placed between floor joists over crawl space or unheated basement instead of on foundation/basement walls or under basement slab.
[5] For information on Brick pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1180.
[6] Consideration must be given to the additional weight of pavers. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists, grade and thickness of subfloor.
[7] Floor joists must bear on solid masonry not less than 4 inch thick. Fire-cut joists as required.
[8] Below grade wall may be used for Direct Gain storage. For information on interior finishes, see Key Pages 3.1142 and 3.1146.
[9] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.
[10] In cooler climates install continuous insulation under the slab used for Direct Gain storage. For further information, see Section 3.1000.
[11] Interior wythe of cavity wall used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.1150.
[12] Width of cavity may vary depending upon the amount of insulation required. A 1 inch minimum airspace must be provided where rigid insulation is used. For further information see Key Page 3.1150.
[13] Insulation must be protected where exposed above grade. Cement plaster over wire lath or other methods may be employed.

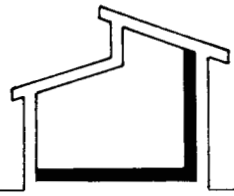


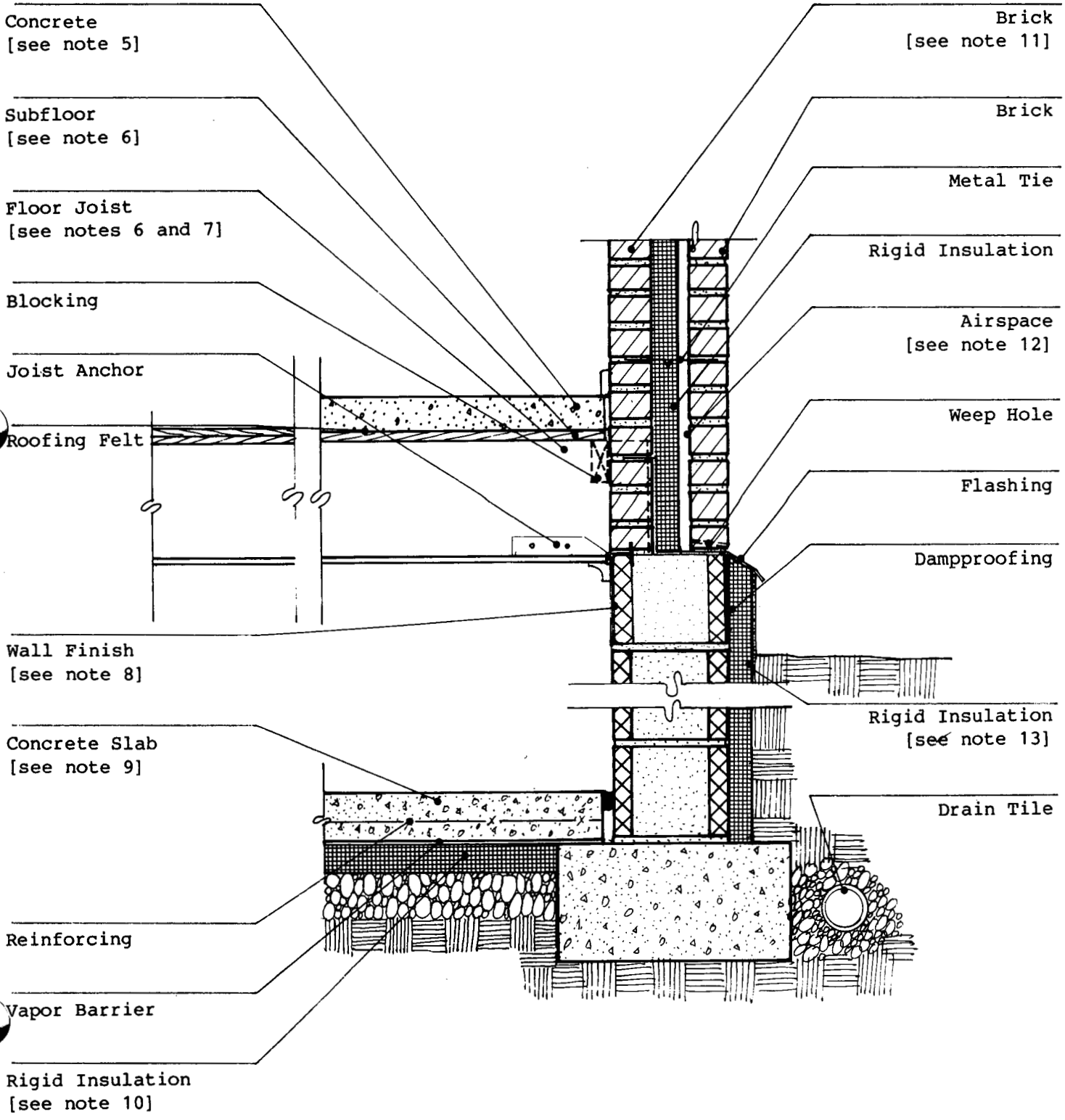
Concrete Basement Wall

Direct Gain
Brick Cavity Exterior Wall
Concrete/Wood First Floor

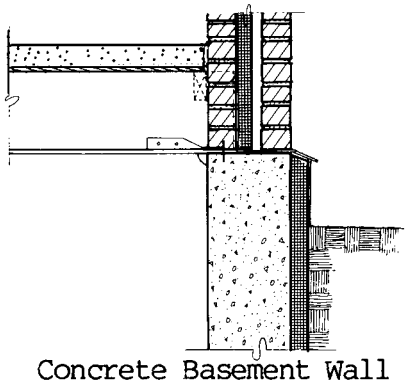
3.1488

Detail





[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local building code restrictions.
[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.
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[4] Insulation may be placed between floor joists over crawl space or unheated basement instead of on foundation/basement walls or under basement slab.
[5] For information on Concrete used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1176.
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[9] For information on finishes for concrete slabs-on-grade used for Direct Gain storage, see Key Page 3.1174.
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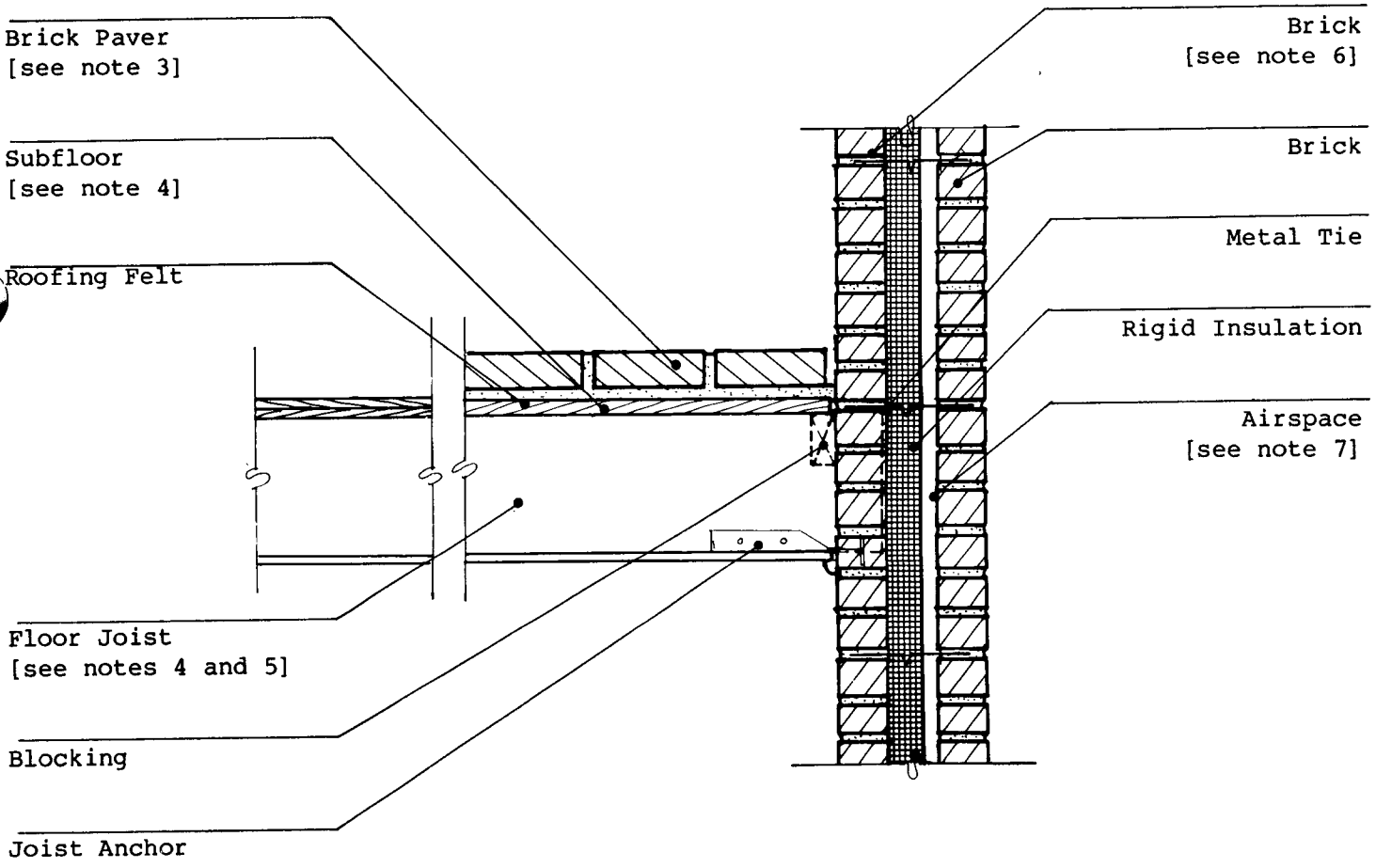


Concrete Basement Wall

Direct Gain

Brick Cavity Exterior Wall
Brick Paver/Wood Upper Floor

Detail



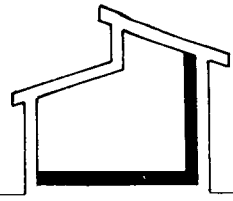
Construction Notes

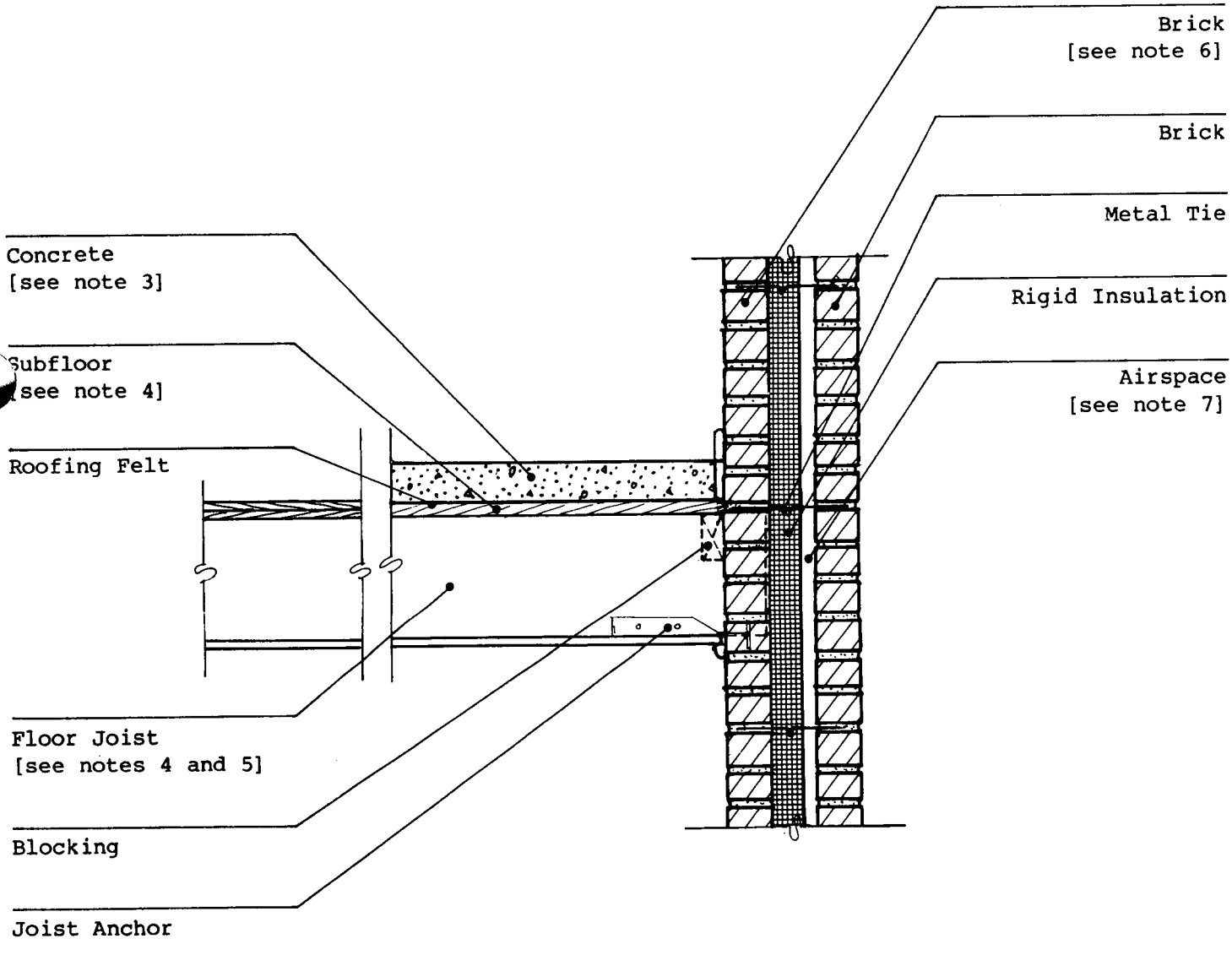
[1] Insulation levels in walls must meet or exceed requirements of local building/ energy codes.
[2] Placement of reinforcing, metal ties and joist anchors to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.
[3] For information on Brick pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1180.
[4] Consideration must be given to the additional weight of pavers. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.
[5] Floor joists must bear on solid masonry not less than 4 inch thick. Fire-cut joists as required.
[6] Interior wythe of cavity wall used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.1150.
[7] Width of cavity may vary depending upon the amount of insulation required. A 1 inch minimum airspace must be provided where rigid insulation is used. For further information see Key Page 3.1150.

Direct Gain

Brick Cavity Exterior Wall
Concrete/Wood Upper Floor

Detail





Construction Notes

[1] Insulation levels in walls must meet or exceed requirements of local building/ energy codes.

[2] Placement of reinforcing, metal ties and joist anchors to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] For information on Concrete used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1176.

[4] Consideration must be given to the additional weight of Concrete. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor.

[5] Floor joists must bear on solid masonry not less than 4 inch thick. Fire-cut joists as required.

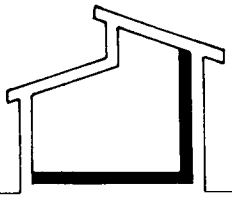
[6] Interior wythe of cavity wall used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.1150.

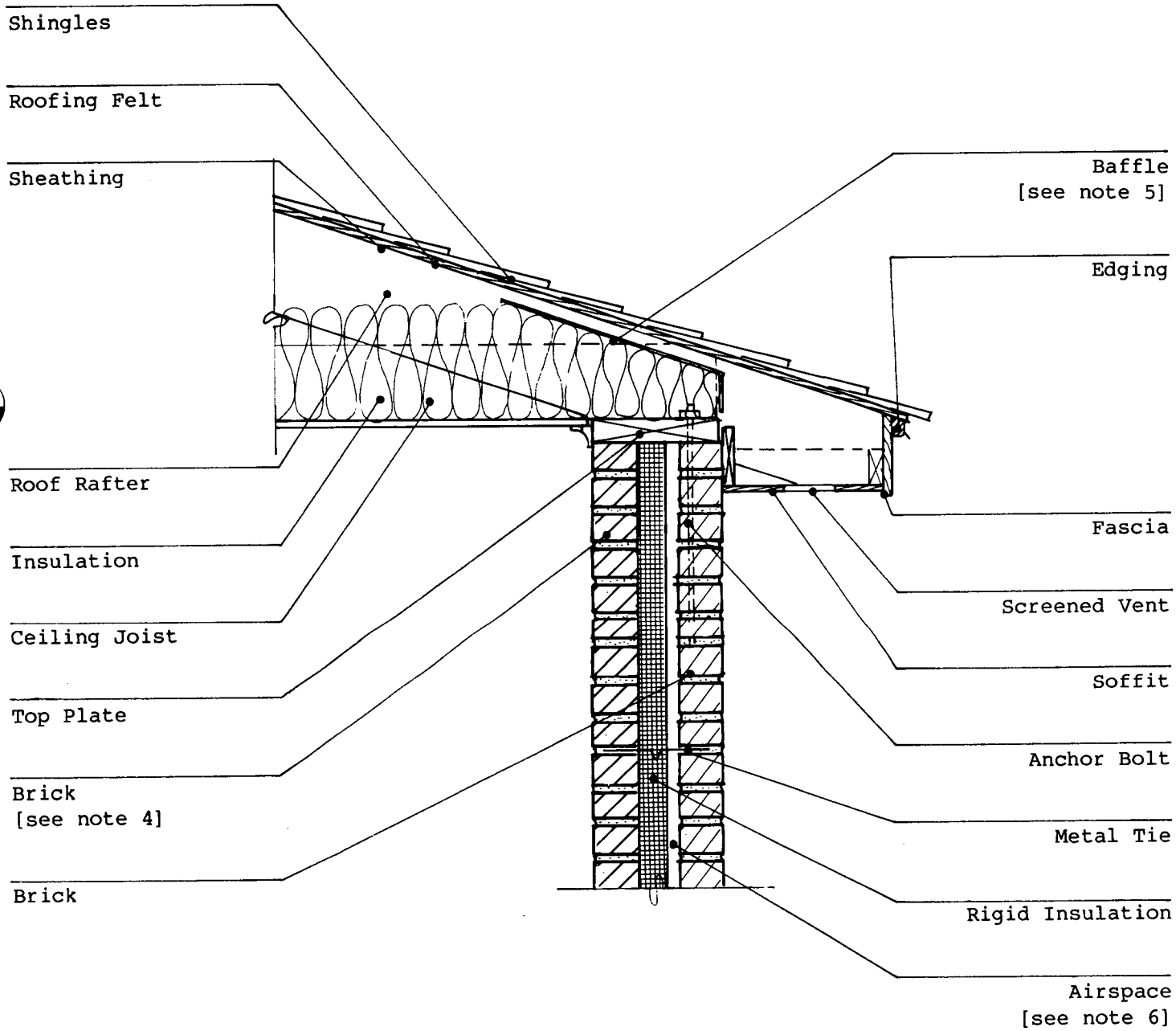
[7] Width of cavity may vary depending upon the amount of insulation required. A 1 inch minimum airspace must be provided where rigid insulation is used. For further information see Key Page 3.1150.

Direct Gain
Brick Cavity Exterior Wall
Roof

3.1494

Detail





Construction Notes

[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof/wall connections, especially in seismic and/or high wind areas.

[2] Insulation levels in ceiling and walls must meet or exceed requirements of local building/energy codes.

[3] Provide gutters and downspouts as required.

[4] Interior wythe of cavity wall used for Direct Gain storage. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.1150.

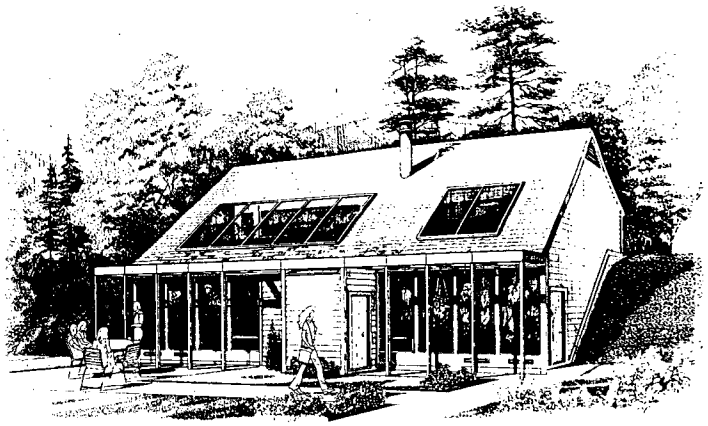
[5] Provide baffles where necessary to maintain 1 inch minimum airspace for venting attic.

[6] Width of cavity may vary depending upon the amount of insulation required. A 1 inch minimum airspace must be provided where rigid insulation is used. For further information see Key Page 3.1150.

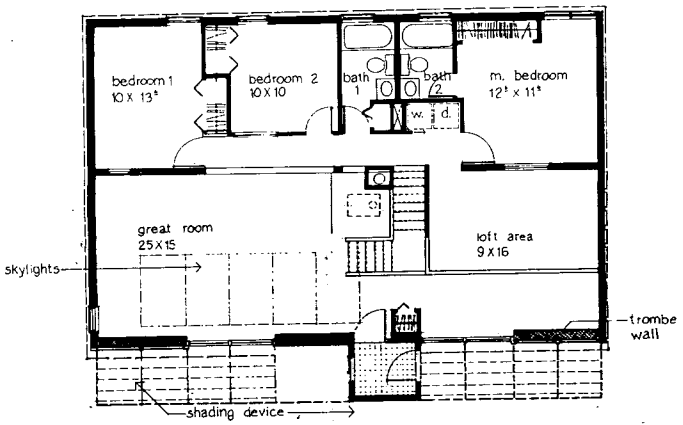
Direct Gain
TVA Solar House 10

3.1900

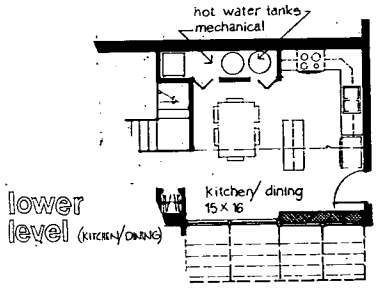
Case Study



Direct Gain and Thermal Storage Wall systems provide passive solar heating to this 1,660 square foot bi-level house. The Direct Gain system design utilizes sky-lights for collection and an interior masonry wall for storage. A trellis type sunscreen provides shading of the Thermal Storage Wall during the cooling season. The south-facing, sloping site takes advantage of earth integration for energy conservation.



upper level : 860 s.f.
lower level : 804 s.f.
total: 1664 s.f.

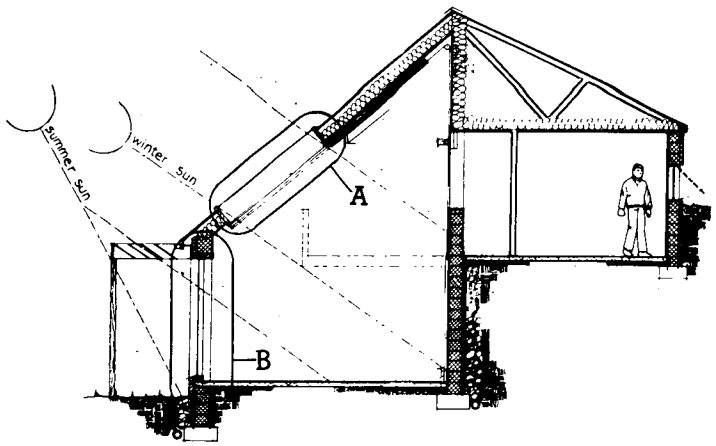


north

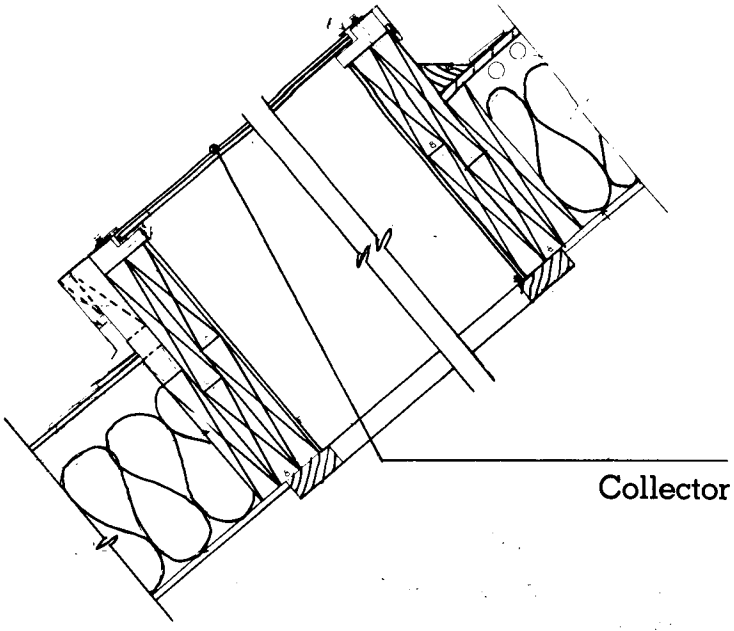
Sponsor

Solar Applications Branch
Architectural Design Branch
Tennessee Valley Authority
Knoxville, Tennessee

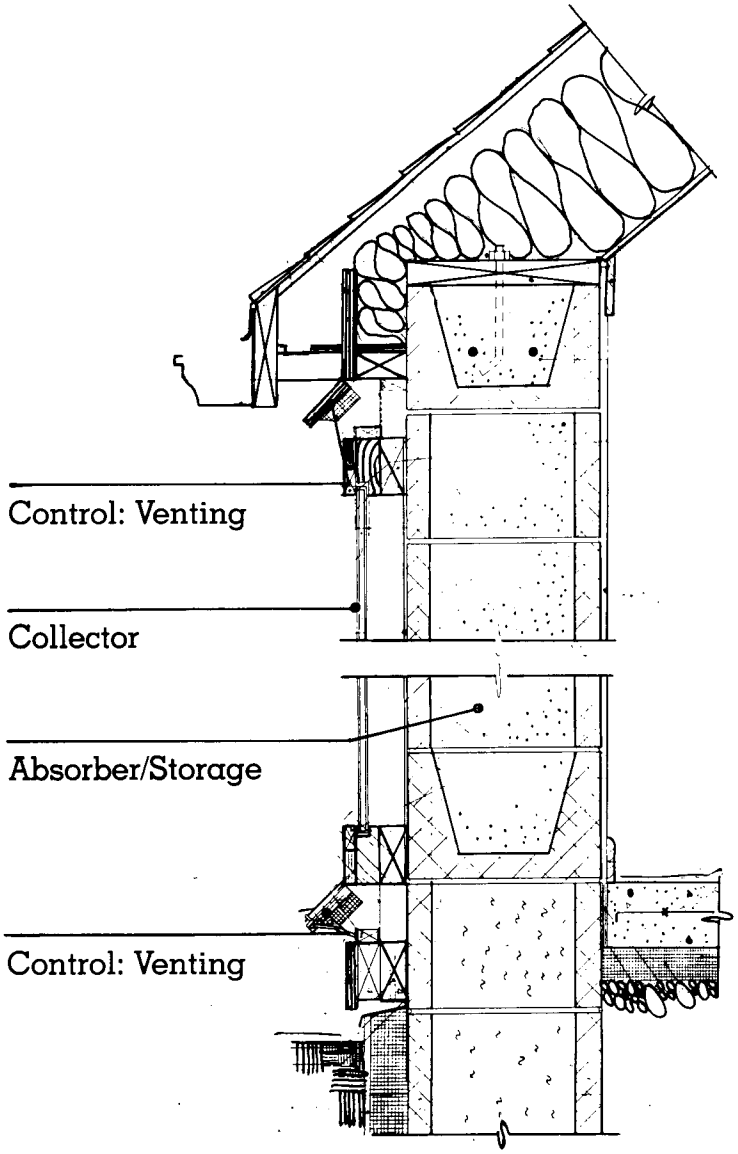
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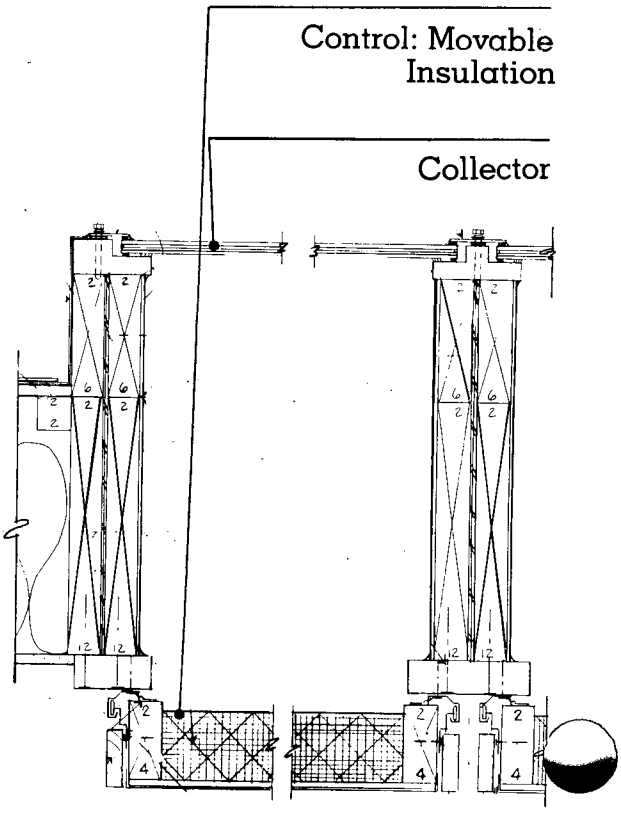
Building Section



A Skylight Detail: Section



B Thermal Storage Wall Detail: Section

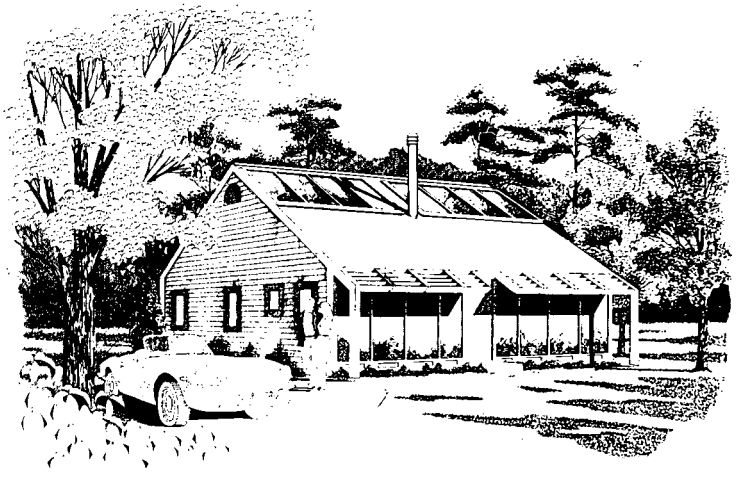


C Skylight Detail: Section

Direct Gain
TVA Solar House II

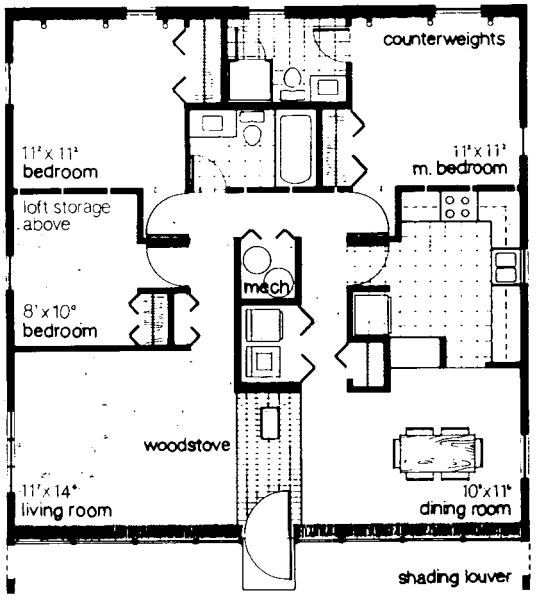
3.1902

Case Study



This 1,200 square foot gable house is designed for flat or slightly sloped sites. Its square floor plan can be rotated so that the living area and main entry can be located on the north, east, south, or west, depending on road access.

Passive solar heating is provided through the use of both Direct Gain and Thermal Storage Wall systems. Skylights in the cathedral ceiling act as collectors in the Direct Gain system. Storage mass is provided by an interior masonry wall and masonry veneer applied to the inside face of the north wall. The high ceiling and open floor plan work with summer vents to enhance ventilation for cooling.



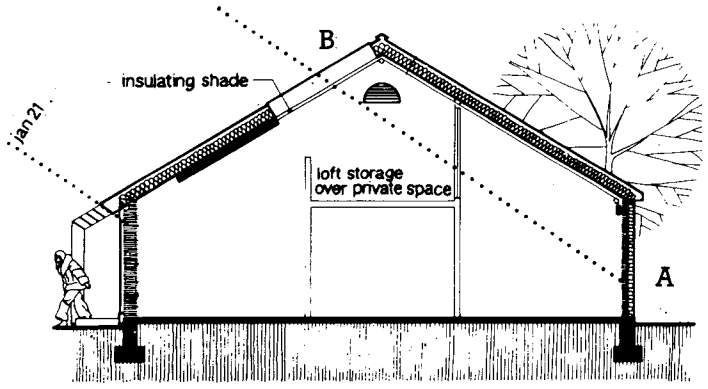
Main Floor Plan

north

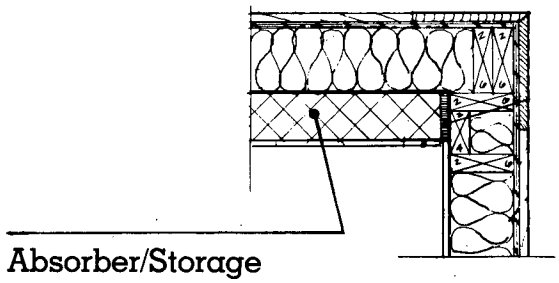
Sponsor

Solar Applications Branch
Architectural Design Branch
Tennessee Valley Authority
Knoxville, Tennessee

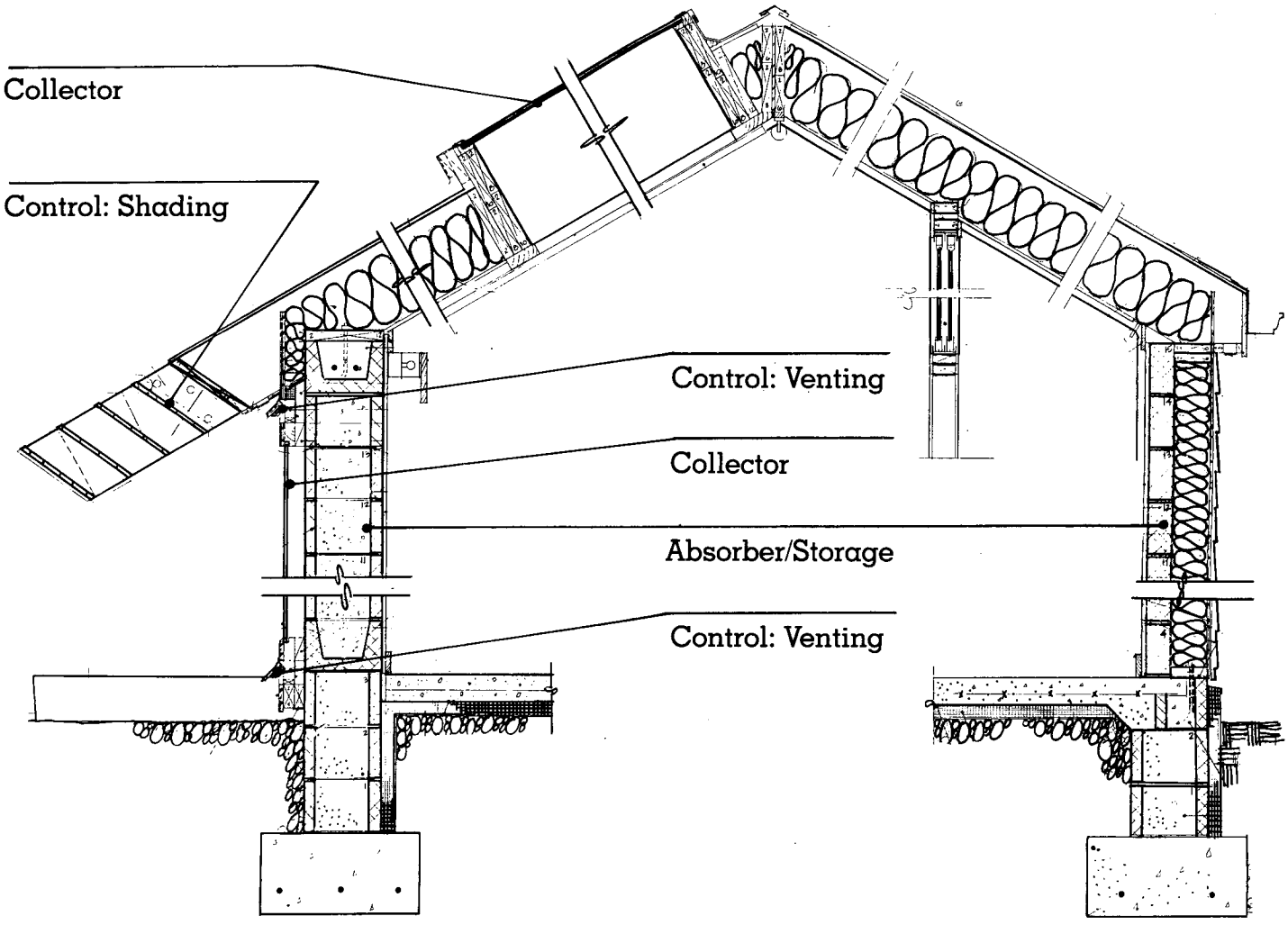
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Building Section



A Corner Detail: Plan



B Building Section

Direct Gain
SSEC Atlanta House

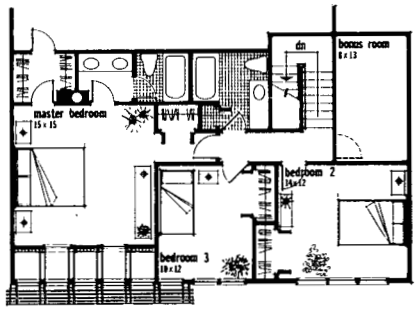
3.1904

Case Study

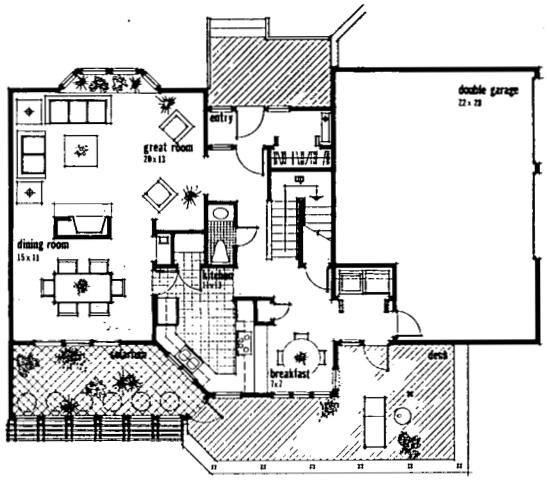


This 2,300 square foot house is expected to operate at a 45% reduction in annual energy use compared to typical new house construction. Primary design consideration for this home, located in Atlanta, Georgia, was given to reducing winter energy demands through the use of passive solar heating.

Direct Gain, Attached Sunspace and Thermal Storage Wall systems have all been incorporated into the design.



2nd floor



north

1st floor

Builder

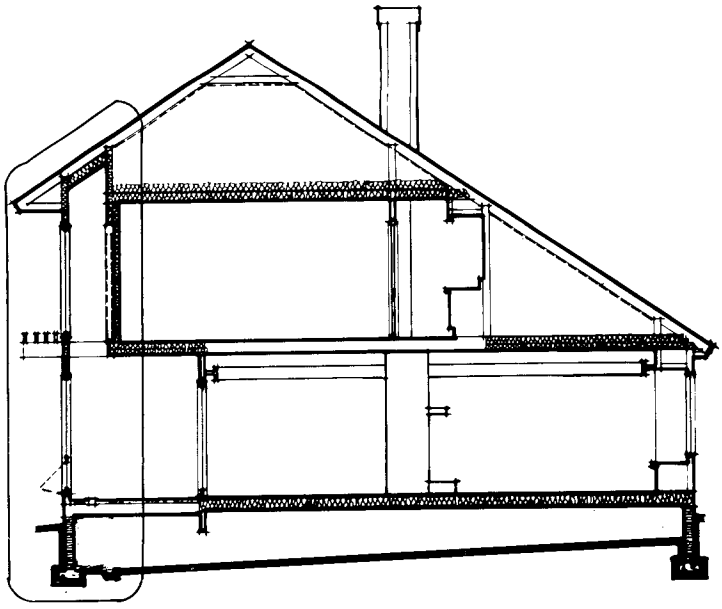
ARVIDA Corporation
Jim Brown
Atlanta, Georgia

Designer

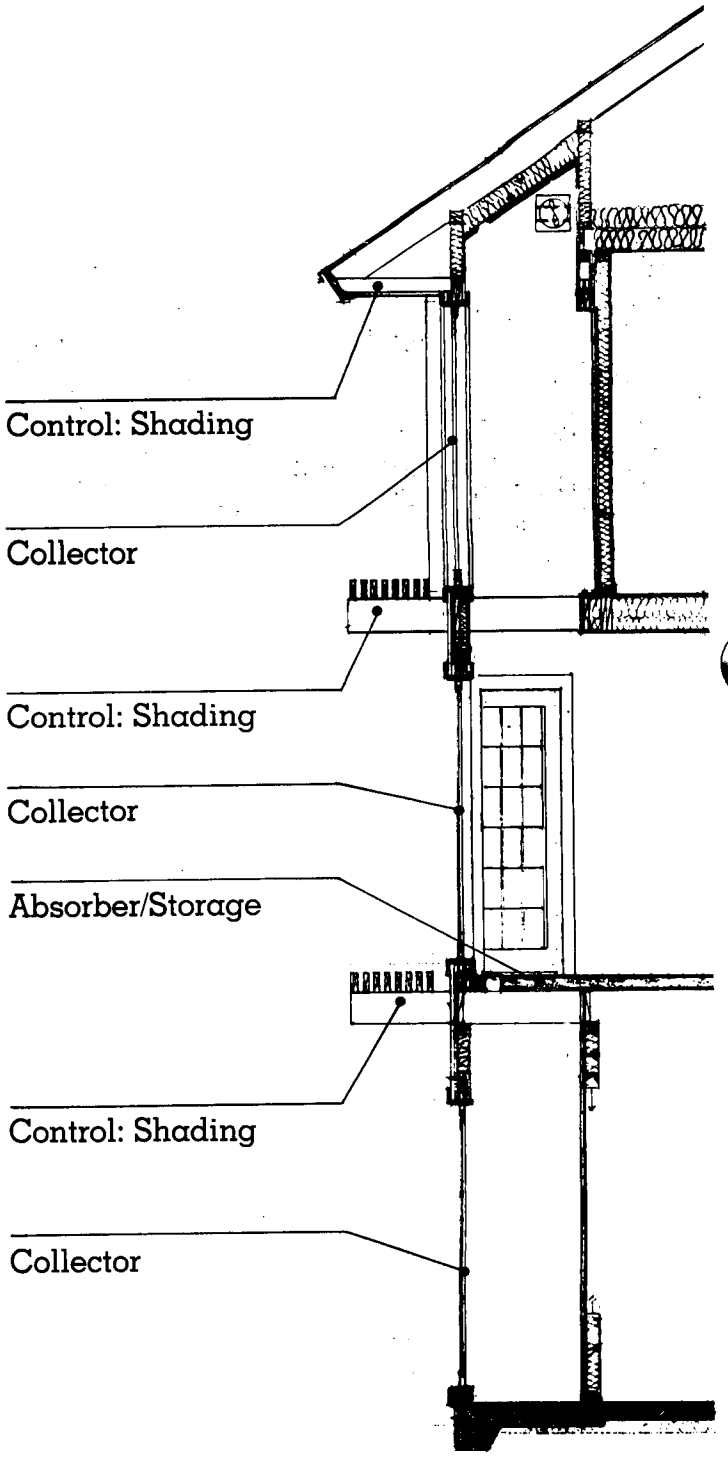
Thompson, Hancock, Witte & Associates, Inc.
Architects and Planners
Atlanta, Georgia

Sponsor

Southern Solar Energy Center
Atlanta, Georgia

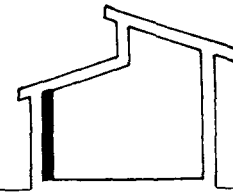


Building Section



Wall Detail: Section

Thermal Storage Wall
Introduction



Design Overview

Thermal Storage Wall systems are designed primarily for space heating, but can be used in certain climate conditions to provide cooling. For heating, they are most effective in areas with moderate or severe winters. For cooling, they are best suited to areas with high daily temperature swings (see "Seasonal Operation" below).

The collector component in a Thermal Storage Wall system is generally a wall of south facing glass or plastic placed directly in front of a wall which serves as the storage component. Control components can be applied outside the collector or between the collector and the storage wall, depending on the specific situation.

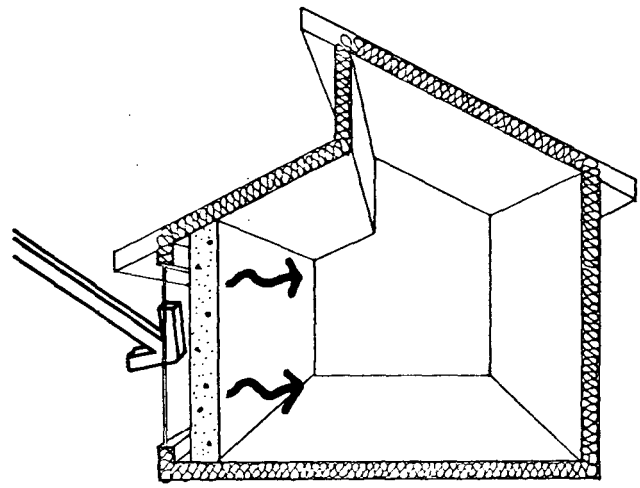


Figure 3.17

In a Thermal Storage Wall system collection, absorption, storage and control of solar energy occur outside the living space. Heat is transferred to the living space by the storage wall itself, which generally forms one side of the space. The wall can be unvented or vents can be provided at the top and bottom. Windows can also be integrated into the wall to provide light, view, and some Direct Gain heating.

Seasonal Operation (Heating)

During the heating season sunlight passes through the collector (usually some form of glass or plastic), strikes the storage wall and heats it. In an unvented Thermal Storage Wall (see Figure 3.17), this heat is stored and slowly migrates to the interior where it heats the adjacent living space. If properly designed the wall can provide adequate heat to the living space throughout the night.

Some of the heat generated in the airspace between the collector and the storage wall is conducted back through the glass or plastic to the outside. The hotter the air in the airspace, the greater this heat loss. Much of this heated air is put to use in a vented storage wall (see Figure 3.18).

Because of the tendency of hot air to rise and cool air to drop, a natural system for providing warm air to the living space can be set up in a vented wall system. Vents placed at the top of the wall allow air, which has been heated in the airspace, to flow naturally into the adjacent living area. Vents low in the wall then pull cooler replacement air into the airspace from the living area, thus setting up a loop for circulating the heated air (thermocirculation). No mechanical means for moving the air are required. Care should be taken to ensure that the circulation pattern does not reverse itself at night,

when temperatures in the airspace drop, allowing heated air from the living space to flow into the airspace, pushing cooler airspace air into the living area. The provision of simple backdraft dampers or operable louvers on the upper vents will prevent this reverse flow from occurring.

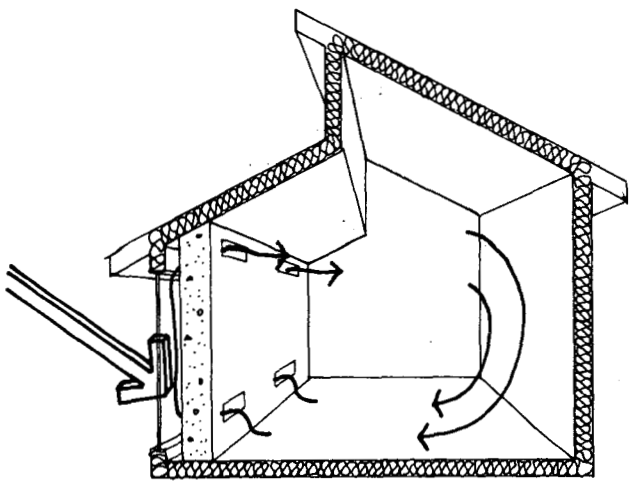


Figure 3.18

In a vented system heated air enters the living space at roughly 90°F. The loss of this heat from the airspace consequently reduces the amount of heat available to be stored by the wall. An unvented system does not "lose" heat in this way and thus has the advantage of storing a greater percentage of the solar energy available to it than does a vented wall. This stored heat is not, however, readily available for immediate use.

In an unvented system there is always a delay between the time at which sunlight first strikes the storage wall and the time when the heat has finally traveled through the wall and reached the living space. Such a delay, called "time lag," is characteristic of certain materials, such as masonry, which are commonly used to construct Thermal Storage Walls. Depending on the design of the system this lag period can last from several hours to an entire day.

In a vented system this "time lag" still occurs, but some of the heat is shortcircuited by the vents which provide heat to the living space throughout the day. Such a trade-off makes sense in colder climates where daytime as well as nighttime heating requirements are high and it is desirable to provide a certain amount of heat directly to the living space during the day. In such situations, a vented wall should be specified. In most moderate climates, on the other hand, where daytime heating is not as important as nighttime, an unvented system will be preferable. If properly designed such a system will be able to store heat throughout the day and release it to the living space throughout the night.

It should be noted that windows integrated into Thermal Storage Walls to provide light, view, and/or some Direct Gain daytime heating, will also reduce the effective area of the storage wall.

Seasonal Operation (Cooling)

The south facing collector should be well shaded to prevent excessive heat gain during cooling season when heat is not required from the system (see Figure 3.19).

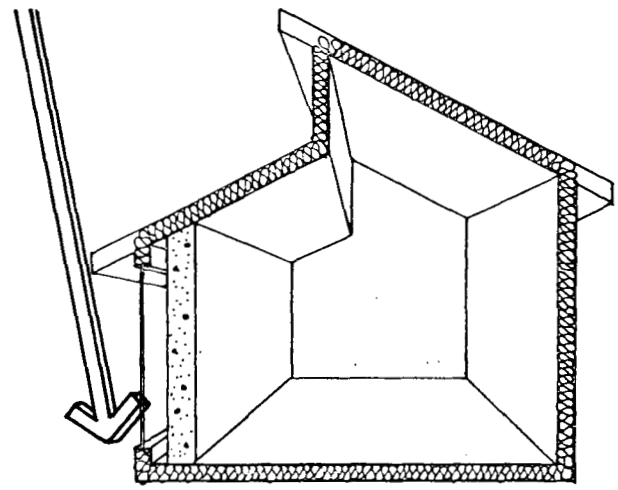


Figure 3.19

Introduction

Shading elements, such as overhangs, should be sized so as to maximize overall system performance. If they are too large they may completely shade the wall preventing unwanted gain during the cooling season, but they will also block a significant amount of radiation during the early part of the heating season. Conversely, if they are too small, solar gain will be maximized when heat is needed, but overheating will occur during the late part of the cooling season adding to the load on the auxiliary energy system. (For a guide to sizing see the "Control: Rules of Thumb" below.)

It should be noted that a Thermal Storage Wall system can contain two sets of vents. In addition to the wall vents discussed above, vents can and should be placed on the exterior in the collector component. In the former case, the vents are placed in the storage wall itself to provide heated air to the living space.

Vents placed in the collector are used to prevent overheating during the cooling season by admitting outside air into the airpace (see Figure 3.20).

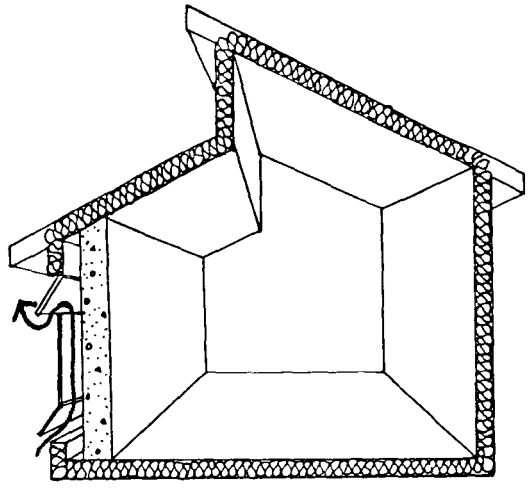


Figure 3.20

These external vents can be opaque panels in the collector system or they can simply be operable glazing elements. In situations where the collector is shaded by a fixed device such as an overhang, an opaque vent may be preferable to glazing for use at the top of the collector. This area will generally receive little or no sun, especially if the overhang is large, but will conduct considerable amounts of heat if it is glazed. Opaque vents, if properly designed, can allow for the inclusion of adequate insulation to reduce such heat flow. Lower vents can be opaque or glazed depending on builder preference. Glazed units will admit more solar radiation.

A combination of these high and low exterior vents in the collector wall will remove much of the heat from the airspace. If the high exterior vents are operated in conjunction with the low interior vents in the storage wall, air will be drawn across the living space and through the low vents to replace the warm airspace air rising naturally out the upper vents. This method not only avoids heat build-up in the airspace but also provides some natural ventilation to the living space.

In certain areas of the country the Thermal Storage Wall itself can be cooled and in turn can be use to cool the living space (see Figure 3.21).

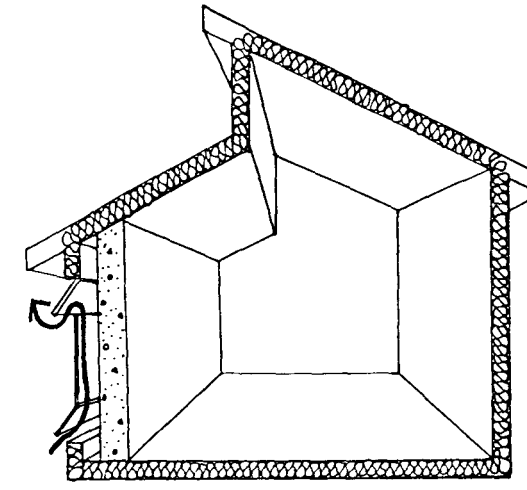


Figure 3.21

In locations where the outside temperature

drops to below 60°F at night, cool outside night air can be drawn through the collector vents and across the storage wall by natural convection or fans. By morning the wall temperature will be low enough to allow the wall to absorb heat from the living space during the day. Movable insulation should be used during this daytime period to cover the collector or the wall in order to reduce heat gain from the outside and to preserve the cool temperature of the wall for as long as possible. At the end of the day the insulation is removed and the cycle is repeated (see Figure 3.22).

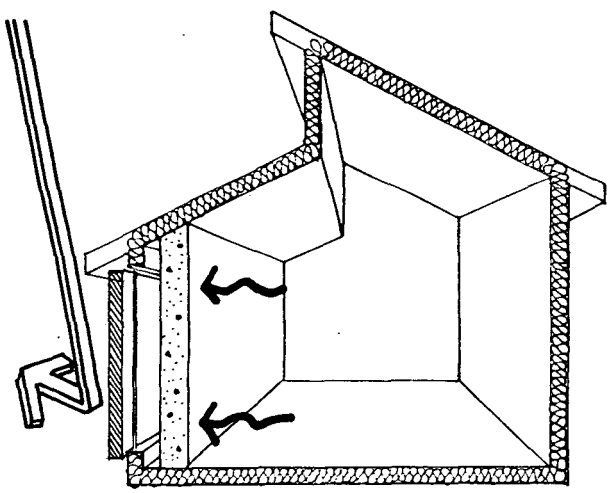


Figure 3.22

Advantages

- Glare and ultraviolet degradation of fabrics are not problems as they are in Direct Gain systems.
- The time lag between the absorption of solar energy by the exterior surface of the wall and the delivery of the resulting heat to the interior living space provides this heat in the evening when it is most needed.
- Sufficient storage mass to achieve a desired level of thermal performance can be provided in a relatively small, concentrated area within the living space.

Disadvantages

- Two south facing walls, one glazed and one made of storage material, are required.
- Mass storage walls can be expensive and may require specially sized foundations and footings. They may also be subject to special building code restrictions, especially in earthquake prone areas.
- The storage mass wall can take up valuable square footage in a residence.
- Without movable insulation, the high temperature differential between outside night air and inside airspace air will cause considerable heat to be lost through the collector glazing at night during the heating season. Therefore, some form of movable insulation is highly recommended, but it can be expensive and awkward to use.
- The storage wall can block view and daylight.

Collector

Thermal Storage Wall collectors can be constructed using off-the-shelf window units, simple patio door replacement glass, various alternate glazing materials, or some combination of these elements incorporated into a framing system specially designed for the specific installation.

If the collector framing system is metal, it should be separated from the storage wall, either by a space or by wood blocking, to avoid conductive heat losses from the wall, through the metal, to the outside. If the frame is wood, rough

sawn and green wood should be avoided in favor of kiln-dried members. Any paint used on the frame should be resistant to high temperatures.

Collector framing systems can be attached to, and supported by, the storage wall itself, or they can be framed conventionally and be supported on a foundation (see Figures 3.23 and 3.24).

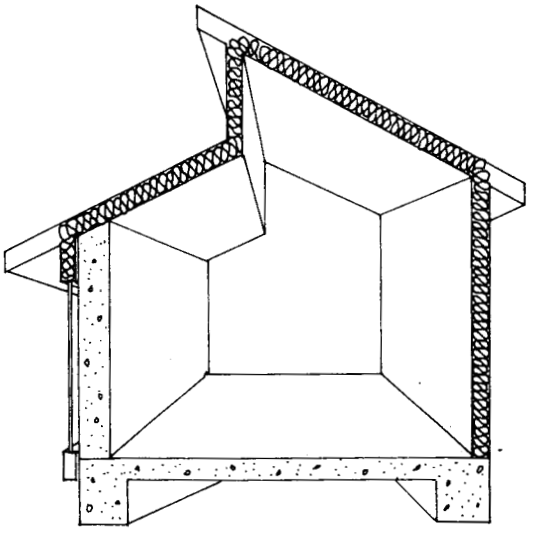


Figure 3.23

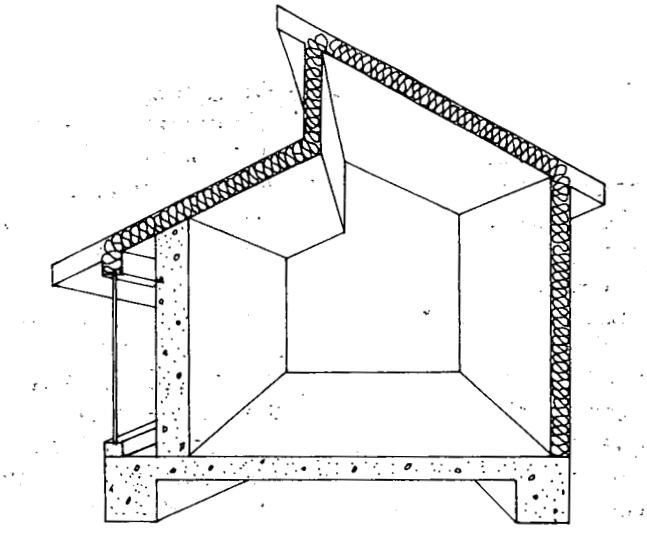


Figure 3.24

Both approaches work well and a choice will be based on specific design considerations and local material costs. Whatever system is chosen the dimensions of the framing members should be kept to a minimum so as to maximize the glazing area and, consequently, the amount of sunlight striking the wall.

The collector material can be glass or any one of a variety of alternate glazing materials including various forms of fiberglass, acrylics, polycarbonates, and certain glazing films such as polyethylene. Each of these products has its own advantages and disadvantages (see Section 4.1000). When reviewing the physical properties of these materials special attention should be paid to the maximum operating temperature of the material as temperatures within an unvented storage wall airspace can get quite high (150-180°F) and may cause some materials to rapidly degrade.

Double glazing is recommended for most installations to reduce heat losses back out through the collector. Triple glazing should be considered in severe climates if some form of movable insulation is not provided. Single glazing may be more cost effective in mild climates especially if movable insulation is provided.

Whatever material is chosen, special attention should be paid to expansion, contraction and sealing. Collector frame joints should allow for significant expansion (1/2" minimum) due to the high temperatures possible in the airspace, particularly in unvented walls. Caulking and sealants used in these applications must be able to accommodate such movement and it is recommended that only high quality products be used.

The collector should be periodically checked for possible sealant repair as some separation may occur during the first few months of operation (see Section 4.1300). It is also recommended that the collector elements be operable or removable to allow for periodic maintenance and cleaning. In systems where the collector material is used to

Introduction

vent summer heat to the exterior, such operability is already partially built-in.

Rules of Thumb

- Orientation:
  Orient the Thermal Storage Wall system to face south. Orientations up to 20° east or west of due south will not significantly affect performance.

- Design:
  The Thermal Storage Wall should be one wall of the living space(s) to be heated.

- Area:
  The surface area of the glazing should be equal to the surface area of the storage component (see Storage Rules of Thumb).

- Airspace:
  The airspace between the wall and the collector can vary from 2" to 6" depending on whether movable insulation is to be included between the wall and collector.

- Number of Glazings:
  Double glazing is recommended for most installations. Triple glazing should be considered in severe climates especially if movable insulation is not provided. Single glazing may be appropriate in mild climates if movable insulation is provided. A 1/2" airspace between glazing layers is recommended where possible.

Storage

The storage wall component of a Thermal Storage Wall system can be made of any one of a variety of materials exhibiting a high capacity to store heat (e.g., concrete masonry, concrete, brick). These materials will transfer heat to the living space slowly and evenly, delivering this heat, if the system is properly designed and sized, when it is most needed.

In general, any of the materials used for a storage wall will require larger foundations and footings to accommodate the extra weight of the wall. Special reinforcing requirements must also be considered if, as is typically the case, the storage wall is taken to the roof and used as a bearing wall.

The exterior face of the wall should be a dark color to increase absorption of incoming solar energy. The exposed surface can be painted or specific colors can be specified from the material manufacturer (see Appendix A for the absorptivities of various materials and colors).

The interior surface of the wall can be painted or left untreated. However, finishes other than paint will decrease the efficiency of the wall by restricting its ability to absorb and reradiate heat. Plaster and wallpaper will have only a minor effect in this regard. Gypsum board can be acceptable if it is attached directly to the wall and if care is taken during installation to apply a very thick coat of construction adhesive in order to increase the thermal connection between the wall and the gypsum board. Interior finishes attached on furring strips will not perform as well and should be avoided.

Mention should be made of a new type of exterior finish material which is gaining in popularity in Thermal Storage Wall applications: the selective surface. The selective surface materials, usually manufactured in thin sheets that are adhered directly to the storage wall surface, absorb almost all incoming solar radiation but only emit a very small portion as heat. They thus reduce heat loss back out through the collector glazing and can increase efficiency to the point where movable night insulation may no longer be necessary. Manufacturer's data should be referenced for performance characteristics before a specific selected surface material is used in a Thermal Storage Wall application.

Introduction

Rules of Thumb

- Area:
  In general, the farther north the building is located, the larger the Thermal Storage Wall system should be. The rough area of storage material per square foot of adjacent living space to be heated can be determined from Table 3.2 (collector area will be equal to the storage area):

  For example for Madison, Wisconsin at 43°NL with an average January temperature of 21.8°F (data available from local and/or national weather bureau), go to the intersection of the closest latitude (44°NL) and the closest "Average Winter Outdoor Temperature" (20°F) to find that .85 square feet of masonry wall, and therefore glazing, per square foot of floor area are required. For a living space of 200 square feet to be heated, 170 square feet of Thermal Storage Wall will be required assuming all other Rules of Thumb for system sizing have been followed.

- Thickness:
  The recommended storage component thickness ranges from 8" to 18".

- Vent Area:
  The area of the thermocirculation vents in the storage wall should be roughly 2 square feet per 100 square feet of wall, divided evenly between upper and lower vents.

- Vent Dampers:
  Vents should be provided with back-draft dampers to prevent reverse thermocirculation.

Control

Shading

To avoid excessive overheating in the cooling periods it is recommended that some method of shading the Thermal Storage Wall system be provided. The range of possible methods is roughly the same as that for Direct Gain shading. Exterior devices include: overhangs (see Figure 3.25), trellises, awnings, louvers (horizontal or vertical, fixed or operable), and wing walls.

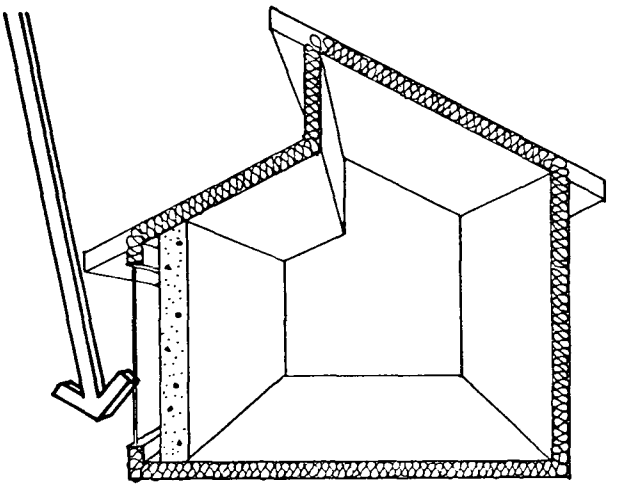


Figure 3.25

These exterior devices can form part of the building frame or be attached to it. They can be stationary or they may require daily operation. If interior devices are used they should be placed in the airspace between the storage wall and the collector (see Figure 3.26).

Interior shades are typically: curtains, blinds, or roller shades. They must be opened and closed daily if the storage wall is used for passive cooling (see paragraph on cooling above). Thermostatically controlled, motor driven interior shades are generally most acceptable to the homeowner, but manually operated interior shades are generally less expensive with fewer maintenance problems. In both cases, special attention must be paid to the method of operation of a specific shade to ensure safe and maintenance free operation from the living space. For optimum performance, these interior shading elements should also be designed to provide insulation during the day during the cooling season and at night during the heating season (see

Table 3.2

Average Winter Outdoor Temperature (Clear Day)*	Masonry Wall/Space Floor Area** 36°NL	40°NL	44°NL	48°NL
COLD CLIMATES				
20°F	.71	.75	.85	.98 (w/NI)
25°F	59	.63	.75	.84 (w/NI)
30°F	.50	.53	.60	.70
TEMPERATE CLIMATES				
35°F	.40	.43	.50	.55
40°F	.32	.35	.40	.44
45°F	.25	.26	.30	.33

Note: NI indicates Night Insulation.

* Temperatures listed are for December and January, usually the coldest months.

** These ratios apply to a well insulated space with a heat loss of 8 btu/degree day/square foot of floor area/°F. If space heat loss is more or less than this figure, adjust the ratios accordingly. The surface area of the wall is assumed to be the same as the glazing.

"Insulating" below).

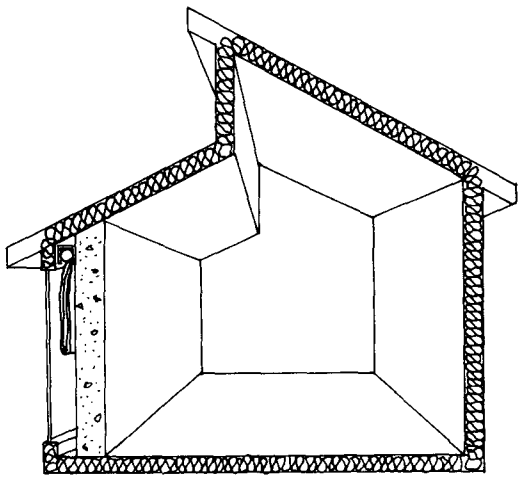


Figure 3.26

Reflecting

Reflectors placed horizontally above or below the Thermal Storage Wall collector can increase overall system performance by increasing the amount of sunlight reaching the collector (see Figure 3.27).

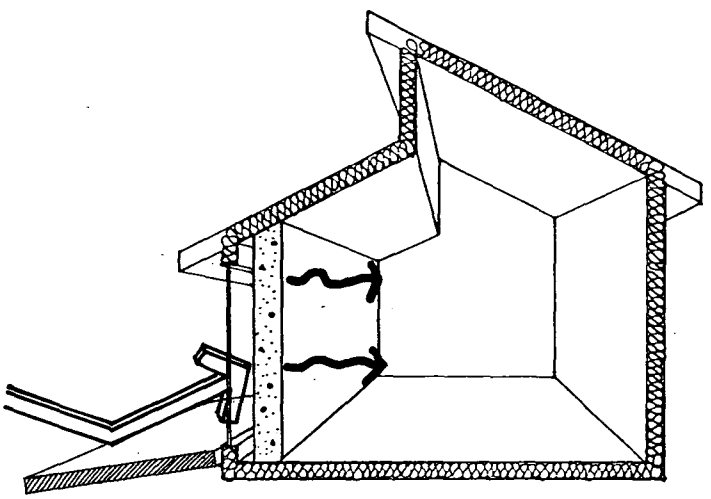


Figure 3.27

In certain cases where physical obstructions (e.g., trees or buildings) on or around the building site shade the collector, the provision of reflectors can increase solar collection 30-40%.

Reflectors are usually panels, coated on one side with a material of high reflectance, which are placed directly in front of the south facing wall. If placed on the ground they should slope slightly downward (5° is recommended), away from the wall, to increase the amount of reflected sunlight and to facilitate drainage. If possible, they should be designed so that they can also be used as movable insulation panels. Light colored exterior landscape elements such as patios or terraces can also serve as reflectors, although with less thermal efficiency than reflective panels.

Insulating (Movable Insulation)

Wherever possible, movable insulation covering the entire Thermal Storage Wall should be provided during the heating season to prevent heat gained during the day from being lost at night or during prolonged overcast periods. This insulation can also be used to shield the wall from unwanted heat gain during in the cooling season.

There are two basic applications of movable insulation: (1) insulation which is applied to the exterior of the collector; and (2) insulation which is placed in the airspace between the collector and the storage wall. The former are usually rigid panels and can be difficult to store, maintain, and operate. If designed properly, however, they can be used as both reflecting panels during the day and insulation at night (see "Reflecting" above). They will also be more effective at reducing unwanted heat gain during the cooling season because they intercept the sunlight before it can enter the collector and be converted to heat. Care must be taken that there is a tight, well sealed fit between the exterior insulation and the collector to avoid heat losses at the edges of the insulation (see

Figure 3.28).

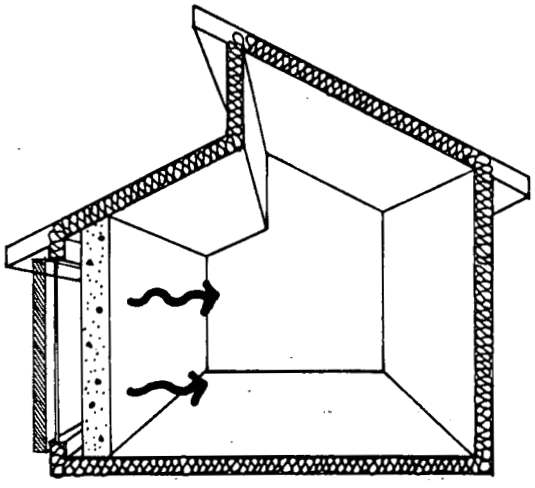


Figure 3.28

Placing the insulation in the airspace generally solves the problems of storage and reduces those of maintenance (see Figure 3.29).

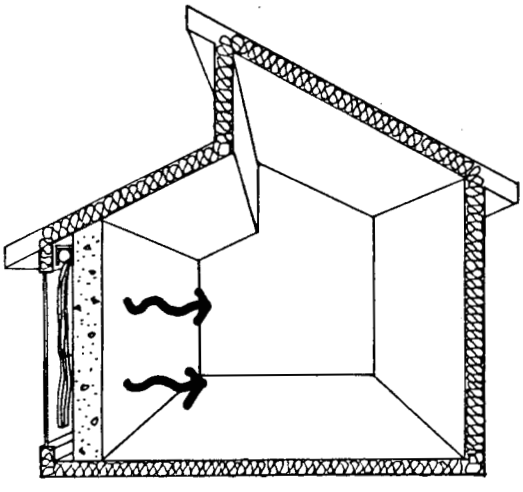


Figure 3.29

Providing for easy operation of airspace insulation, however, can pose significant problems. It is recommended that an adequate operating mechanism, whether manual or automatic, be developed very early in the design process to avoid potential future problems. Care should also be taken that this airspace insulation not interfere with the proper operation of the interior thermocirculation vents (if provided) or the exterior summer cooling vents.

Rules of Thumb

Shading

- Overhang:
  The projection of the overhang that will be adequate (provide 100% shading at noon on June 21) at particular latitudes can be quickly calculated by using the following formula:

$$\text{Projection} = \frac{\text{window opening (height)}}{\text{F (see table below)}}$$

A slightly longer overhang may be desirable in latitudes where this formula does not provide enough shade during the latter part of the cooling season (see Figure 3.30).

North Latitude	F Factor*
28°	5.6-11.1
32°	4.0- 6.3
36°	3.0- 4.5
40°	2.5- 3.4
44°	2.0- 2.7
48°	1.7- 2.2
52°	1.5- 1.8
56°	1.3- 1.5

* Select a factor according to your latitude. The higher values will provide 100% shading at noon on June 21, the lower values until August 1.

For example, for Madison, Wisconsin, at 43°NL, select an F factor between 2.0 and 2.7 (values for 44°NL). Assuming shade is desired until August 1, choose the lower value of 2.0. If the collector height (h) is 8 feet, the projection (l) of the overhang placed at the top of the collector will be: $\frac{8}{2.0}$ = 4 feet.

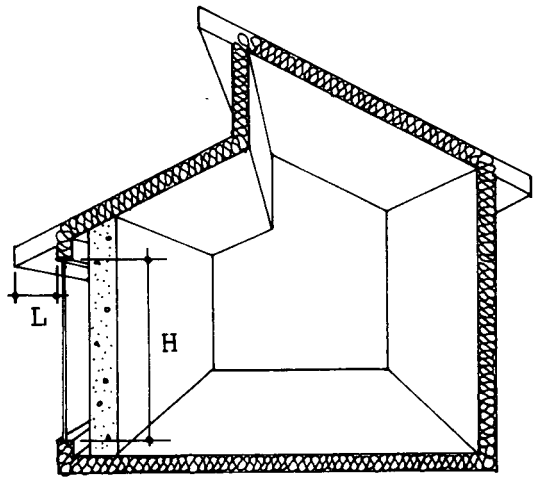


Figure 3.30

Insulating

- Movable Insulation:
  Movable insulation of R-4 through R-9 is recommended.

Reflecting

- Slope:
  A downward slope (away from collector) of roughly 5° is recommended for reflector (see Figure 3.31).

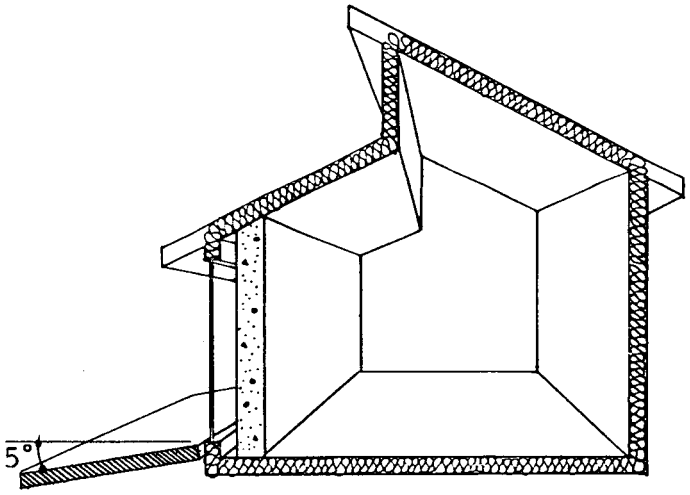


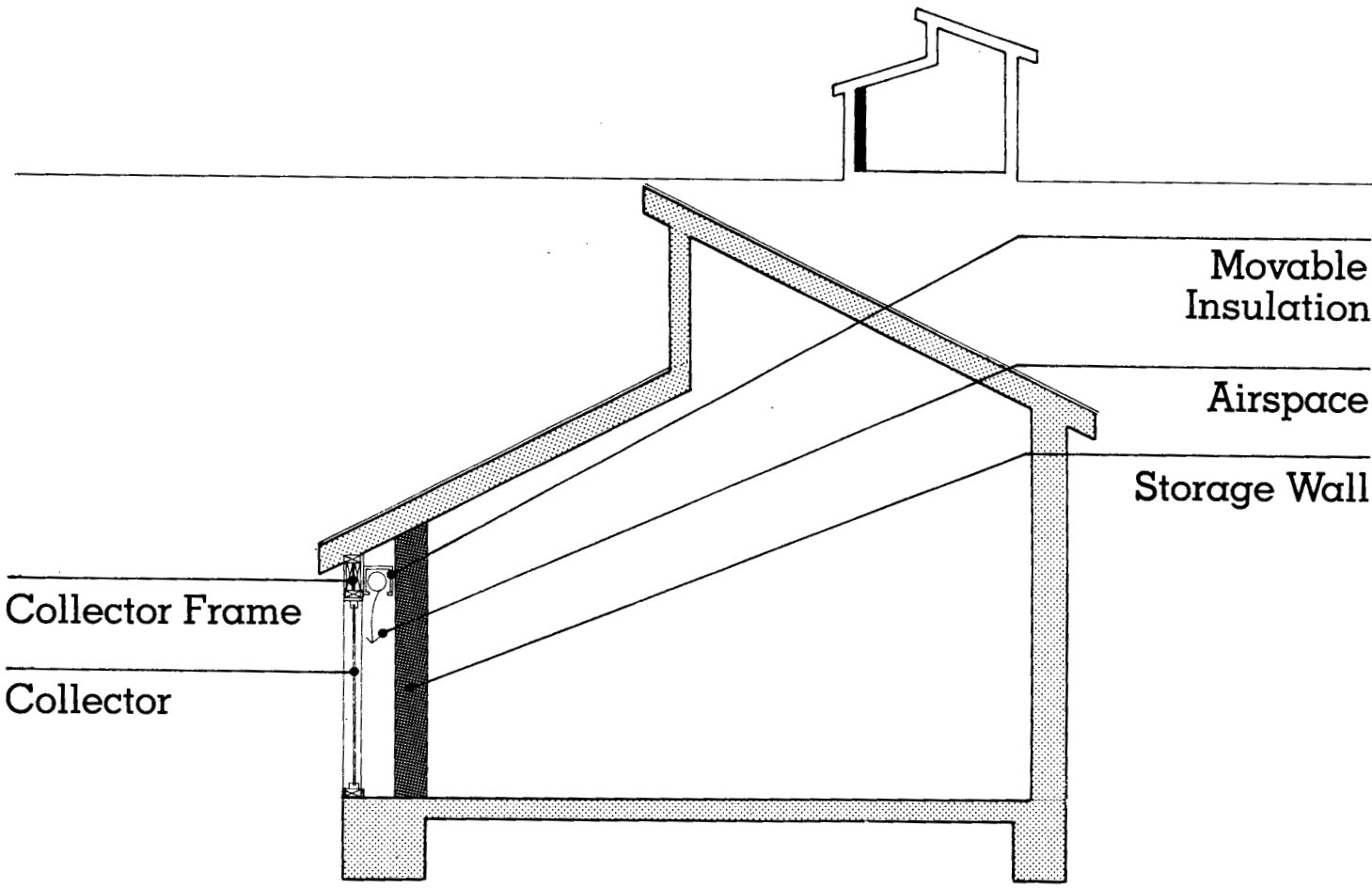
Figure 3.31

- Sizing:
  The reflector should be the same length as the collector and roughly twice as wide as the collector is high.

Thermal Storage Wall
Collector Component
Collector Detached From Wall

3.2100

Key



Index to Details

CONNECTION DETAIL AT:	
CMU/CMU Composite Wall	3.2200 thru 3.2210
CMU Cavity Wall	3.2224 thru 3.2234
Single Wythe CMU Wall	3.2248 thru 3.2258
Concrete Wall	3.2272 thru 3.2282
Brick/CMU Composite Wall	3.2296 thru 3.2306
Brick Cavity Wall	3.2320 thru 3.2330
Solid Brick Wall	3.2344 thru 3.2354

Thermal Storage Wall
Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

o Operable glazing units may be specified to allow for venting of the Thermal Storage Wall during the cooling season. Operable units of this type should be equipped with demountable insect screens which can be removed during the heating season.

o It is generally recommended that the collector unit be demountable or externally operable to aid in maintenance and cleaning. For further discussion of collector operation see Section 4.1200.

COLLECTOR FRAME

o The collector frame is the overall supporting system for the glazing units. The frame is detached from the masonry wall and is designed to support the glazing, glazing frame (if preframed), roof and other related loads.

o Wood is generally recommended for the collector frame. Where applicable the wood should be pressure-treated.

o Framing members should be kept to a minimum as they reduce the effective collector area and may cast shadows, both of which will affect the thermal performance of the wall.

COLLECTOR

o Double glazing is generally recommended to ensure optimum thermal performance. A 1/2" airspace between the glazing layers is recommended where feasible.

o The glazing material can be glass or plastic. For specific material information see Section 4.1100.

o Glazing units can be preframed or unframed. In either case the units specified will be incorporated into and supported by the collector frame. For further information on glazing frames see Section 4.1200.

MOVABLE INSULATION

o Movable insulation to reduce nighttime heat loss during the heating season and daytime heat gain during the cooling season may be installed in the airspace. Prior to detailing the collector component assembly, the insulation manufacturer's specifications should be consulted to ensure adequate space has been provided for proper installation and operation.

AIRSPACE

o It is recommended that the airspace between the glazing and the storage mass be a minimum of 3/4" and a maximum of 6" to avoid excessive heat loss.

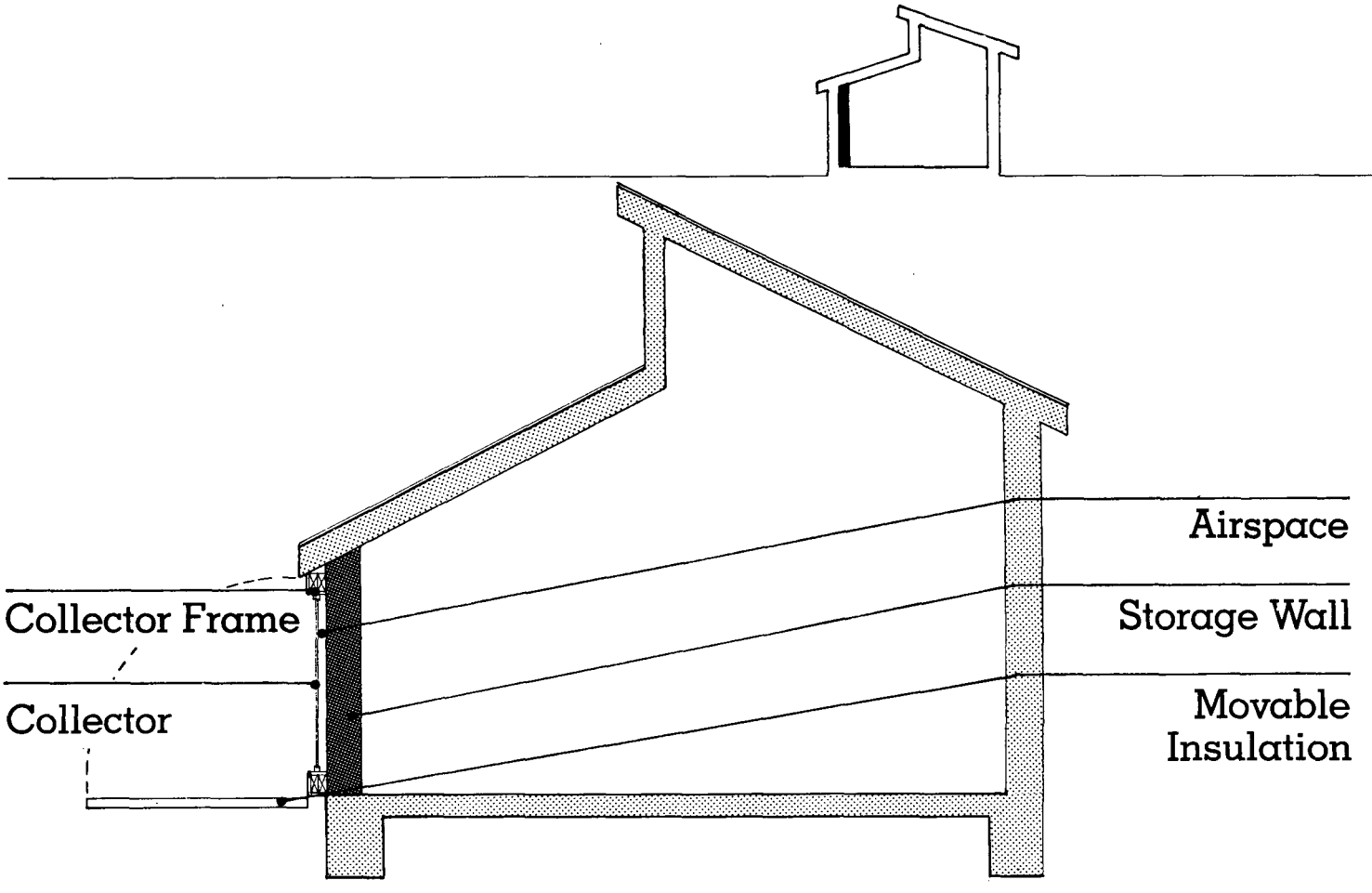
STORAGE WALL

o For specific information on storage wall materials and configurations see Key Pages 3.2120 and following.

Thermal Storage Wall
Collector Component
Collector Attached To Wall

3.2102

Key



Index to Details

CONNECTION DETAIL AT:

CMU/CMU Composite Wall	3.2212 thru 3.2222
CMU Cavity Wall	3.2236 thru 3.2246
Single Wythe CMU Wall	3.2260 thru 3.2270
Concrete Wall	3.2284 thru 3.2294
Brick/CMU Composite Wall	3.2308 thru 3.2318
Brick Cavity Wall	3.2332 thru 3.2342
Solid Brick Wall	3.2356 thru 3.2366

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

o Operable glazing units may be specified to allow for venting of the Thermal Storage Wall during the cooling season. Operable units of this type should be equipped with demountable insect screens which can be removed during the heating season.

o It is generally recommended that the collector unit be demountable or externally operable to aid in maintenance and cleaning. For further discussion of collector operation see Section 4.1200.

COLLECTOR FRAME

o The collector frame is the overall supporting system for the glazing units. The frame is attached to and supported by the masonry wall.

o Wood is generally recommended for the collector frame. Where applicable the wood should be pressure-treated. 2x framing members bolted to the masonry wall will also serve as spacers ensuring adequate airspace.

o Frame should be continuous at edges but discontinuous elsewhere, allowing for free circulation of air behind the collector.

o Framing members should be kept to a minimum as they reduce the effective collector area and may cast shadows, both of which affect the thermal performance of the wall.

COLLECTOR

o Double glazing is generally recommended to ensure optimum thermal performance. A 1/2" airspace between the glazing layers is recommended where feasible.

o The glazing material can be glass or plastic. For specific material information see Section 4.1100.

o Glazing units can be preframed or unframed. In either case the units specified will be incorporated into and supported by the collector frame. For further information on glazing frames see Section 4.1200.

AIRSPACE

o It is recommended that the airspace between the glazing and the storage mass be a minimum of 3/4" and a maximum of 6" to avoid excessive heat loss.

STORAGE WALL

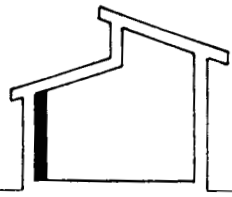
o For specific information on storage wall materials and configurations see Key Pages 3.2120 and following.

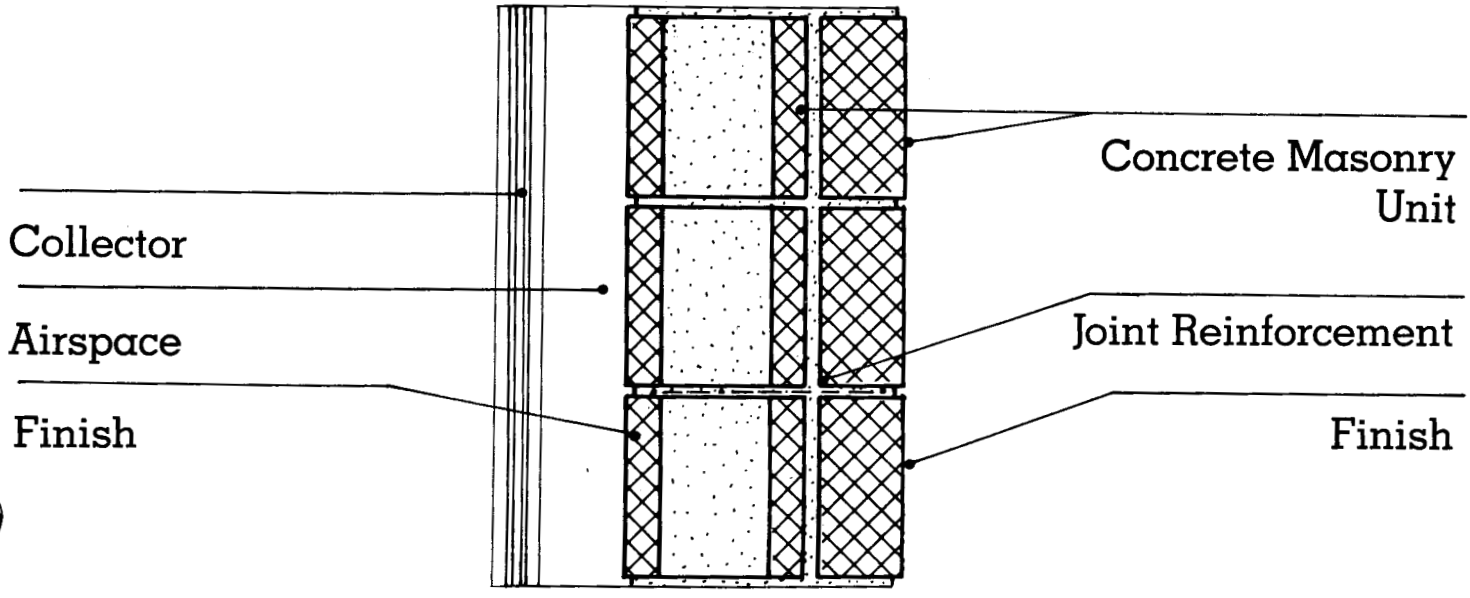
MOVABLE INSULATION

o Due to the limited amount of space between the storage wall and the collector in this configuration, movable insulation to reduce nighttime heat loss during the heating season and daytime heat gain during the cooling season may not fit within the airspace and may need to be placed on the exterior of the collector. Insulating shutters and panels can be used. Care must be taken to ensure a tight fit between this insulation and the collector to reduce heat loss at the panel or shutter edges.

Thermal Storage Wall
Storage Component
CMU/CMU Composite Wall

3.2120
Key





Index to Details

CONNECTION DETAIL AT:	Collector Detached from Wall	Collector Attached to Wall
Concrete Slab-On-Grade	3.2200	3.2212
Wood First Floor	3.2202	3.2214
Direct Gain Window	3.2204	3.2216
Wood Upper Floor	3.2206	3.2218
Wood Upper Floor Overhang	3.2208	3.2220
Roof	3.2210	3.2222

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

o The surfaces of the wall should be covered with clear plastic for one week to allow the wall to outgas properly prior to glazing.

o Thicknesses of individual wythes can vary. For information on recommended composite wall thickness see Section 3.2000.

o It is recommended that wythes be laid simultaneously. The first wythe laid is parged (backplastered) with mortar not less than 3/8" thick before the adjacent wythe is laid.

o Openings in masonry walls may be spanned by arches, steel angle lintels, or reinforced masonry lintels (constructed using standard and/or special-shaped masonry units, mortar, grout, and reinforcing steel). Specifications for all three should conform to local building code reuirements depending on load, span, and type of wall construction.

COLLECTOR

o Collector can be an independent, free-standing component, or it can be attached directly to the storage wall.

o For specific information, see Key Pages 3.2100 and 3.2102.

AIRSPACE

o It is generally recommended that the airspace between the storage and collector components be a minimum of 3/4" and a maximum of 6" to ensure optimum performance of the thermal storage wall system. For specific information on airspace requirements and restrictions, see Key Pages 3.2100 and 3.2102.

o If movable insulation is installed within the airspace sufficient space should be provided to allow for proper installation, operation and maintenance.

FINISH - Exterior

o For optimum thermal performance masonry exposed to solar radiation should be a dark color and left exposed wherever feasible. A slurry mix of Portland cement and sand can be used as a finish and will not affect the thermal performance of the wall. Particular colors can be specified from the masonry manufacturer, or the masonry/slurry can be stained or painted. For further information on finishes and their effect on thermal performance, see Sections 3.2000 and 4.2100.

CONCRETE MASONRY UNIT

o Concrete block, concrete brick or architectural facing units such as split, slump, fluted, scored or recessed block may be used for thermal storage. To ensure optimum thermal performance, units must be solid or hollow with grout-filled cores. For further material information see Section 4.2100. For recommended thicknesses see Section 3.2000.

JOINT REINFORCEMENT

o Joint reinforcement should be provided to control cracking caused by thermal movement and shrinkage. Truss, ladder, or x-tie configurations are suitable and can be embedded in the wall at vertical intervals per local code requirements or industry recommendations. Splices in the reinforcing should be lapped a minimum of 6" and the width of the reinforcement should be 2" less than the nominal width of the storage wall.

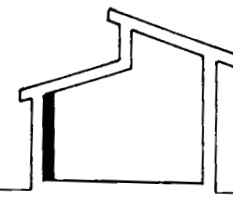
o An alternate technique (not shown) is to lay CMU stretcher units transversely to overlay specially shaped CMU header units. Care should be taken in this technique to maintain a continuous mortar bond between the header and stretcher units.

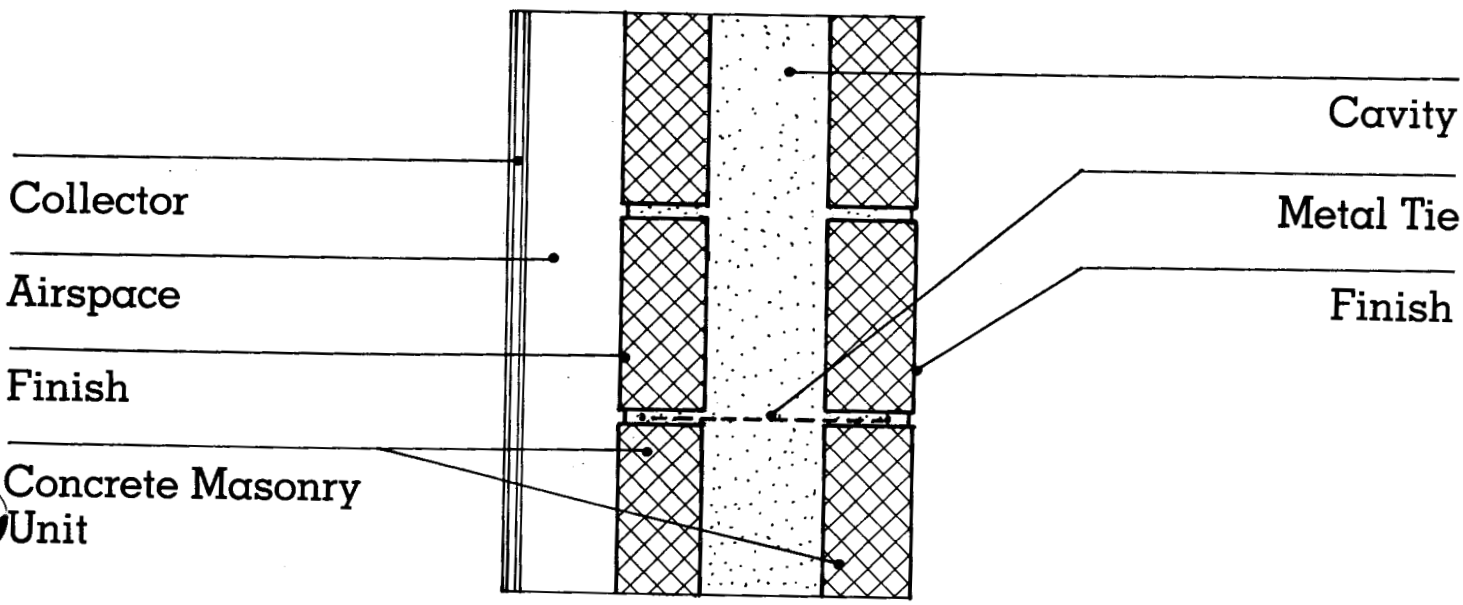
FINISH - Interior

o For optimum thermal performance masonry should be left exposed wherever feasible. Certain finishes (e.g. plaster and gypsum board) can be acceptable if properly applied. Particular colors can also be specified from the manufacturer or the masonry can be stained or painted. For further information on finishes and their effect on thermal performance see Sections 3.2000 and 4.2100.

Thermal Storage Wall
Storage Component
CMU/Cavity Wall

3.2122
Key





Index to Details

CONNECTION DETAIL AT:	Collector Detached from Wall	Collector Attached to Wall
Concrete Slab-On-Grade	3.2224	3.2236
Wood First Floor	3.2226	3.2238
Direct Gain Window	3.2228	3.2240
Wood Upper Floor	3.2230	3.2242
Wood Upper Floor Overhang	3.2232	3.2244
Roof	3.2234	3.2246

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

o The surfaces of the wall should be covered with clear plastic for one week to allow the wall to outgas properly prior to glazing.

o For recommended specifications for non-structural grout see Appendix E or Section 4.2100.

COLLECTOR

o Collector can be an independent, free-standing component, or it can be attached directly to the storage wall.

o For specific information, see Key Pages 3.2100 and 3.2102.

AIRSPACE

o It is generally recommended that the airspace between the storage and collector components be a minimum of 3/4" and a maximum of 6" to ensure optimum performance of the thermal storage wall system. For specific information on airspace requirements and restrictions, see Key Pages 3.2100 and 3.2102.

o If movable insulation is installed within the airspace sufficient space should be provided to allow for proper installation, operation and maintenance.

FINISH - Exterior

o For optimum thermal performance masonry exposed to solar radiation should be a dark color and left exposed wherever feasible. A slurry mix of Portland cement and sand can be used as a finish and will not affect the thermal performance of the wall. Particular colors can be specified from the masonry manufacturer, or the masonry/slurry can be stained or painted. For further information on finishes and their effect on thermal performance, see Sections 3.2000 and 4.2100.

CONCRETE MASONRY UNIT

o Concrete block, concrete brick or architectural facing units such as split, slump, fluted, scored or recessed block may be used for thermal storage. To ensure optimum thermal performance, units must be solid or hollow with grout-filled cores. For further material information see Section 4.2100. For recommended thicknesses see Section 3.2000.

CAVITY

o It is generally recommended that the cavity be 2" to 4 1/2" in width. The cavity must be filled solid in order to ensure proper thermal performance. The cavity may be filled with grout or other suitable materials. A curing period of not less than three days is recommended before filling the cavity with grout. This is necessary to prevent "blow-outs" caused by fluid pressure from the grout.

METAL TIE

o Adjacent wythes must be tied together. Use of 3/16" corrosion-resistant steel ties or metal tie wire of equivalent stiffness, embedded in the horizontal mortar joints, is generally recommended. Use one tie for each 4 1/2 square feet of wall area. Where the cavity is more than 3 1/2" use one tie for each 3 square feet of wall area. The maximum vertical distance between ties should not exceed 36". Individual ties in alternate courses should be staggered.

o Continuous horizontal wall ties (joint reinforcement) of either truss or ladder type may be used instead of individual metal ties. Individual lengths of reinforcement should be lapped at least 6" to provide continuity. Vertical spacing of joint reinforcement at 8", 16", or 24" is recommended, depending on length and height of wall and the number of openings.

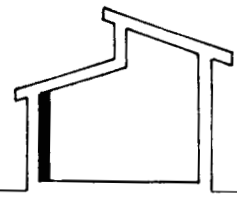
o Metal ties or joint reinforcement should be of sufficient strength to resist "blow-out" due to fluid pressure of grout when filling cavity.

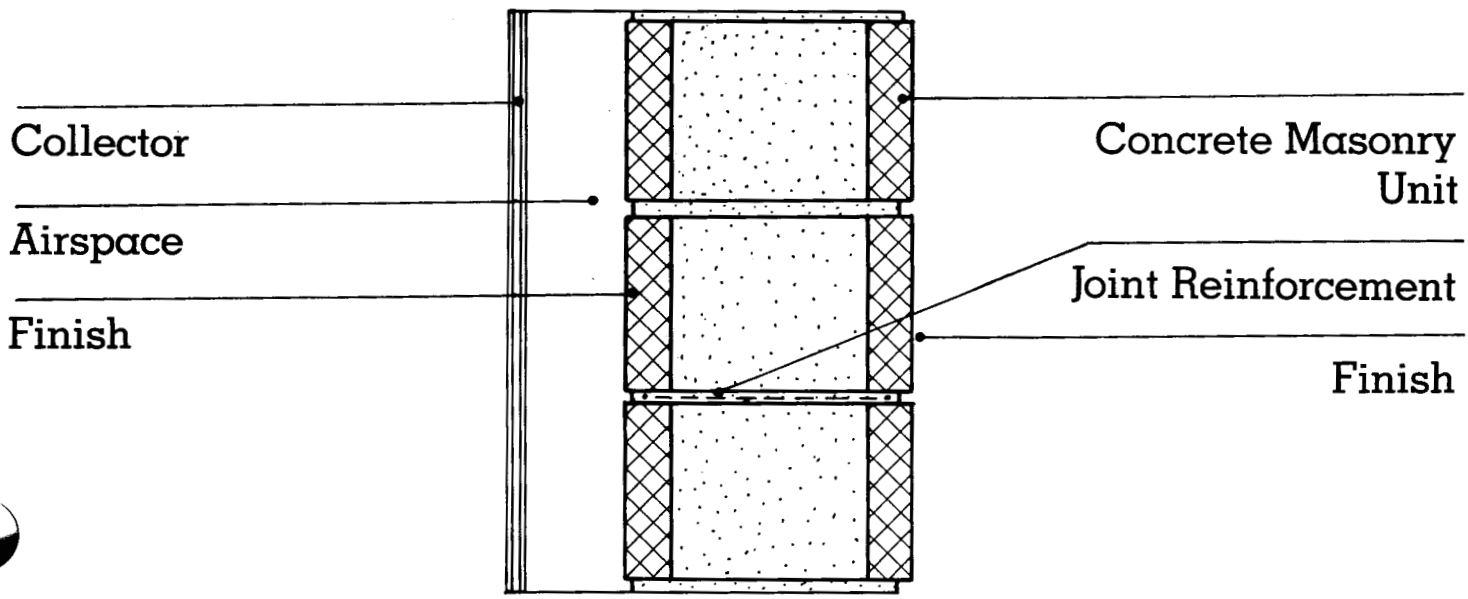
FINISH - Interior

o For optimum thermal performance masonry should be left exposed wherever feasible. Certain finishes (e.g. plaster and gypsum board) can be acceptable if properly applied. Particular colors can also be specified from the manufacturer or the masonry can be stained or painted. For further information on finishes see Sections 3.2000 and 4.2100.

Thermal Storage Wall
Storage Component
Single Wythe CMU Wall

3.2124
Key





Index to Details

CONNECTION DETAIL AT:	Collector Detached from Wall	Collector Attached to Wall
Concrete Slab-On-Grade	3.2248	3.2260
Wood First Floor	3.2250	3.2262
Direct Gain Window	3.2252	3.2264
Wood Upper Floor	3.2254	3.2266
Wood Upper Floor Overhang	3.2256	3.2268
Roof	3.2258	3.2270

Thermal Storage Wall
Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

o The surfaces of the wall should be covered with clear plastic for one week to allow the wall to outgas properly prior to glazing.

o Single wythe concrete masonry units may be built with conventional mortar joints or may be surface bonded. For further information on surface bonding see Section 4.2100.

o Openings in masonry walls may be spanned by arches, steel angle lintels, or reinforced masonry lintels (constructed using standard and/or special-shaped masonry units, mortar, grout, and reinforcing steel). Specifications for all three should conform to local building code requirements depending on load, span, and type of wall construction.

COLLECTOR

o Collector can be an independent, free-standing component, or it can be attached directly to the storage wall.

o For specific information, see Key Pages 3.2100 and 3.2102.

AIRSPACE

o It is generally recommended that the airspace between the storage and collector components be a minimum of 3/4" and a maximum of 6" to ensure optimum performance of the thermal storage wall system. For specific information on airspace requirements and restrictions, see Key Pages 3.2100 and 3.2102.

o If movable insulation is installed within the airspace sufficient space should be provided to allow for proper installation, operation and maintenance.

FINISH - Exterior

o For optimum thermal performance masonry exposed to solar radiation should be a dark color and left exposed wherever feasible. A slurry mix of Portland cement and sand can be used as a finish and will not affect the thermal performance of the wall. Particular colors can be specified from the masonry manufacturer, or the masonry/slurry can be stained or painted. For further information on finishes and their effect on thermal performance, see Sections 3.2000 and 4.2100.

CONCRETE MASONRY UNIT

o Concrete block, concrete brick or architectural facing units such as split, slump, fluted, scored or recessed block may be used for thermal storage. To ensure optimum thermal performance, units must be solid or hollow with grout-filled cores. For further material information see Section 4.2100. For recommended thicknesses see Section 3.2000.

JOINT REINFORCEMENT

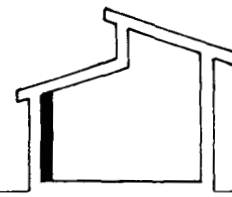
o Joint reinforcement should be provided to control cracking caused by thermal movement and shrinkage. Truss, ladder, or x-tie configurations are suitable and can be embedded in the wall at vertical intervals per local code requirements or industry recommendations. Splices in reinforcing should be lapped a minimum of 6" and the width of the reinforcement should be 2" less than the nominal width of storage wall.

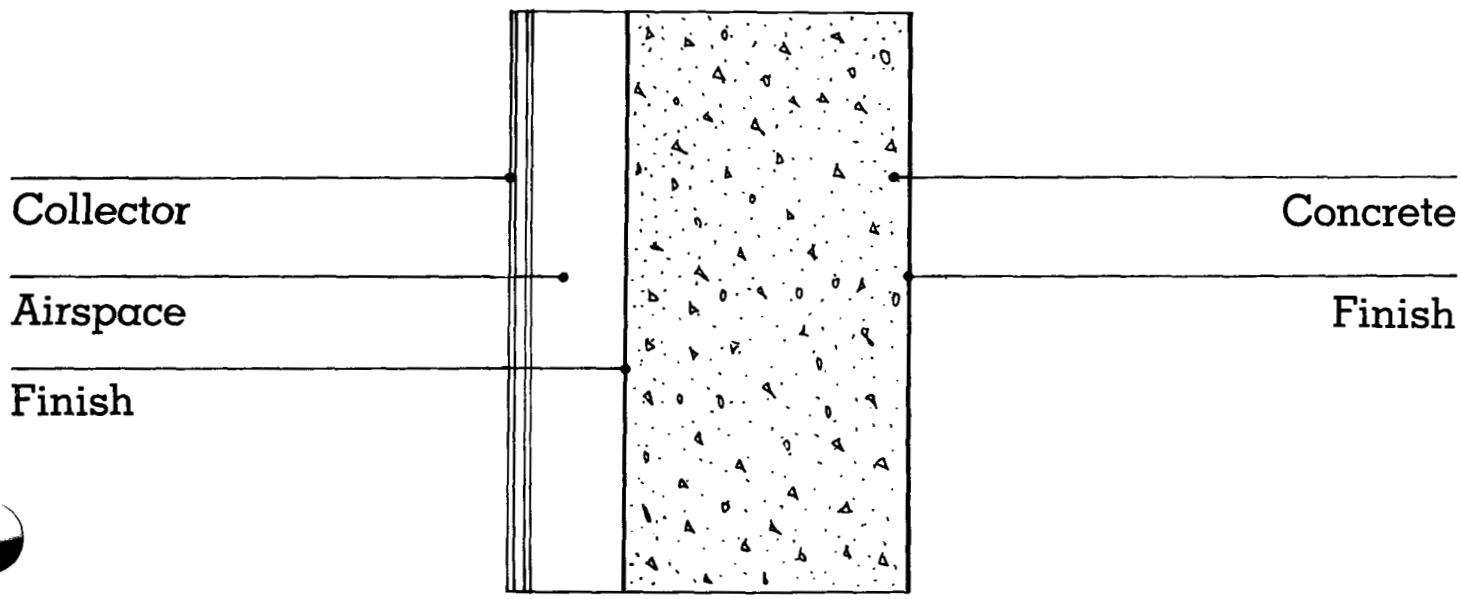
FINISH - Interior

o For optimum thermal performance masonry should be left exposed wherever feasible. Certain finishes (e.g. plaster and gypsum board) can be acceptable if properly applied. Particular colors can also be specified from the manufacturer or the masonry can be stained or painted. For further information on finishes and their effect on thermal performance see Sections 3.2000 and 4.2100.

Thermal Storage Wall
Storage Component
Concrete Wall

3.2126
Key





Index to Details

CONNECTION DETAIL AT:	Collector Detached from Wall	Collector Attached to Wall
Concrete Slab-On-Grade	3.2272	3.2284
Wood First Floor	3.2274	3.2286
Direct Gain Window	3.2276	3.2288
Wood Upper Floor	3.2278	3.2290
Wood Upper Floor Overhang	3.2280	3.2292
Roof	3.2282	3.2294

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

o The surfaces of the wall should be covered with clear plastic for one week to allow the wall to outgas properly prior to glazing.

o Openings in masonry walls may be spanned by arches, steel angle lintels, or reinforced concrete lintels. Specifications for all three should conform to local building code requirements depending on load, span, and type of wall construction.

COLLECTOR

o Collector can be an independent, free-standing component, or it can be attached directly to the storage wall.

o For specific information, see Key Pages 3.2100 and 3.2102.

AIRSPACE

o It is generally recommended that the airspace between the storage and collector components be a minimum of 3/4" and a maximum of 6" to ensure optimum performance of the thermal storage wall system. For specific information on airspace requirements and restrictions, see Key Pages 3.2100 and 3.2102.

o If movable insulation is installed within the airspace, sufficient space should be provided to allow for proper installation, operation and maintenance.

FINISH - Exterior

o For optimum thermal performance concrete should be a dark color and left exposed wherever feasible. Particular colors can be specified from the supplier or the concrete can be stained or painted. For further information on finishes and their effect on thermal performance, see Sections 3.2000 and 4.2200.

CONCRETE

o The use of normal weight concrete (140-150 lb.) is generally recommended. Placement of formwork and pouring of concrete should follow standard practice and/or local building codes. For further information see Section 4.2200. For recommended material thicknesses see Section 3.2000.

FINISH - Interior

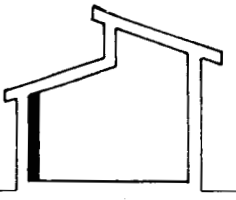
o For optimum thermal performance concrete should be left exposed wherever feasible. Textured finishes can be obtained using standard construction practice without significant impact on thermal performance.

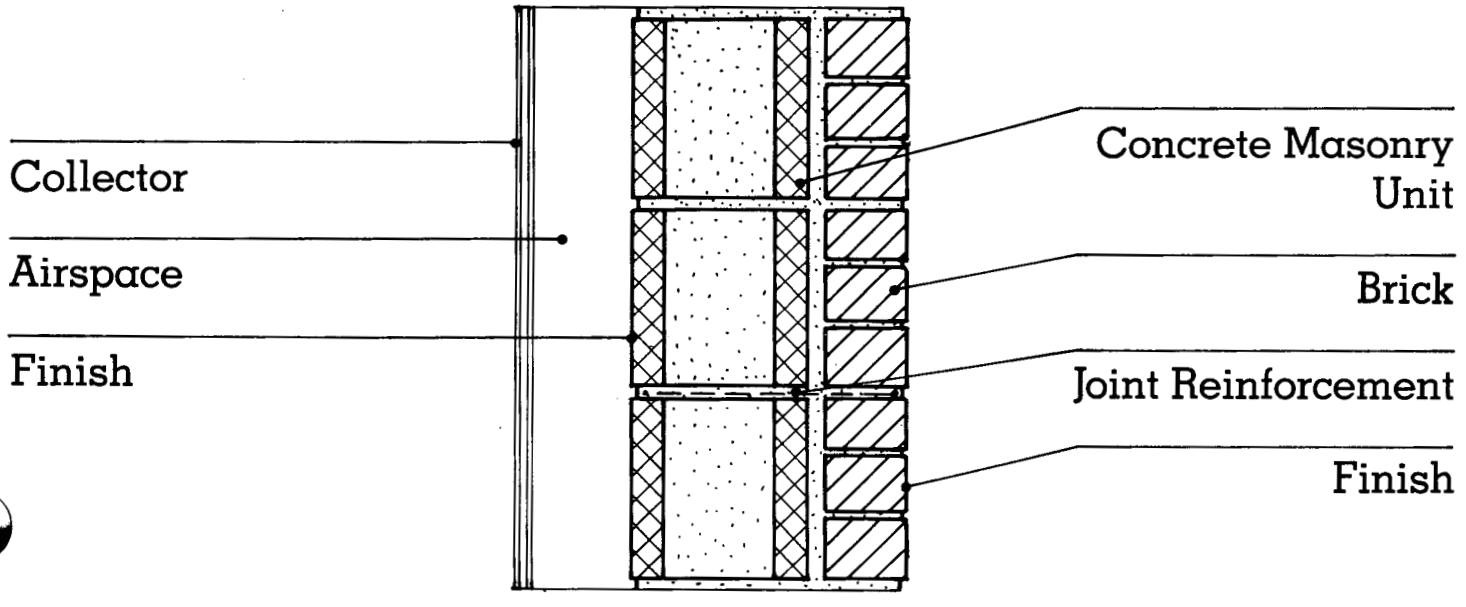
o Certain finishes (e.g. plaster and gypsum board) can be acceptable if properly applied. Particular colors can also be specified from the supplier or the concrete can be stained or painted. For further information on finishes and their effect on thermal performance see Sections 3.2000 and 4.2200.

Thermal Storage Wall

Storage Component
Brick/CMU Composite Wall

3.2128
Key





Index to Details

CONNECTION DETAIL AT:	Collector Detached from Wall	Collector Attached to Wall
Concrete Slab-On-Grade	3.2296	3.2308
Wood First Floor	3.2298	3.2310
Direct Gain Window	3.2300	3.2312
Wood Upper Floor	3.2302	3.2314
Wood Upper Floor Overhang	3.2304	3.2316
Roof	3.2306	3.2318

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

o The surfaces of the wall should be covered with clear plastic for one week to allow the wall to outgas properly prior to glazing.

o Thicknesses of individual wythes can vary. For information on recommended composite wall thickness see Section 3.2000.

o It is recommended that wythes be laid simultaneously. The first wythe laid is parged (backplastered) with mortar not less than 3/8" thick before the adjacent wythe is laid.

o Openings in masonry walls may be spanned by arches, steel angle lintels, or reinforced masonry lintels (constructed using standard and/or special-shaped masonry units, mortar, grout, and reinforcing steel). Specifications for all three should conform to local building code requirements depending on load, span, and type of wall construction.

COLLECTOR

o Collector can be an independent, free-standing component, or it can be attached directly to the storage wall.

o For specific information, see Key Pages 3.2100 and 3.2102.

AIRSPACE

o It is generally recommended that the airspace between the storage and collector components be a minimum of 3/4" and a maximum of 6" to ensure optimum performance of the thermal storage wall system. For specific information on airspace requirements and restrictions, see Key Pages 3.2100 and 3.2102.

o If movable insulation is installed within the airspace sufficient space should be provided to allow for proper installation, operation and maintenance.

FINISH - Exterior

o For optimum thermal performance masonry exposed to solar radiation should be a dark color and left exposed wherever feasible. A slurry mix of Portland cement and sand can be used as a finish and will not affect the thermal performance of the wall. Particular colors can be specified from the masonry manufacturer, or the masonry/slurry can be stained or painted. For further information on finishes and their effects on thermal performance, see Sections 3.2000 and 4.2100.

CONCRETE MASONRY UNIT

o Concrete block, concrete brick or architectural facing units such as split, slump, fluted, scored or recessed block may be used for thermal storage. To ensure optimum thermal performance, units must be solid or hollow with grout-filled cores. For further material information see Section 4.2100. For recommended thicknesses see Section 3.2000.

BRICK

o Any of the wide variety of standard bricks are suitable for thermal storage. To ensure proper thermal performance bricks must be solid or hollow with grout-filled cores. For further material information see Section 4.2300. For recommended thicknesses see Section 3.2000.

JOINT REINFORCEMENT

o Joint reinforcement should be provided to control cracking caused by thermal movement and shrinkage. Truss, ladder, or x-tie configurations are suitable and can be embedded in the wall at vertical intervals per local code requirements or industry recommendations. Splices in the reinforcing should be lapped a minimum of 6" and the width of the reinforcement should be 2" less than the nominal width of the storage wall.

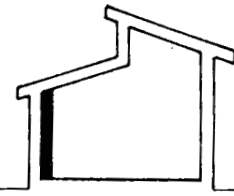
o An alternate technique (not shown) is to lay brick stretcher units transversely to overlay specially shaped CMU header units.

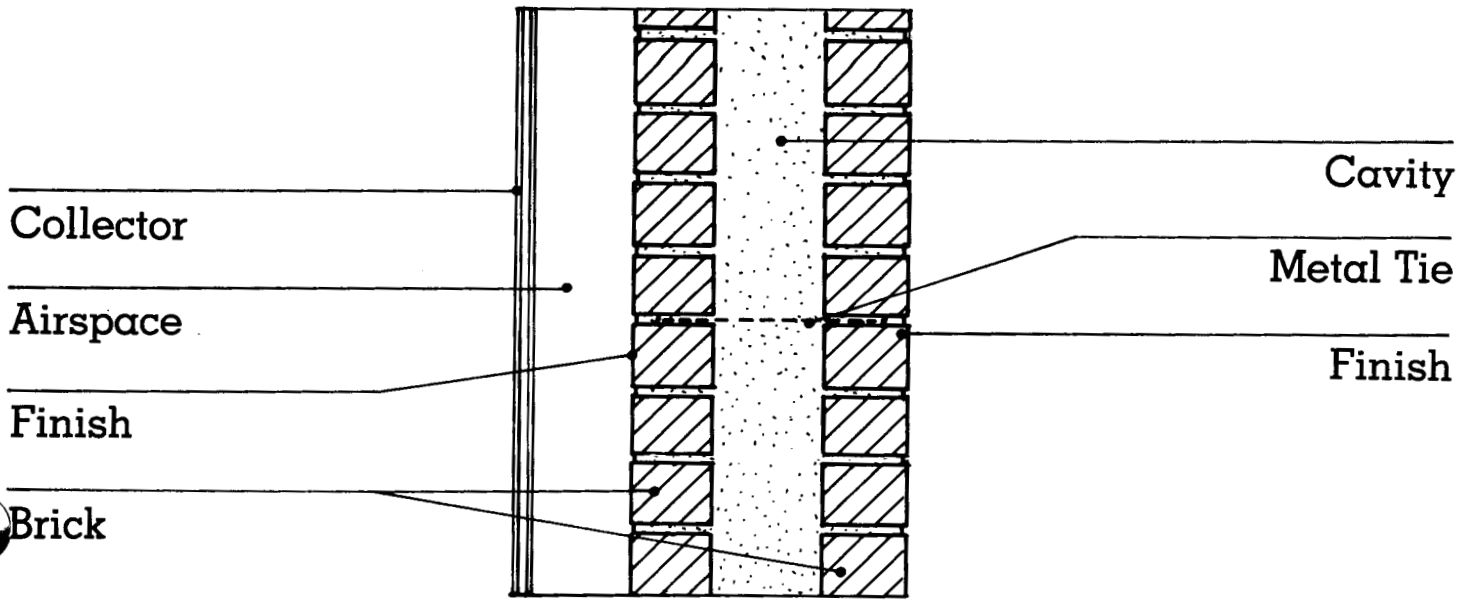
FINISH - Interior

o For optimum thermal performance masonry should be left exposed wherever feasible. Certain finishes (e.g. plaster and gypsum board) can be acceptable if properly applied. Particular colors can also be specified from the manufacturer or the masonry can be stained or painted. For further information on finishes and their effect on thermal performance see Sections 3.2000 and 4.2300.

Thermal Storage Wall
Storage Component
Brick Cavity Wall

3.2130
Key





Index to Details

CONNECTION DETAIL AT:	Collector Detached from Wall	Collector Attached to Wall
Concrete Slab-On-Grade	3.2320	3.2332
Wood First Floor	3.2322	3.2334
Direct Gain Window	3.2324	3.2336
Wood Upper Floor	3.2326	3.2338
Wood Upper Floor Overhang	3.2328	3.2340
Roof	3.2330	3.2342

GENERAL CONSTRUCTION
o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.
o The surfaces of the wall should be covered with clear plastic for one week to allow the wall to outgas properly prior to glazing.

COLLECTOR
o Collector can be an independent, free-standing component, or it can be attached directly to the storage wall.
o For specific information, see Key Pages 3.2100 and 3.2102.

AIRSPACE
o It is generally recommended that the airspace between the storage and collector components be a minimum of 3/4" and a maximum of 6" to ensure optimum performance of the thermal storage wall system. For specific information on airspace requirements and restrictions, see Key Pages 3.2100 and 3.2102.
o If movable insulation is installed within the airspace sufficient space should be provided to allow for proper installation, operation and maintenance.

FINISH - Exterior
o For optimum thermal performance brick exposed to solar radiation should be a dark color and left exposed wherever feasible. Particular colors can be specified from the manufacturer or the masonry can be stained or painted. For further information on finishes and their effect on thermal performance, see Sections 3.2000 and 4.2300.

BRICK
o Any of the wide variety of standard bricks are suitable for thermal storage. To ensure proper thermal performance bricks must be solid or hollow with grout-filled cores. For further material information see Section 4.2300. For recommended thicknesses see Section 3.2000.

CAVITY
o It is generally recommended that the cavity be 2" to 4 1/2" in width. The cavity must be filled solid in order to ensure proper thermal performance. The cavity may be filled with grout or other suitable materials. A curing period of not less than three days is recommended before filling the cavity with grout. This is necessary to prevent "blow-outs" caused by fluid pressure from the grout.
o In seismic areas it may be necessary to place reinforcing steel in the cavity before grouting.

METAL TIE
o Adjacent wythes must be tied together. Use of 3/16" corrosion-resistant steel ties or metal tie wire of equivalent stiffness, embedded in the horizontal mortar joints, is generally recommended. Use one tie for each 4 1/2 square feet of wall area. Where the cavity is more than 3 1/2" use one tie for each 3 square feet of wall area. The maximum vertical distance between ties should not exceed 36". Individual ties in alternate courses should be staggered.
o Continuous horizontal wall ties (joint reinforcement) of either truss or ladder type may be used instead of individual metal ties. Individual lengths of reinforcement should be lapped at least 6" to provide continuity. Vertical spacing of joint reinforcement at 8", 16", or 24" is recommended, depending on length and height of wall and the number of openings.
o Metal ties or joint reinforcement should be of sufficient strength to resist "blow-out" due to fluid pressure of grout when filling cavity.

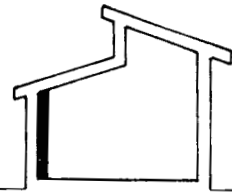
FINISH - Interior
o For optimum thermal performance masonry should be left exposed wherever feasible. Certain finishes (e.g. plaster and gypsum board) can be acceptable if properly applied. Particular colors can also be specified from the manufacturer or the masonry can be painted. For further information on finishes and their effect on thermal performance see Sections 3.2000 and 4.2300.

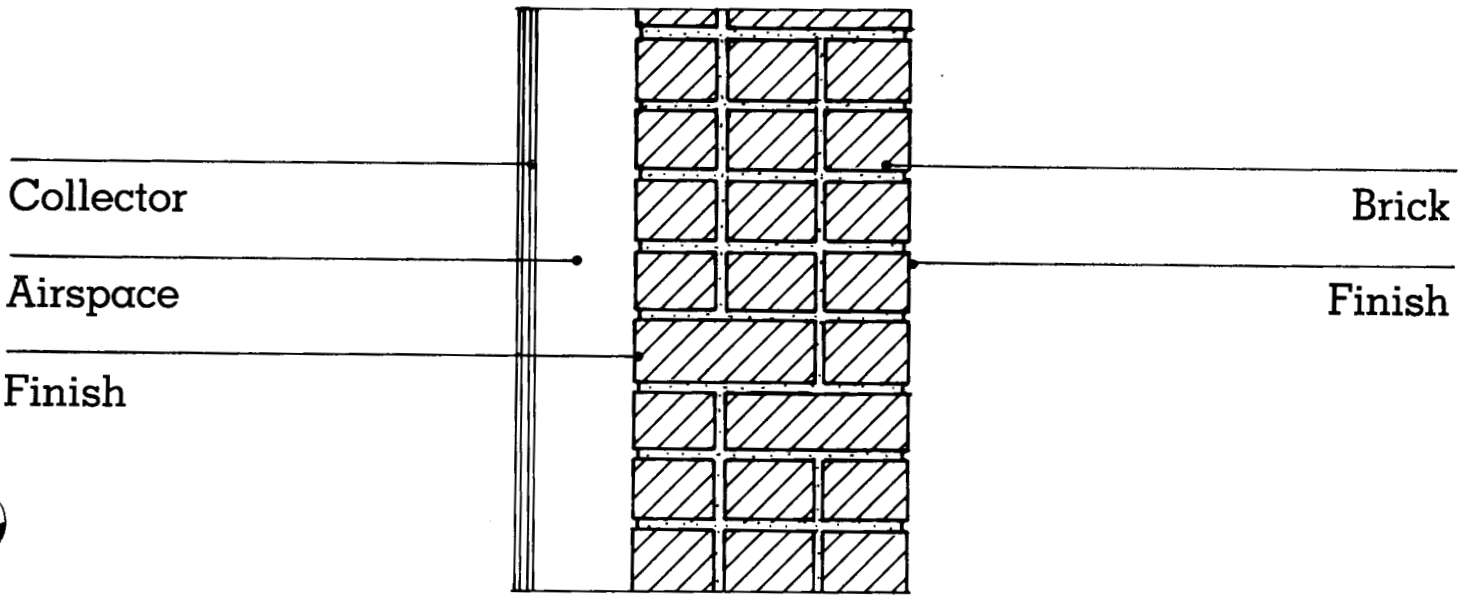
Thermal Storage Wall

Storage Component
Solid Brick Wall

3.2132

Key





Index to Details

	Collector Detached from Wall	Collector Attached to Wall
CONNECTION DETAIL AT:		
Concrete Slab-On-Grade	3.2344	3.2356
Wood First Floor	3.2346	3.2358
Direct Gain Window	3.2348	3.2360
Wood Upper Floor	3.2350	3.2362
Wood Upper Floor Overhang	3.2352	3.2364
Roof	3.2354	3.2366

Construction Notes

GENERAL CONSTRUCTION

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

o The surfaces of the wall should be covered with clear plastic for one week to allow the wall to outgas properly prior to glazing.

o Structural bonding of the wall may be accomplished by overlapping (interlocking) masonry units. The maximum vertical and horizontal distance between headers is generally recommended to be 24" subject to local code restrictions.

o Openings in brick walls may be spanned by arches, steel angle lintels, or reinforced brick lintels (constructed using standard and/or special-shaped brick units, mortar, grout, and reinforcing steel). Specifications for all three should conform to the Brick Institute of America recommendations and local building code requirements depending on load, span, and type of wall construction.

COLLECTOR

o Collector can be an independent, free-standing component, or it can be attached directly to the storage wall.

o For specific information, see Key Pages 3.2100 and 3.2102.

AIRSPACE

o It is generally recommended that the airspace between the storage and collector components be a minimum of 3/4" and a maximum of 6" to ensure optimum performance of the thermal storage wall system. For specific information on airspace requirements and restrictions, see Key pages 3.2100 and 3.2102.

o If movable insulation is installed within the airspace sufficient space should be provided to allow for proper installation, operation and maintenance.

FINISH - Exterior

o For optimum thermal performance masonry should be a dark color and left exposed wherever feasible. Particular colors can be specified from the manufacturer or the masonry can be stained or painted. For further information on finishes and their effect on thermal performance, see Sections 3.2000 and 4.2300.

BRICK

o Any of the wide variety of standard bricks are suitable for thermal storage. To ensure proper thermal performance bricks must be solid or hollow with grout-filled cores. For further material information see Section 4.2300. For recommended thicknesses see Section 3.2000.

o Through-the-wall units may also be specified for thermal storage. Such units are generally cored and must be fully grouted to ensure proper performance.

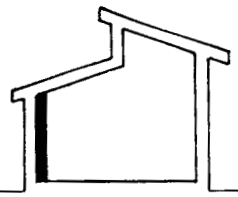
FINISH - Interior

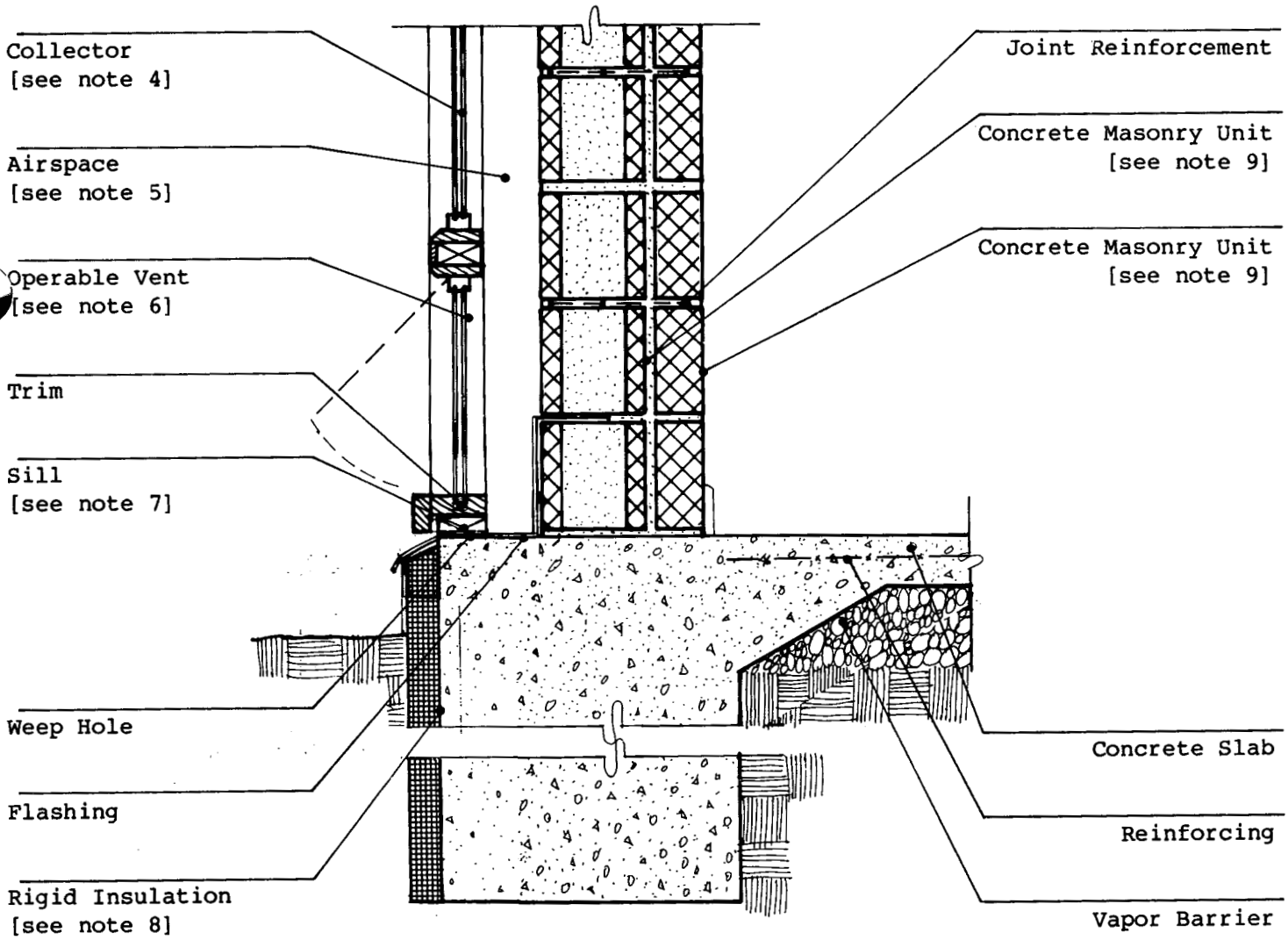
o For optimum thermal performance masonry should be left exposed wherever feasible. Certain finishes (e.g. plaster and gypsum board) can be acceptable if properly applied. Particular colors can also be specified from the manufacturer or the masonry can be stained or painted. For further information on finishes and their effect on thermal performance see Sections 3.2000 and 4.2300.

Thermal Storage Wall
CMU/CMU Composite Wall
Concrete Slab-On-Grade

3.2200

Detail





Thermal Storage Wall
Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code. Where ground water problems exist, provide sufficient granular fill at haunch to prevent water penetration at slab.

[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab is not recommended except where required by local conditions and/or code.

[3] Insulation levels at foundation/slab must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

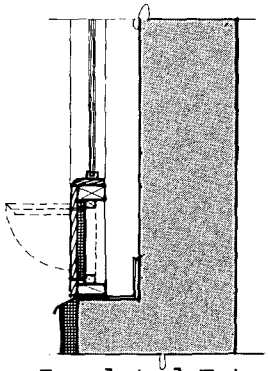
[5] Width of airspace may vary. For further information, see Key Page 3.2100.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. For more information, see Section 3.2000.

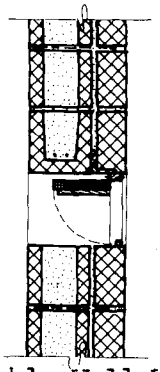
[7] Sill can be wood or masonry at builder's option. Pressure treating should be specified if lumber is used. Sill to foundation and collector frame to foundation connections must meet local building codes.

[8] Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

[9] Concrete Masonry facing and back-up units must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2120.



Opaque Insulated Exterior Vent

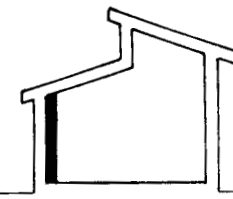


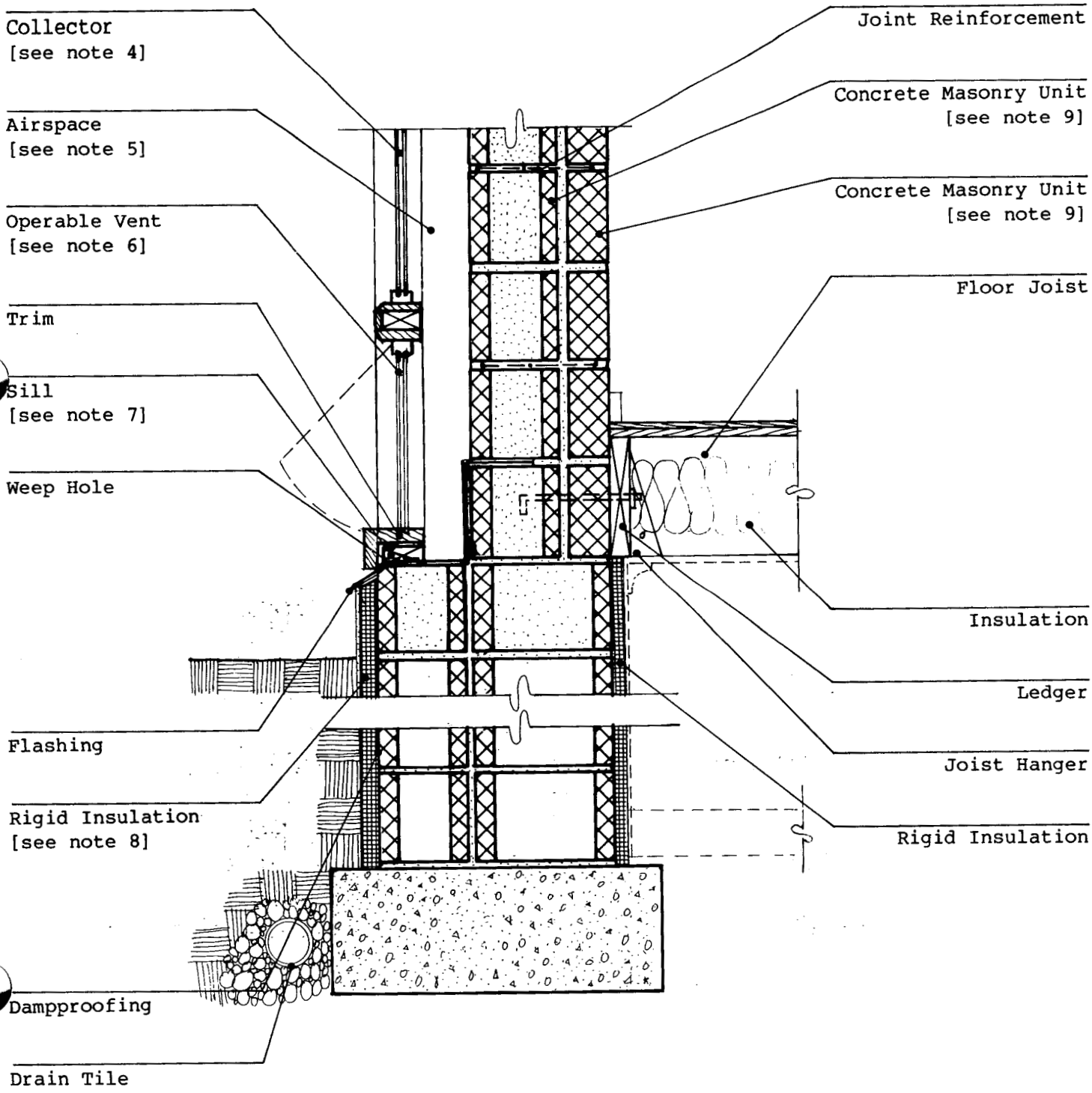
Operable Wall Vent

Thermal Storage Wall
CMU/CMU Composite Wall
Wood First Floor

3.2202

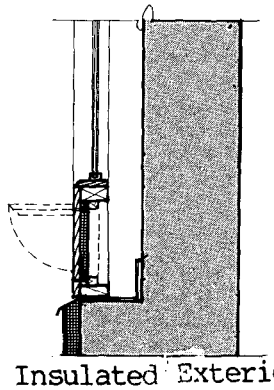
Detail



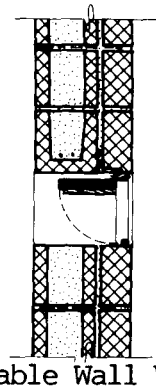


Thermal Storage Wall
Construction Notes

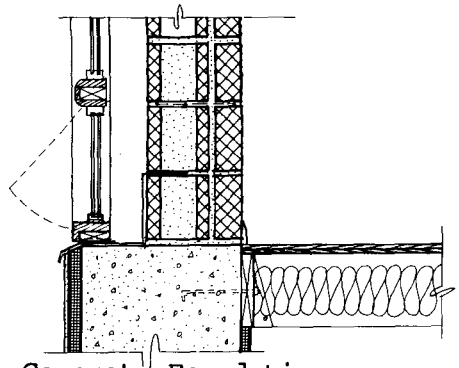
[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.
[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice.
[3] Insulation levels at floor must meet or exceed requirements of local building/ energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.
[5] Width of airspace may vary. For further information, see Key Page 3.2100.
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[7] Sill can be wood or masonry at builder's option. Pressure treating should be specified if lumber is used. Sill to foundation and collector frame to foundation connections must meet local building codes.
[8] It is recommended that the Thermal Storage Wall foundation be insulated on both sides to prevent heat losses to the outside and to the ground. In heated basements and heated crawl spaces insulation is not required on the inside. Insulation levels on both sides should be equal and should meet code requirements for foundation insulation. Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.
[9] Concrete Masonry facing and back-up units must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2120.



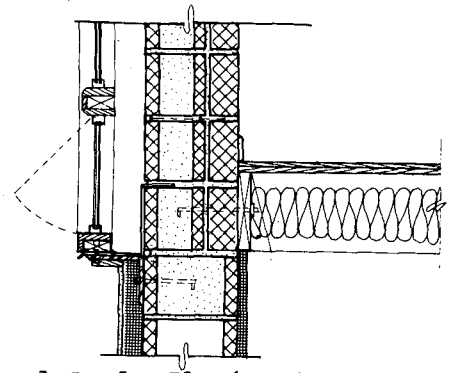
Opaque Insulated Exterior Vent



Operable Wall Vent



Concrete Foundation

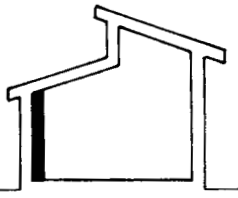


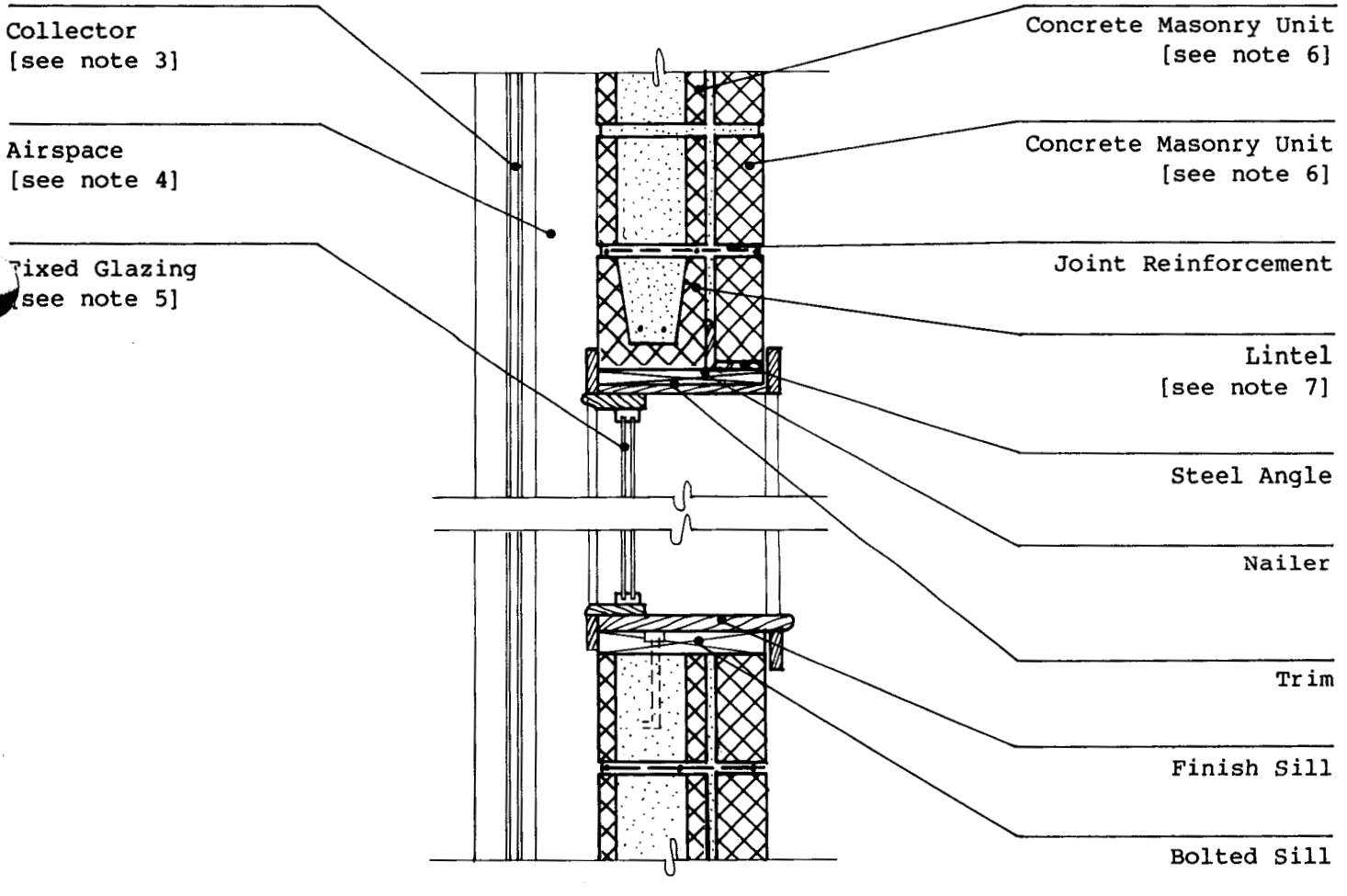
Steel Angle Glazing Support

Thermal Storage Wall
CMU/CMU Composite Wall
Direct Gain Window

3.2204

Detail





Construction Notes

[1] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice.

[2] The storage mass should not be insulated. For further information, see Section 3.2000.

[3] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

[4] Width of airspace may vary. For further information, see Key Page 3.2100.

[5] Conventional window for light, view and/or Direct Gain may be single or double glazed. For information on Direct Gain systems, see Section 3.1000.

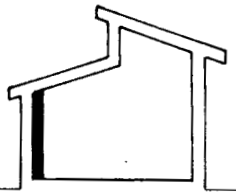
[6] Concrete Masonry facing and back-up units must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2120.

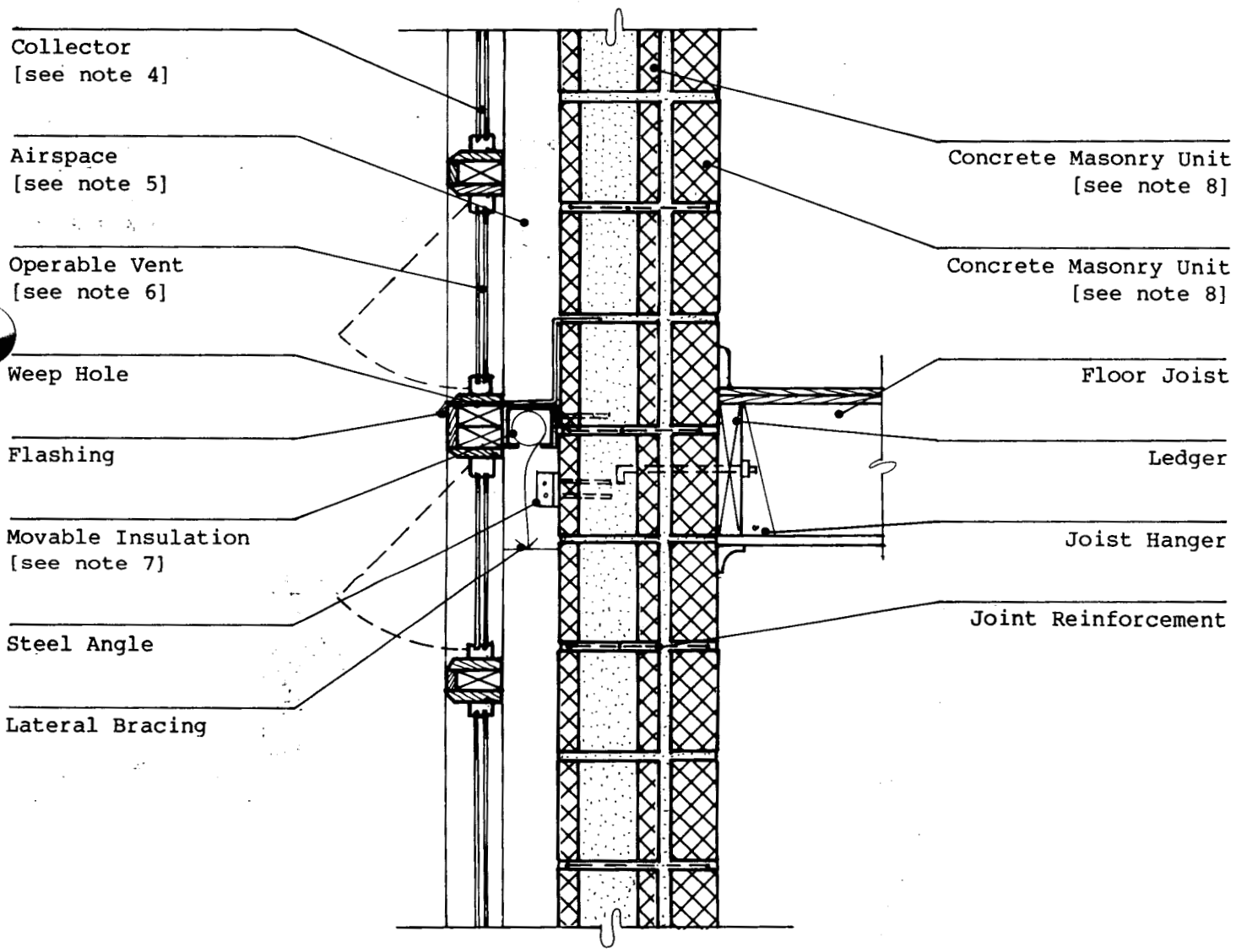
[7] Lintel may be bond-beam, lintel, standard Concrete Masonry units with depressed, cut-out or grooved webs, or precast concrete. Provide 6" minimum bearing at each end. Reinforcing designed for loading and clear span per local building codes and/or accepted practice. Facing unit is supported by steel angle.

Thermal Storage Wall
CMU/CMU Composite Wall
Wood Upper Floor

3.2206

Detail





Construction Notes

[1] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.

[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice.

[3] The storage mass should not be insulated. For further information, see Section 3.2000.

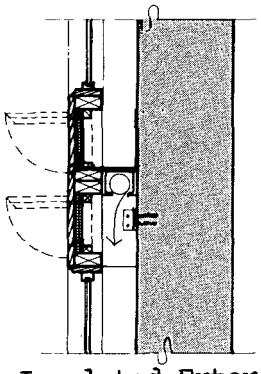
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

[5] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.

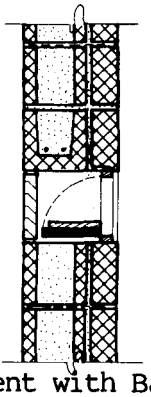
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Where airspace is not continuous, top and bottom vents should be provided for each section. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

[7] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. Where upper and lower portions of Thermal Storage Wall are separated, movable insulation must be installed in each section. For further information, see Sections 3.2000 and 4.4300.

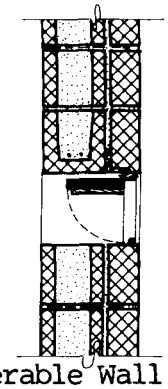
[8] Concrete Masonry facing and back-up units must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2120.



Opaque Insulated Exterior Vents



Operable Wall Vent with Backdraft Damper

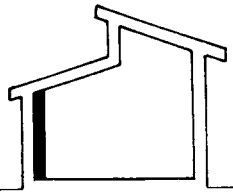


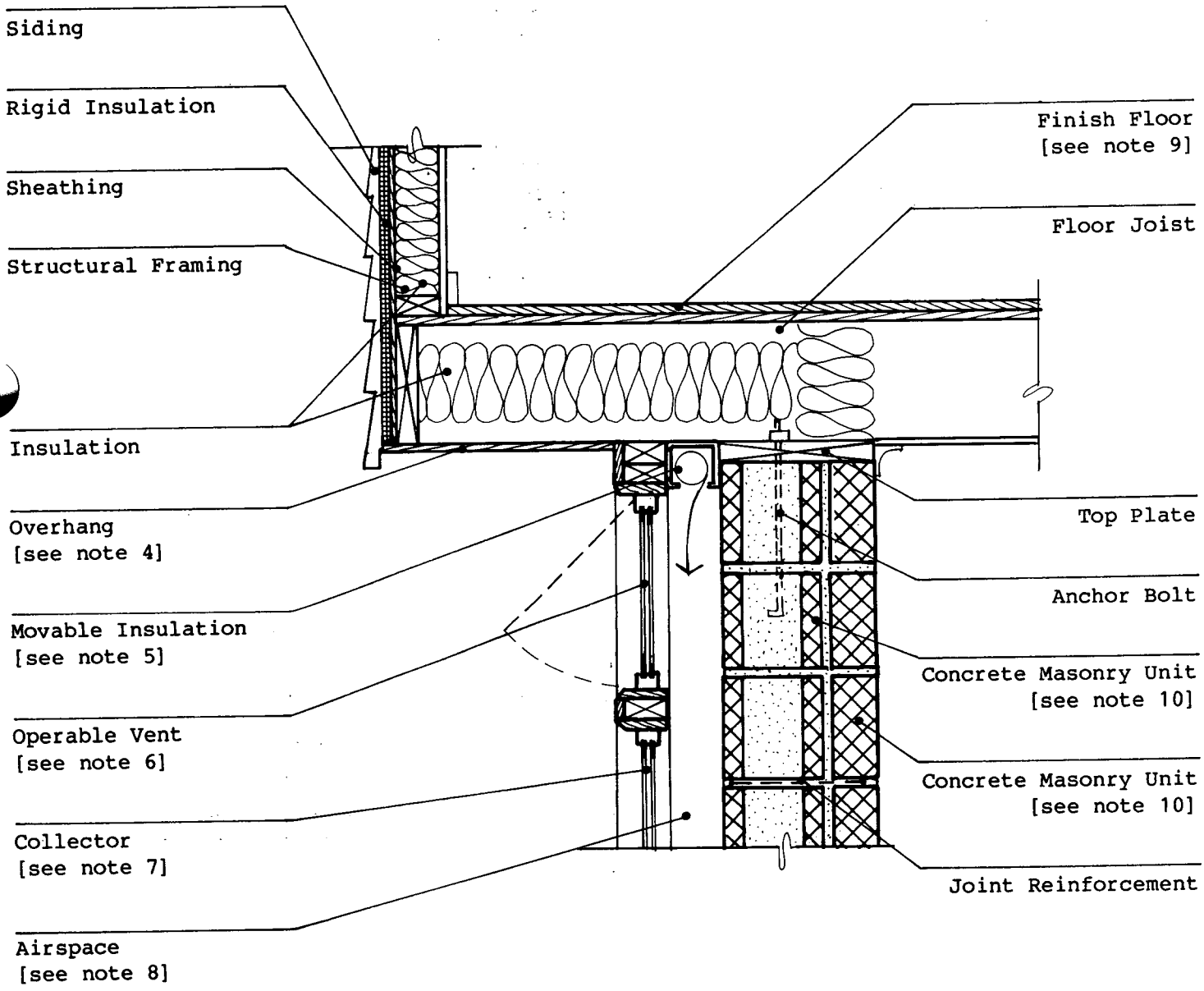
Operable Wall Vent

Thermal Storage Wall
CMU/CMU Composite Wall
Wood Upper Floor Overhang

3.2208

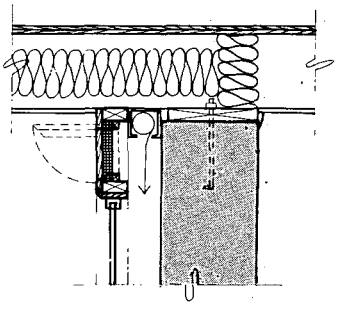
Detail



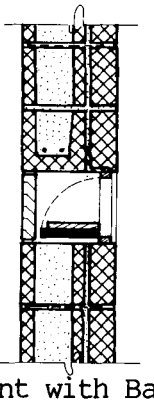


Construction Notes

[1] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.
[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.
[3] Insulation levels at frame wall and floor at overhang must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.
[5] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. For further information see Sections 3.2000 and 4.4300.
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[7] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.
[8] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.
[9] Direct Gain system may be incorporated into upper level design. For further information, see Section 3.1000.
[10] Concrete Masonry facing and back-up units must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2120.



Opaque Insulated Exterior Vent

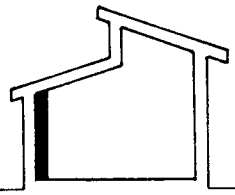


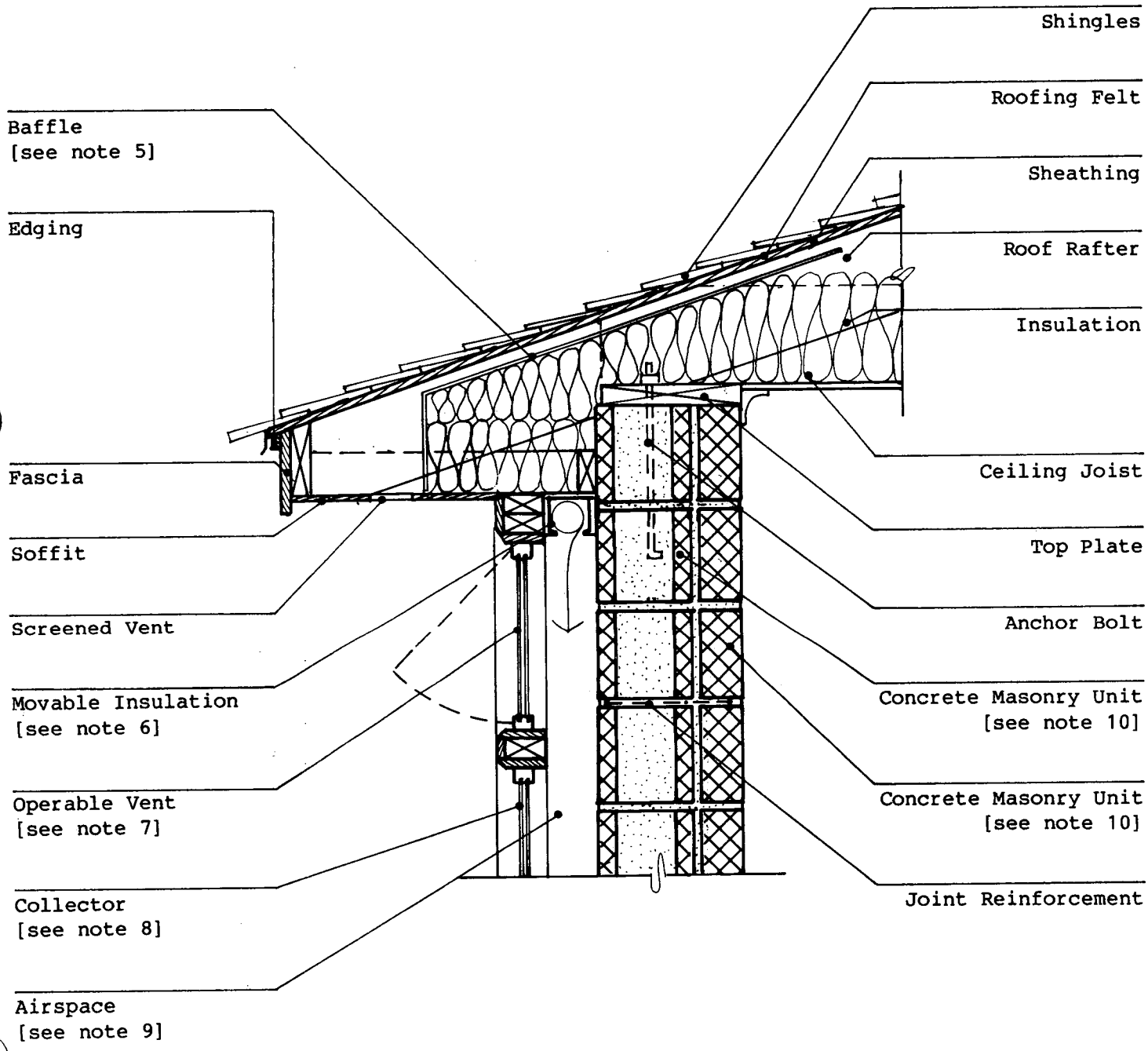
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
CMU/CMU Composite Wall
Roof

3.2210

Detail





[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections. Provide gutters and downspouts as required. Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.

[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.

[3] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.

[4] Insulation in ceiling must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[5] Provide baffles where necessary to maintain 1" minimum airspace for venting attic.

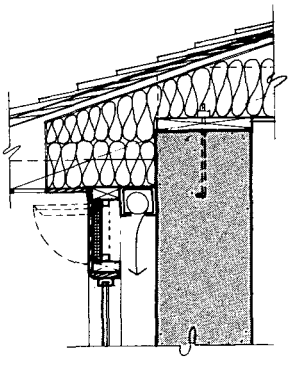
[6] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. For further information see Sections 3.2000 and 4.4300.

[7] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

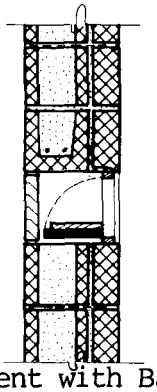
[8] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

[9] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.

[10] Concrete Masonry facing and back-up units must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2120.



Opaque Insulated Exterior Vent

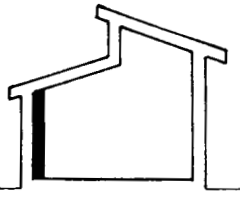


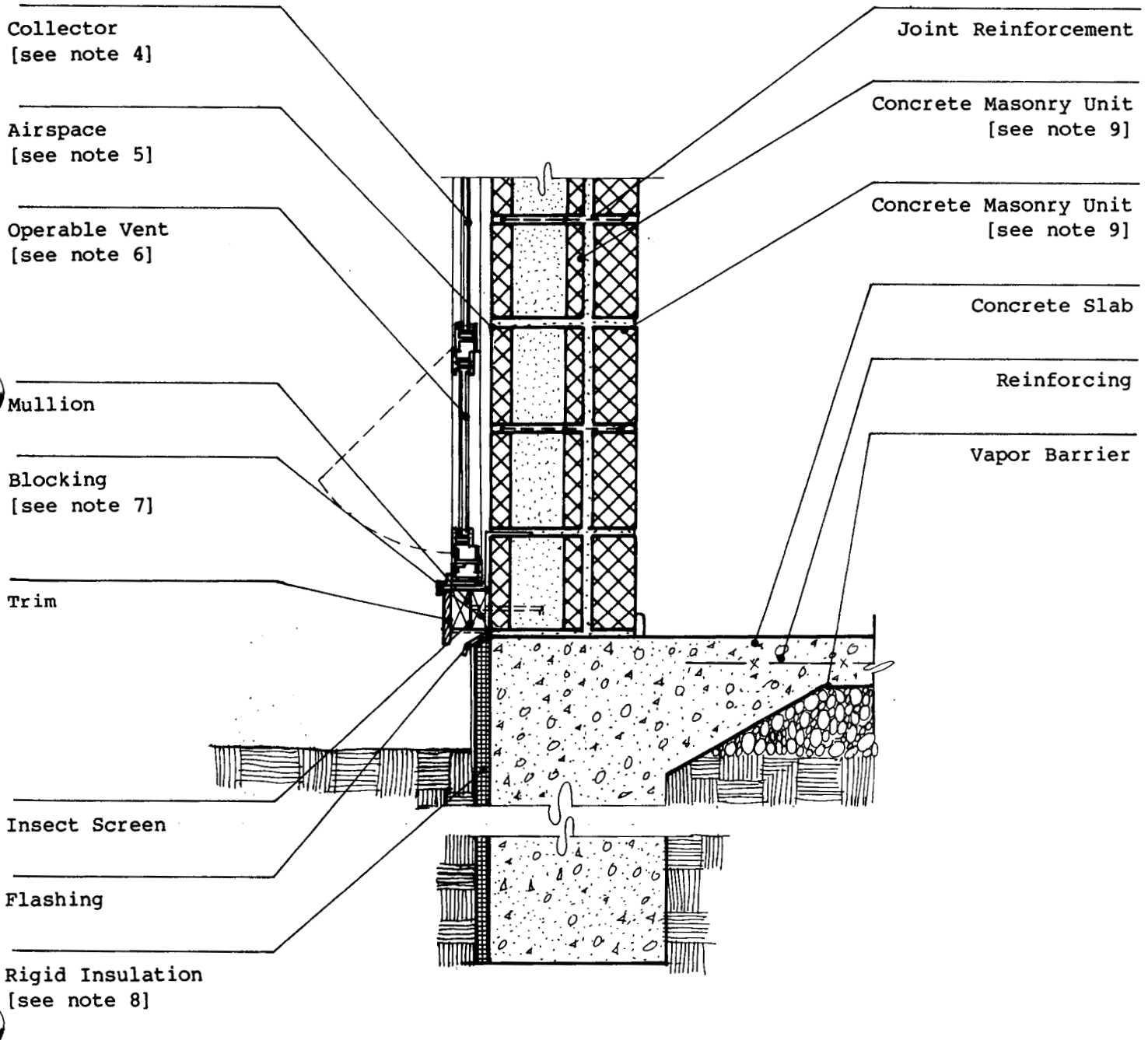
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
CMU/CMU Composite Wall
Concrete Slab-On-Grade

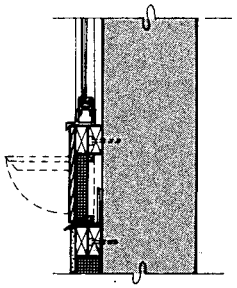
3.2212

Detail

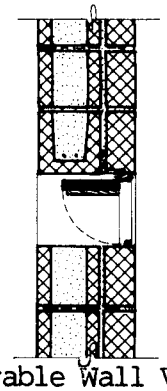




[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code. Where ground water problems exist, provide sufficient granular fill at haunch to prevent water penetration at slab.
[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code.
[3] Insulation levels at foundation/slab must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[5] Width of airspace may vary. For further information, see Key Page 3.2102.
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[7] Blocking can be discontinuous to provide weep holes where required. It is recommended that wood be pressure treated and insect screens (as shown) be provided at weep holes.
[8] Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.
[9] Concrete Masonry facing and back-up units must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2120.



Opaque Insulated Exterior Vent

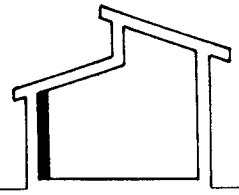


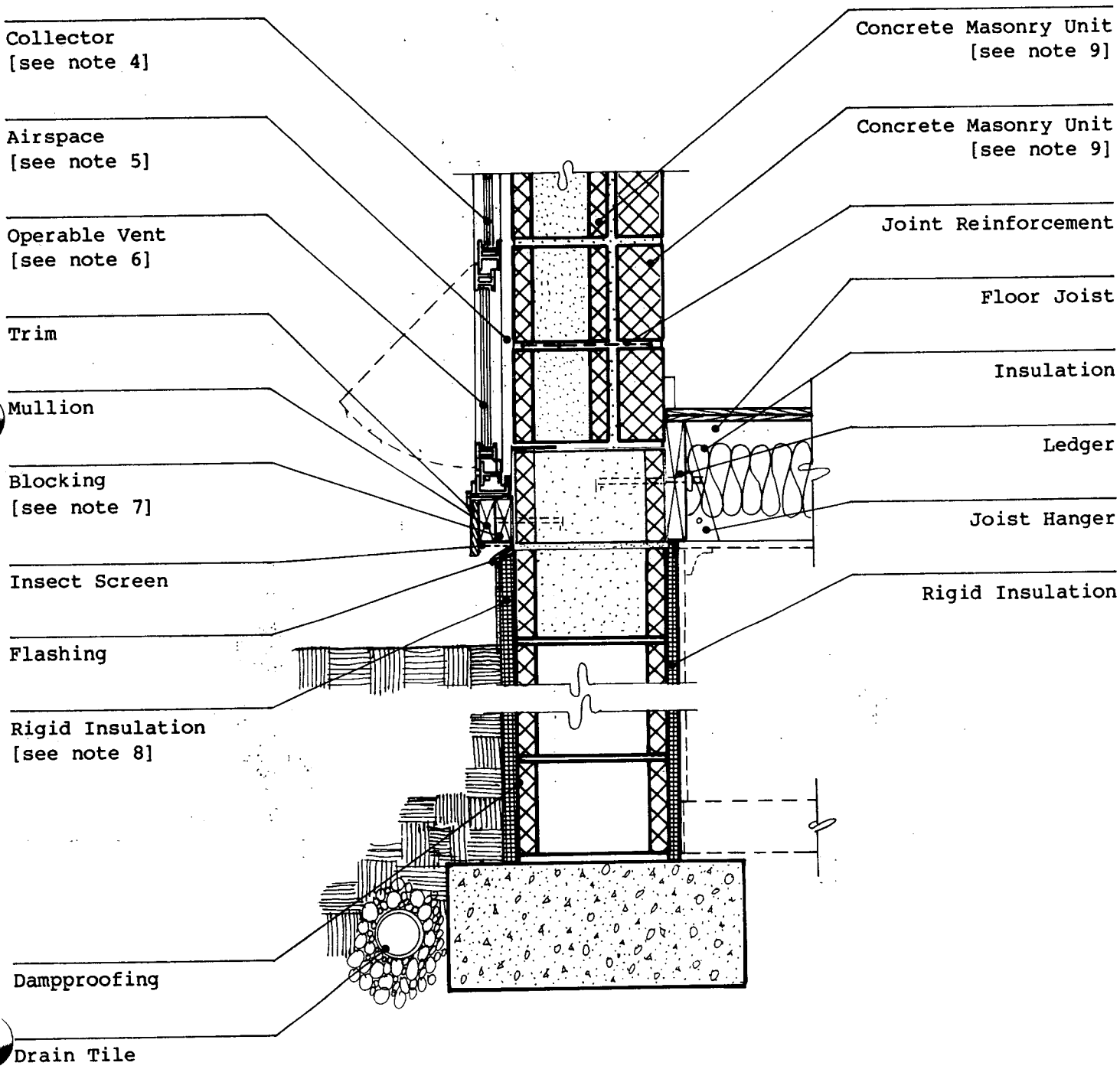
Operable Wall Vent

Thermal Storage Wall
CMU/CMU Composite Wall
Wood First Floor

3.2214

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.

[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice.

[3] Insulation levels at floor must meet or exceed requirements of local building/ energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

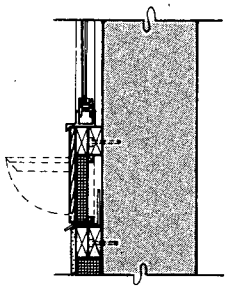
[5] Width of airspace may vary. For further information, see Key Page 3.2102.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

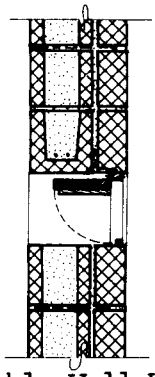
[7] Blocking can be discontinuous to provide weep holes where required. It is recommended that wood be pressure treated and insect screens (as shown) be provided at weep holes.

[8] It is recommended that the Thermal Storage Wall foundation be insulated on both sides to prevent heat losses to the outside and to the ground. In heated basements and heated crawl spaces insulation is not required on the inside. Insulation levels on both sides should be equal and should meet code requirements for foundation insulation. Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

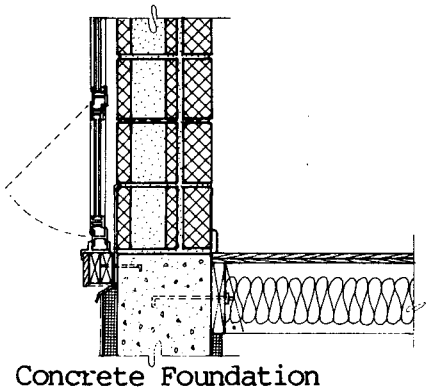
[9] Concrete Masonry facing and back-up units must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2120.



Opaque Insulated Exterior Vent



Operable Wall Vent

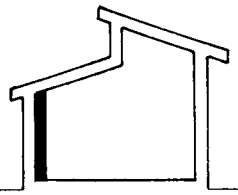


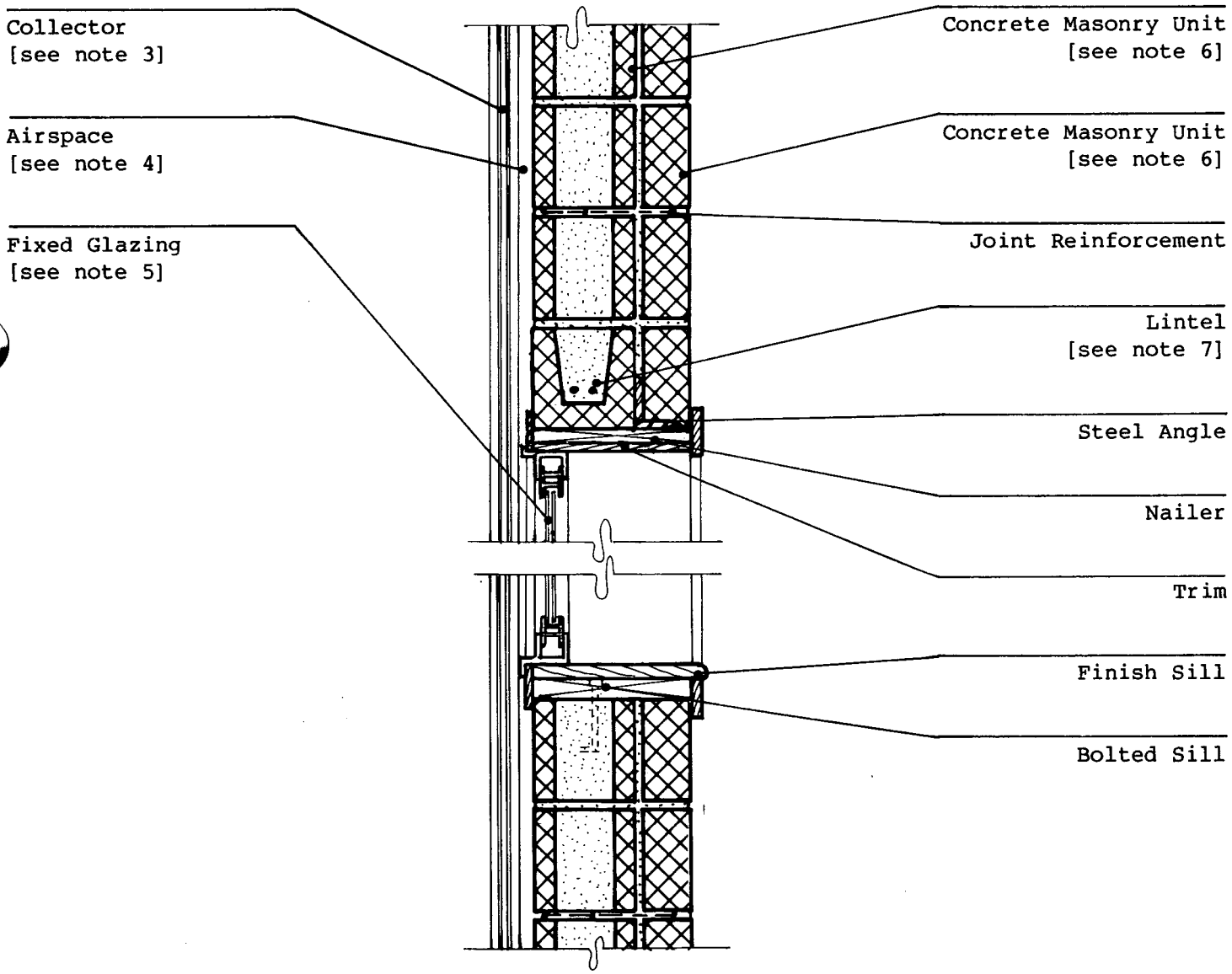
Concrete Foundation

Thermal Storage Wall
CMU/CMU Composite Wall
Direct Gain Window

3.2216

Detail





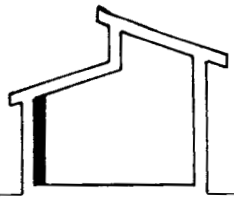
Construction Notes

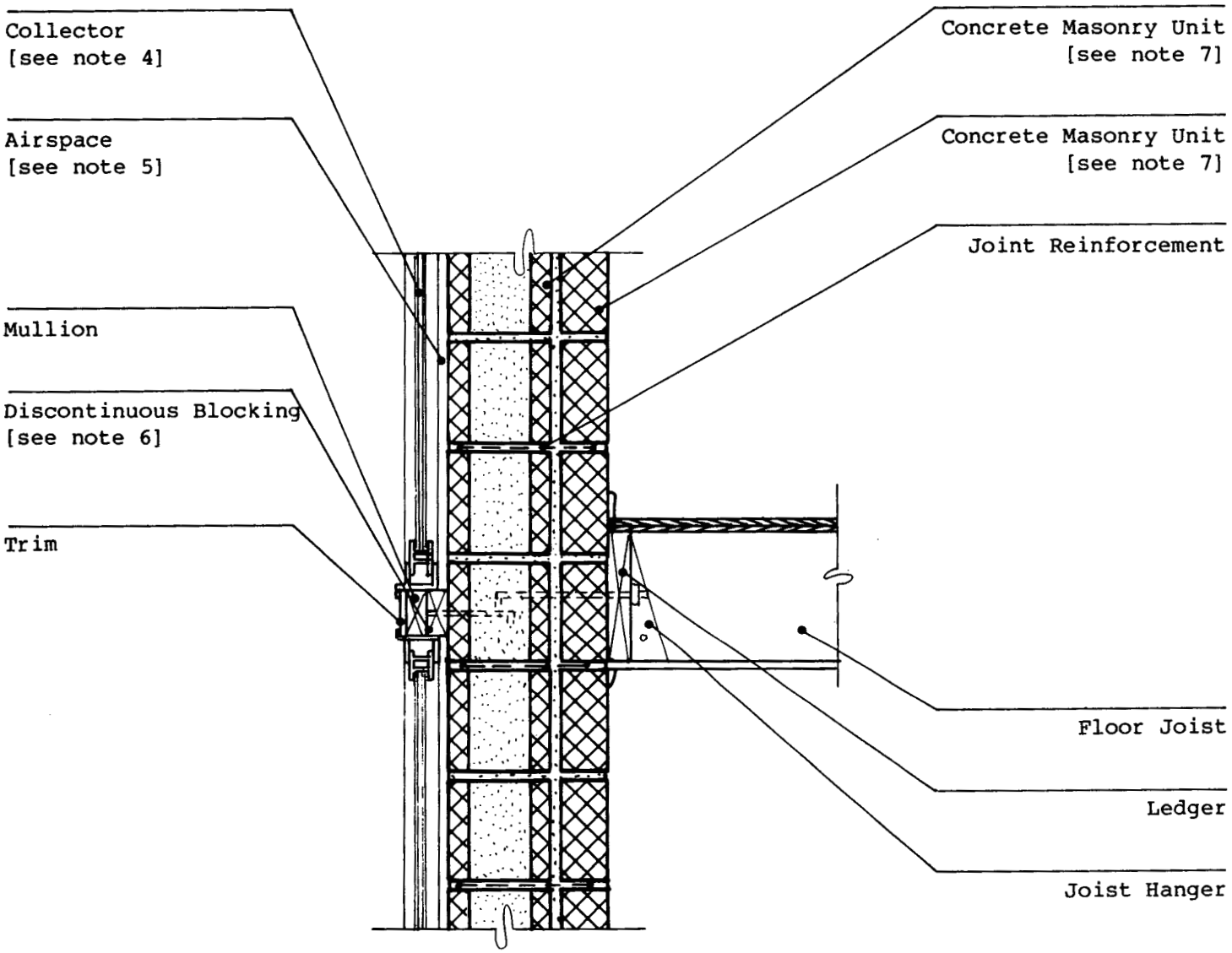
[1] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice.
[2] The storage mass should not be insulated. For further information, see Section 3.2000.
[3] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[4] Width of airspace may vary. For further information, see Key Page 3.2102.
[5] Conventional window for light, view and/or Direct Gain may be single or double glazed. For information on Direct Gain systems, see Section 3.1000.
[6] Concrete Masonry facing and back-up units must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2120.
[7] Lintel may be bond-beam, lintel, or standard Concrete Masonry units with depressed, cut-out or grooved webs, or precast concrete. Provide 6" minimum bearing at each end. Reinforcing designed for loading and clear span per local building codes and/or accepted practice. Facing unit is supported by steel angle.

Thermal Storage Wall
CMU/CMU Composite Wall
Wood Upper Floor

3.2218

Detail





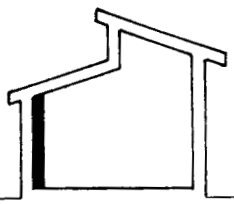
Construction Notes

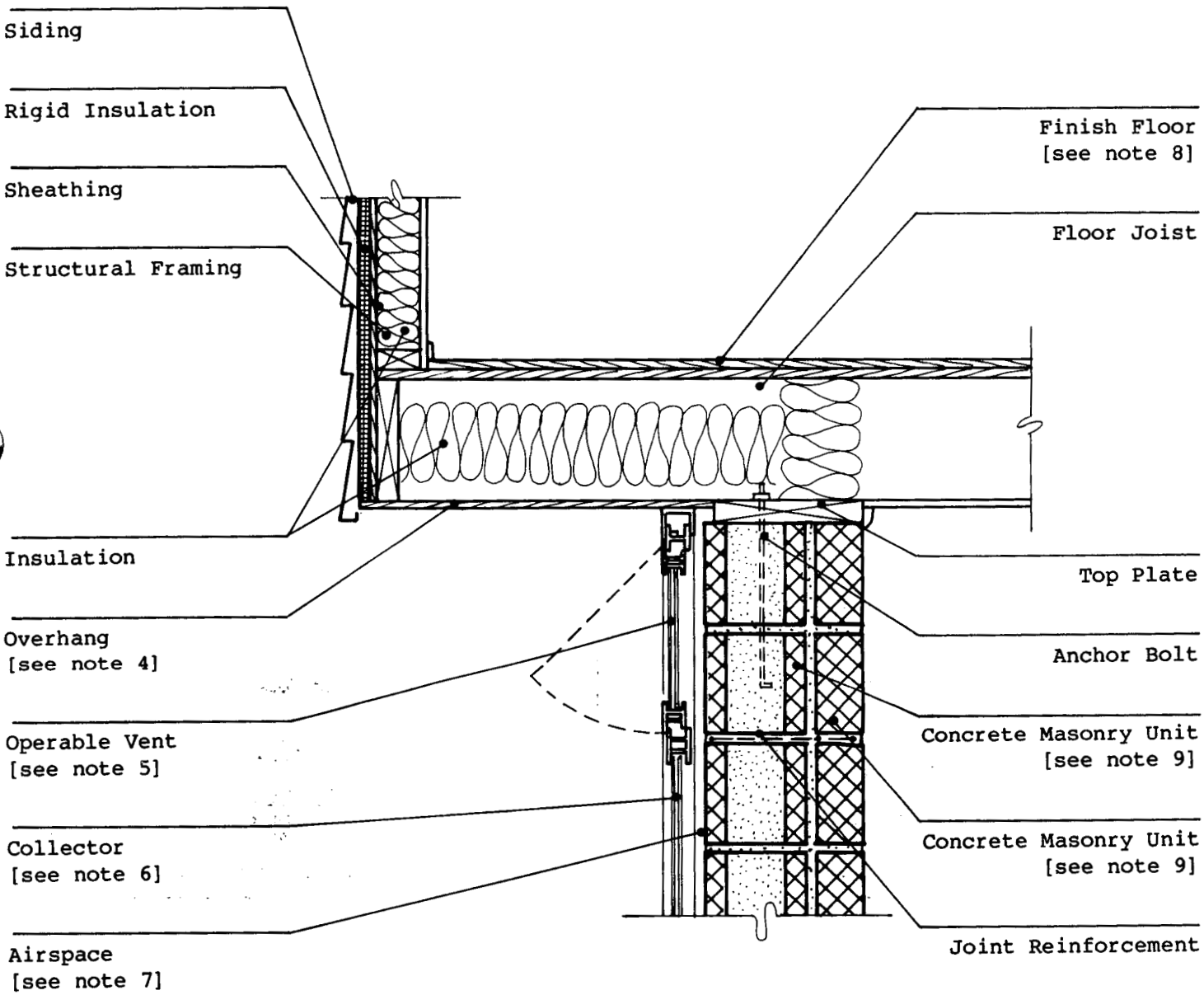
[1] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.
[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice.
[3] The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[5] Width of airspace may vary. For further information, see Key Page 3.2102.
[6] Discontinuous blocking to allow for adequate air circulation in airspace.
[7] Concrete Masonry facing and back-up units must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2120.

Thermal Storage Wall
CMU/CMU Composite Wall
Wood Upper Floor Overhang

3.2220

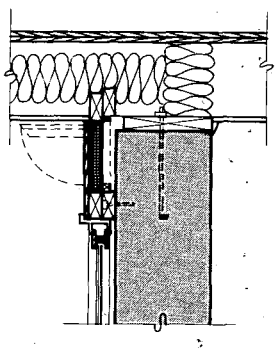
Detail



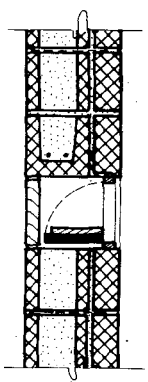


Thermal Storage Wall
Construction Notes

[1] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.
[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.
[3] Insulation levels at frame wall and floor at overhang must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.
[5] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[6] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[7] Width of airspace may vary. For further information, see Key Page 3.2102.
[8] Direct Gain system may be incorporated into upper level design. For further information, see Section 3.1000.
[9] Concrete Masonry facing and back-up units must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2120.



Opaque Insulated Exterior Vent

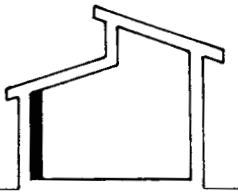


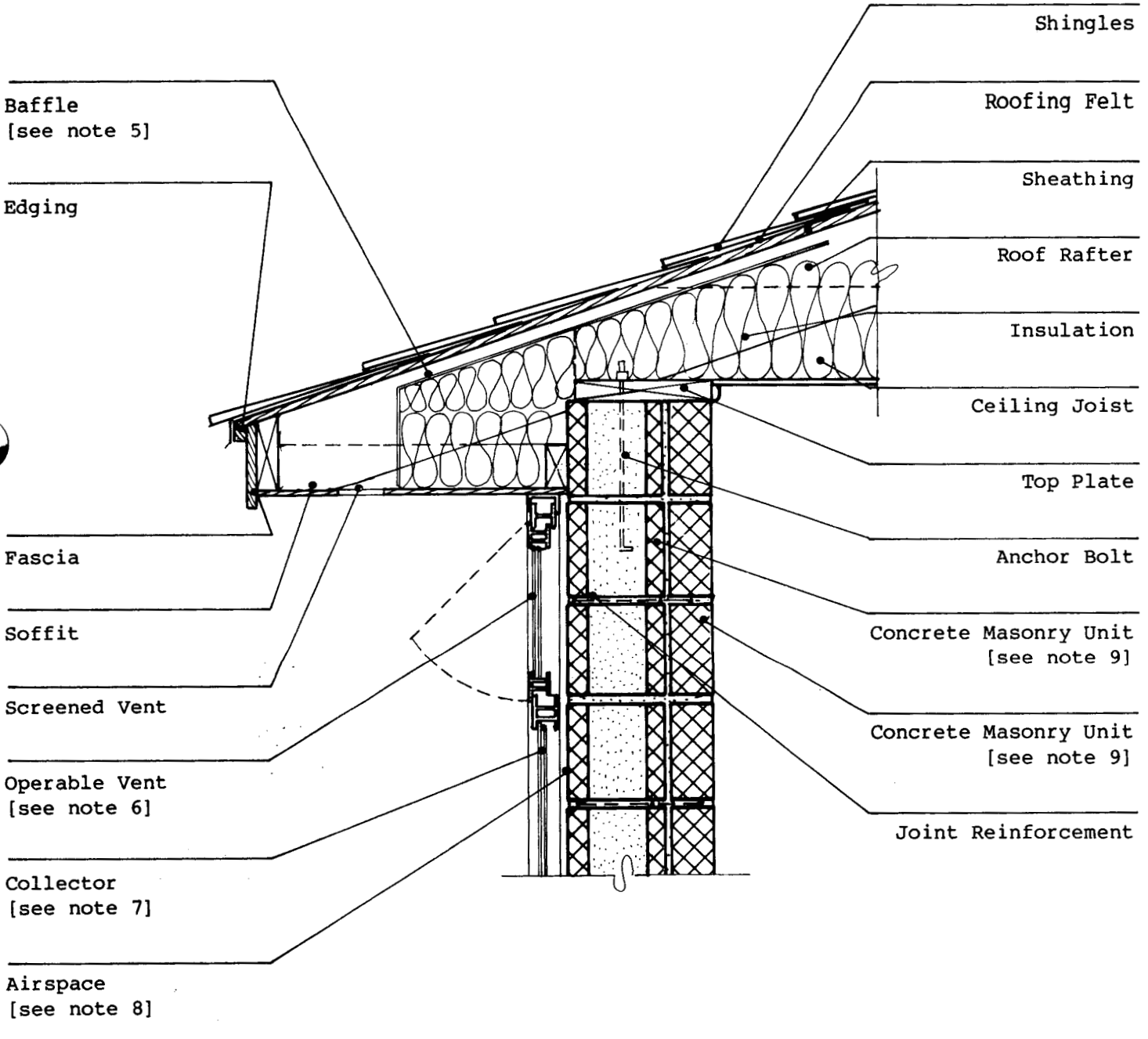
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
CMU/CMU Composite Wall
Roof

3.2222

Detail





Thermal Storage Wall
Construction Notes

[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections. Provide gutters and downspouts as required. Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.

[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.

[3] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.

[4] Insulation in ceiling must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

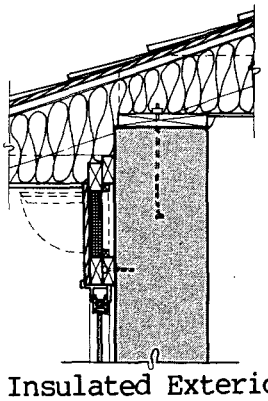
[5] Provide baffles where necessary to maintain 1" minimum airspace for venting attic.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

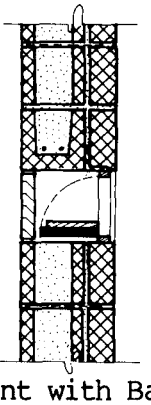
[7] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

[8] Width of airspace may vary. For further information, see Key Page 3.2102.

[9] Concrete Masonry facing and back-up units must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2120.



Opaque Insulated Exterior Vent

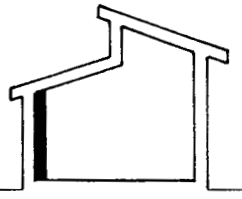


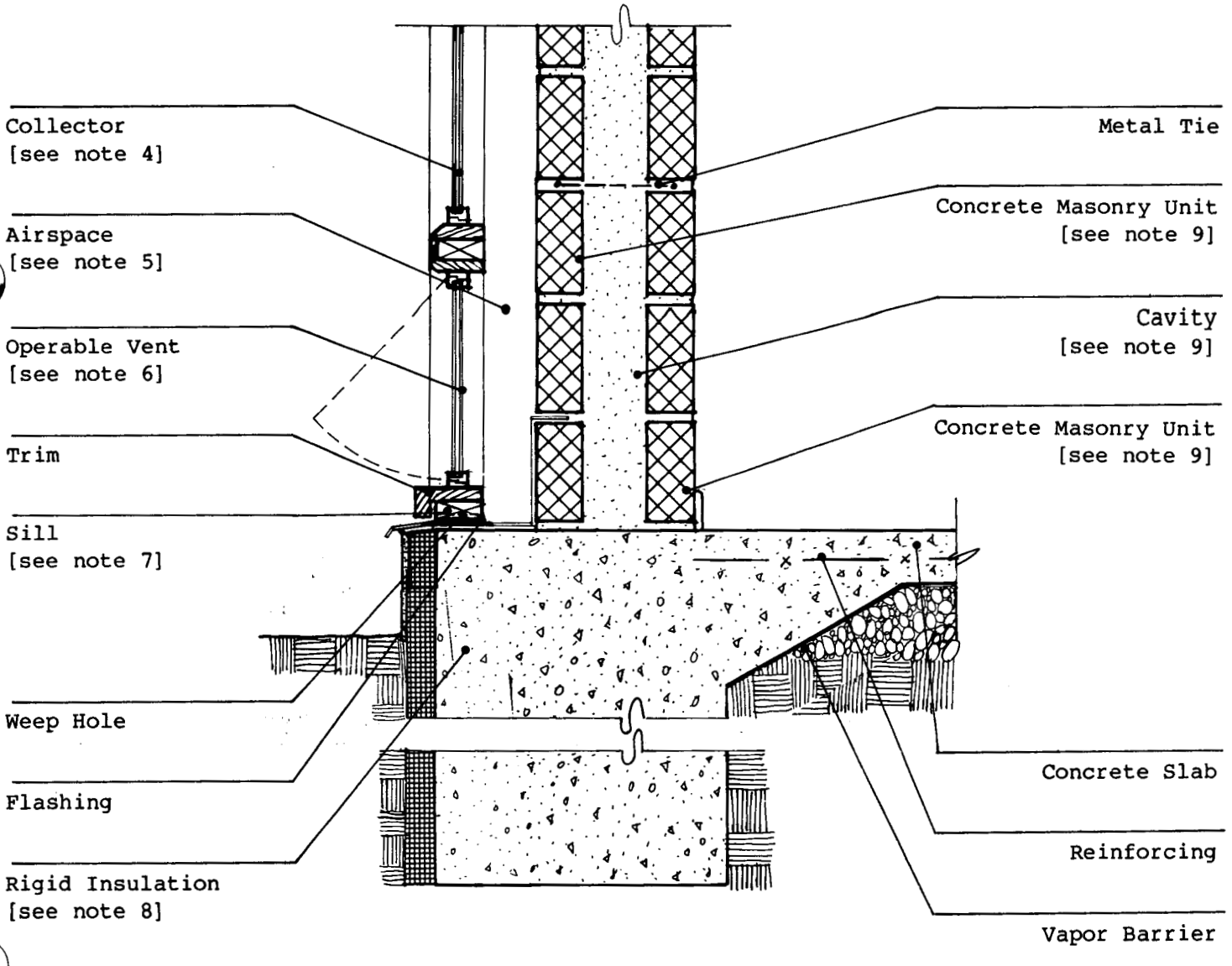
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
CMU/Cavity Wall
Concrete Slab-On-Grade

3.2224

Detail





Thermal Storage Wall
Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code. Where ground water problems exist, provide sufficient granular fill at haunch to prevent water penetration at slab.

[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab is not recommended except where required by local conditions and/or code.

[3] Insulation levels at foundation/slab must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

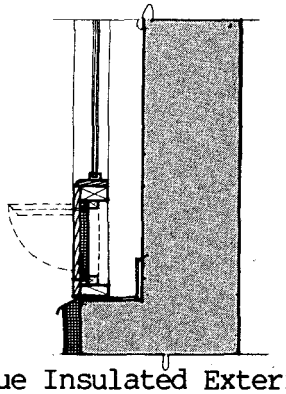
[5] Width of airspace may vary. For further information, see Key Page 3.2100.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. For more information, see Section 3.2000

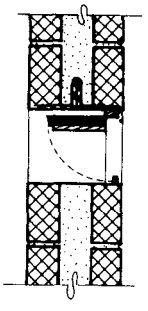
[7] Sill can be wood or masonry at builder's option. Pressure treating should be specified if lumber is used. Sill to foundation and collector frame to foundation connections must meet local building codes.

[8] Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation.

[9] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics see Key Page 3.2122.



Opaque Insulated Exterior Vent

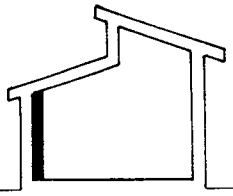


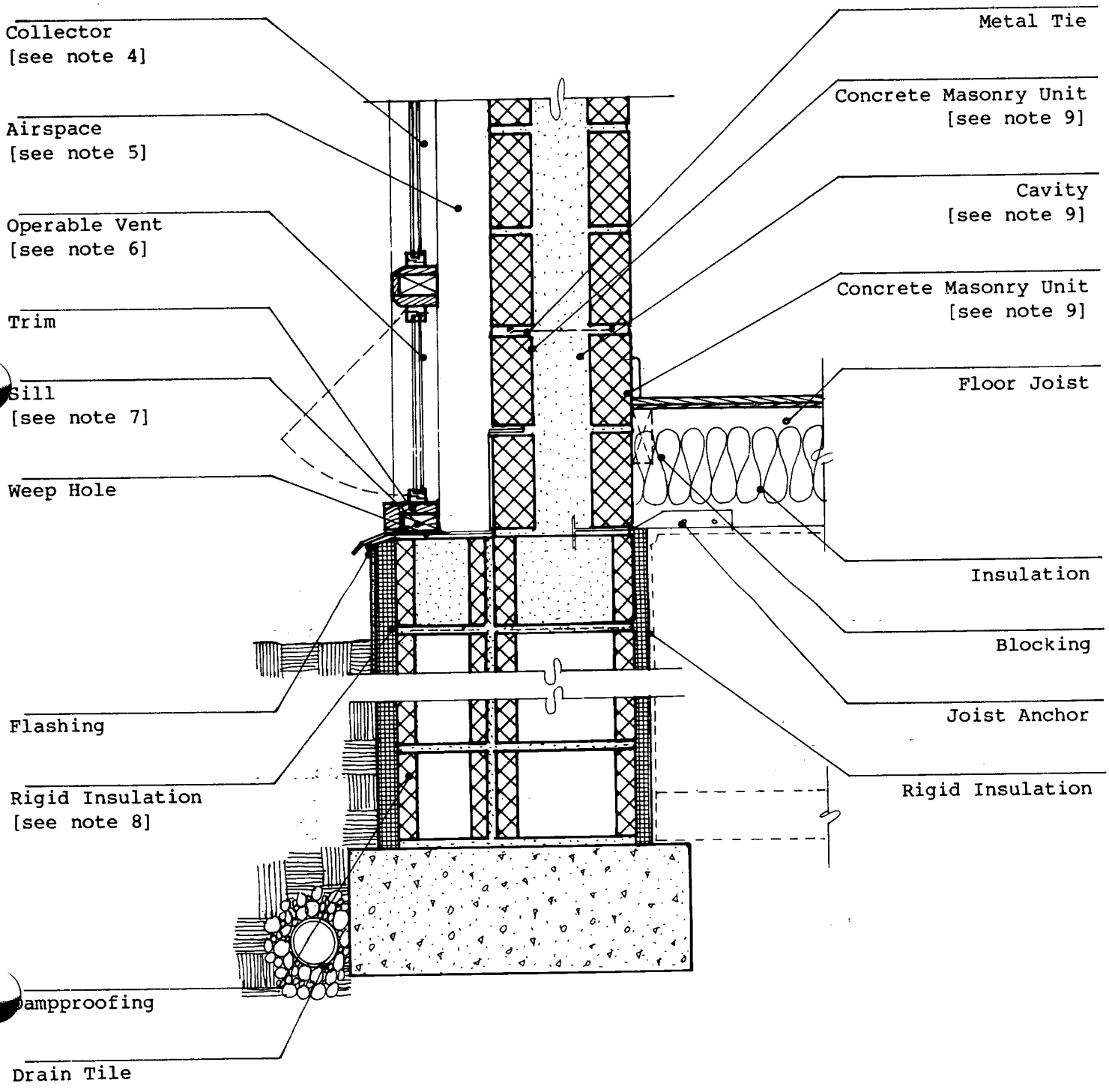
Operable Wall Vent

Thermal Storage Wall
CMU/Cavity Wall
Wood First Floor

3.2226

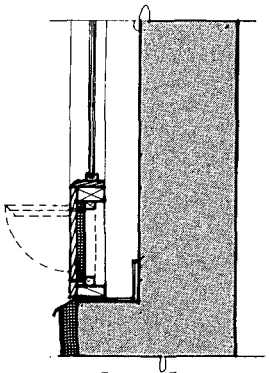
Detail



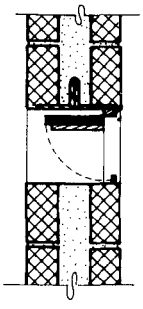


Thermal Storage Wall
Construction Notes

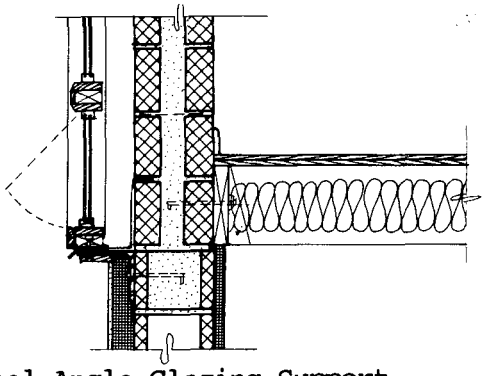
[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.
[2] Placement of reinforcing, metal ties, joist anchors, flashing and weep holes to be determined by local building codes and/or accepted practice. Floor joists must bear on solid masonry not less than 4" thick. Fire-cut joists as required.
[3] Insulation levels at floor must meet or exceed requirements of local building/ energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.
[5] Width of airspace may vary. For further information, see Key Page 3.2100.
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[7] Sill can be wood or masonry at builder's option. Pressure treating should be specified if lumber is used. Sill to foundation and collector frame to foundation connections must meet local building codes.
[8] It is recommended that the Thermal Storage Wall foundation be insulated on both sides to prevent heat losses to the outside and to the ground. In heated basements and heated crawl spaces insulation is not required on the inside. Insulation levels on both sides should be equal and should meet code requirements for foundation insulation. Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.
[9] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2122.



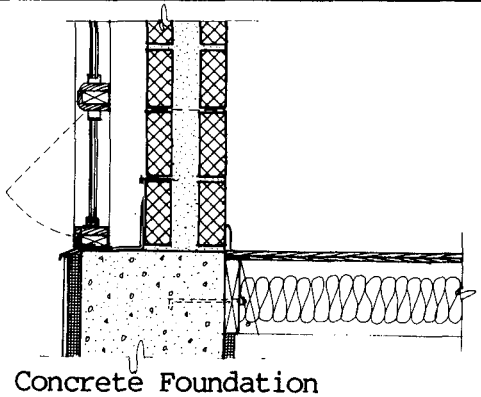
Opaque Insulated Exterior Vent



Operable Wall Vent



Steel Angle Glazing Support

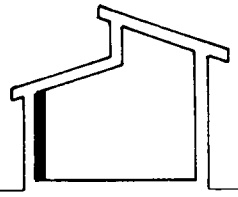


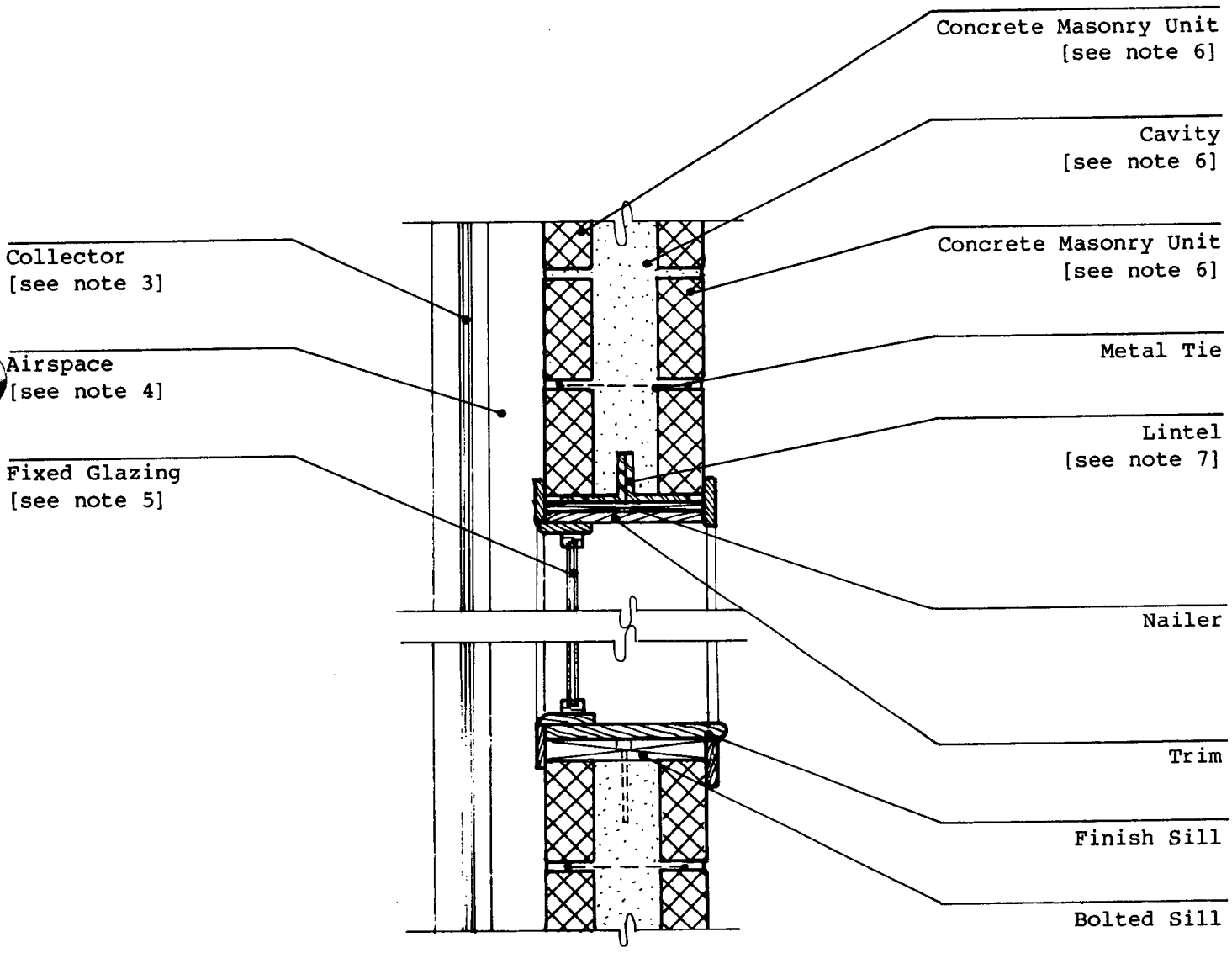
Concrete Foundation

Thermal Storage Wall
CMU/Cavity Wall
Direct Gain Window

3.2228

Detail



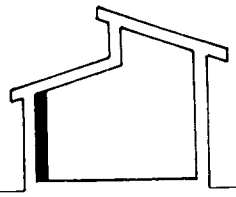


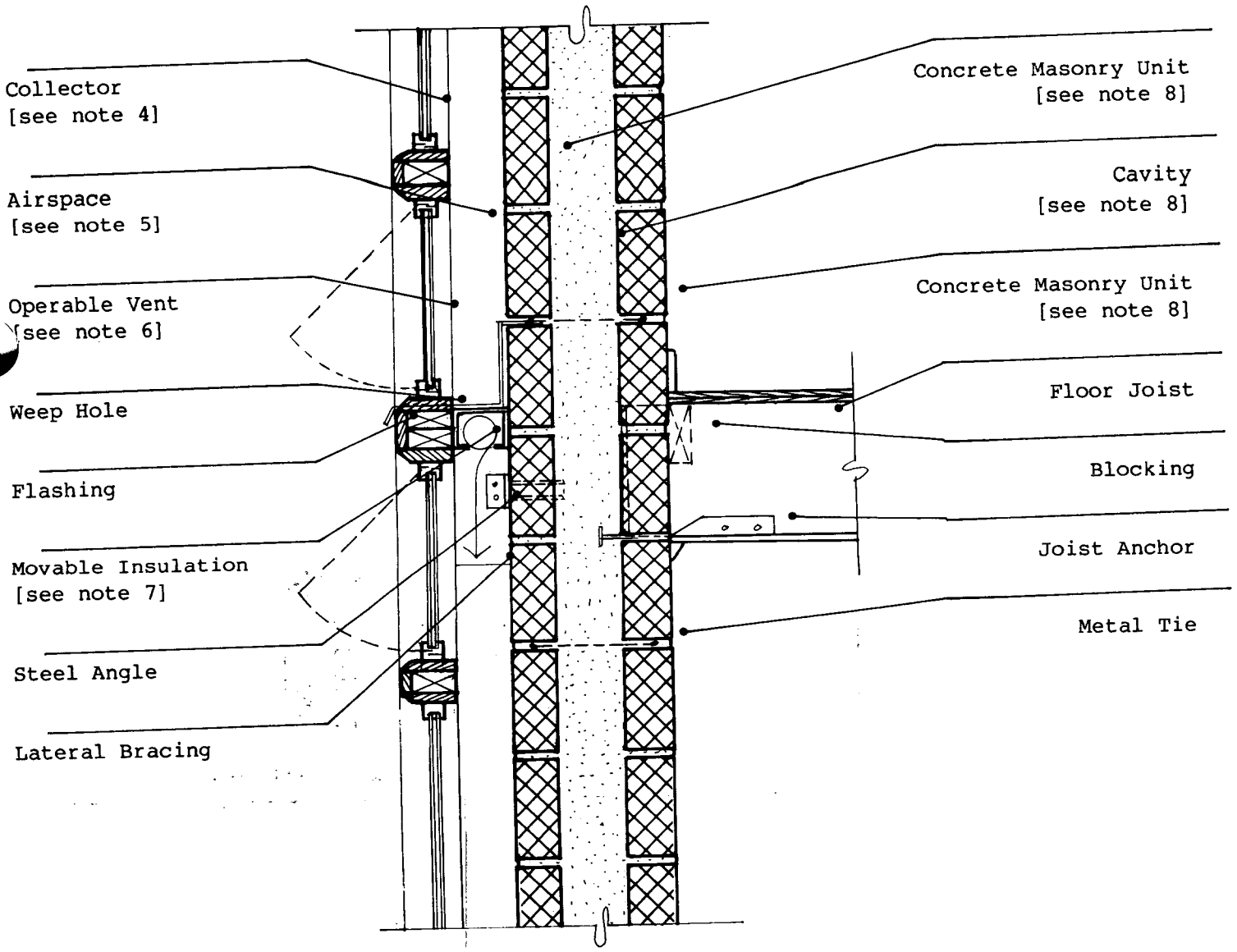
[1] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice.
[2] The storage mass should not be insulated. For further information, see Section 3.2000.
[3] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.
[4] Width of airspace may vary. For further information, see Key Page 3.2100.
[5] Conventional window for light, view and/or Direct Gain may be single or double glazed. For information on Direct Gain systems, see Section 3.1000.
[6] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2122.
[7] Lintel fabricated from steel angles designed for loading and clear span per local building codes and/or accepted practice. Provide 6" minimum bearing at each end. Alternate reinforced CMU or precast concrete lintel may be specified at builder's option.

Thermal Storage Wall
CMU/Cavity Wall
Wood Upper Floor

3.2230

Detail





Thermal Storage Wall
Construction Notes

[1] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.

[2] Placement of reinforcing, metal ties, joist anchors, flashing and weep holes to be determined by local building codes and/or accepted practice. Floor joists must bear on solid masonry not less than 4" thick. Fire-cut joists as required.

[3] The storage mass should not be insulated. For further information, see Section 3.2000.

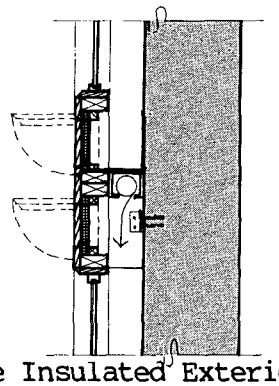
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

[5] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.

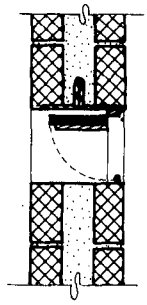
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Where airspace is not continuous, top and bottom vents should be provided for each section. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

[7] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. Where upper and lower portions of Thermal Storage Wall are separated, movable insulation must be installed in each section. For further information, see Sections 3.2000 and 4.4300.

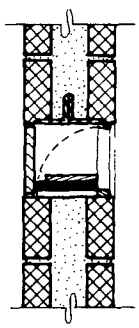
[8] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2122.



Opaque Insulated Exterior Vents



Operable Wall Vent

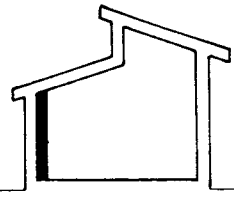


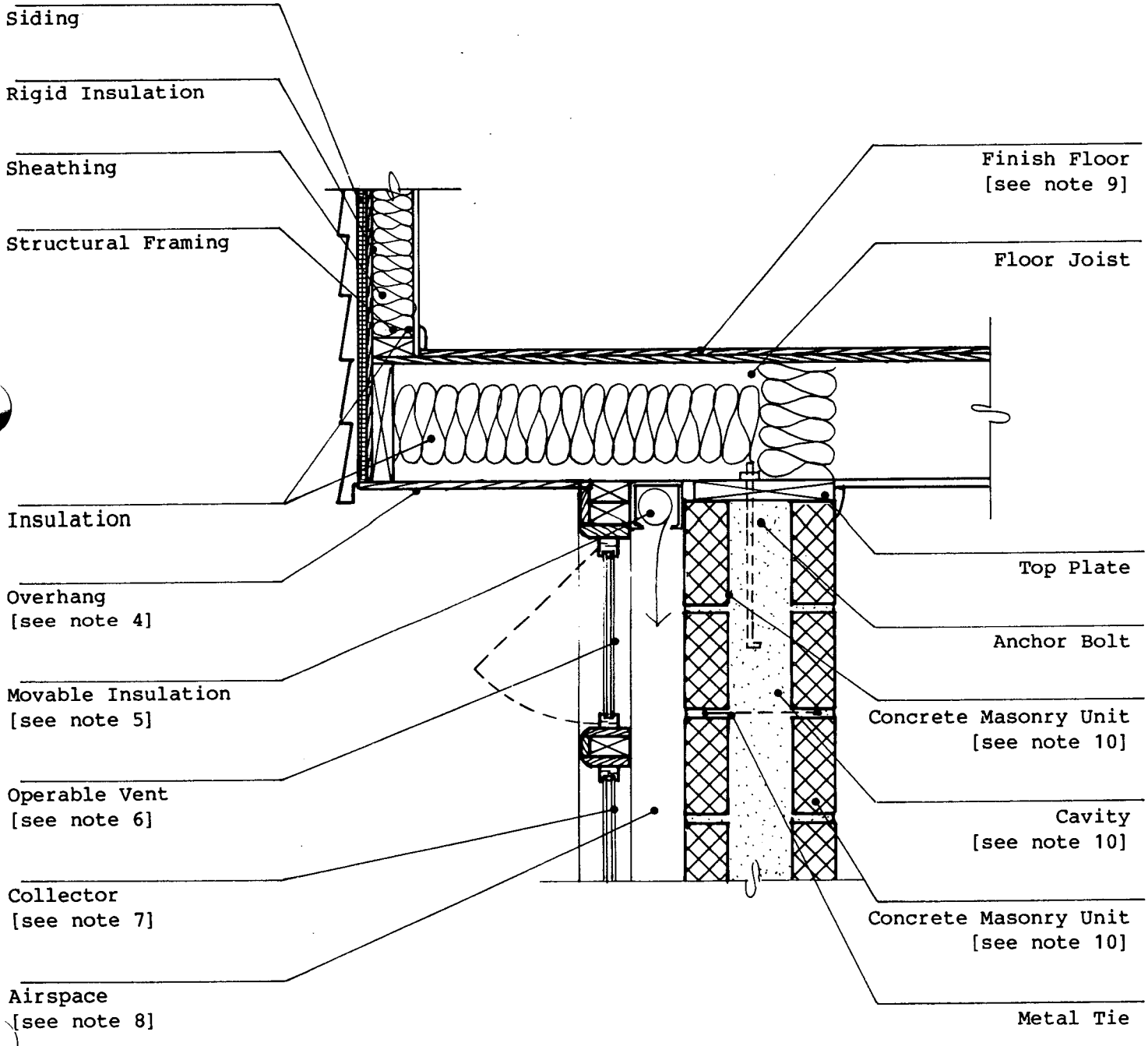
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
CMU/Cavity Wall
Wood Upper Floor Overhang

3.2232

Detail





Construction Notes

[1] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.

[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.

[3] Insulation levels at frame wall and floor at overhang must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.

[5] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. For further information see Sections 3.2000 and 4.4300.

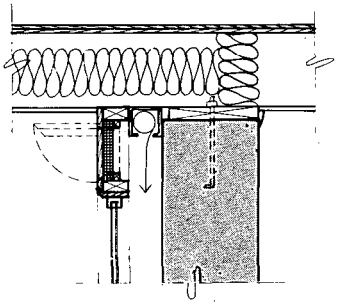
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

[7] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

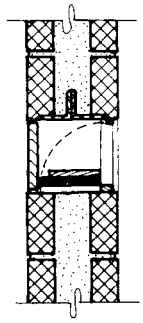
[8] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.

[9] Direct Gain system may be incorporated into upper level design. For further information, see Section 3.1000.

[10] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2122.



Opaque Insulated Exterior Vent

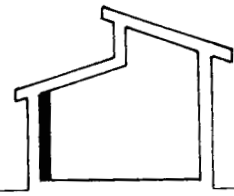


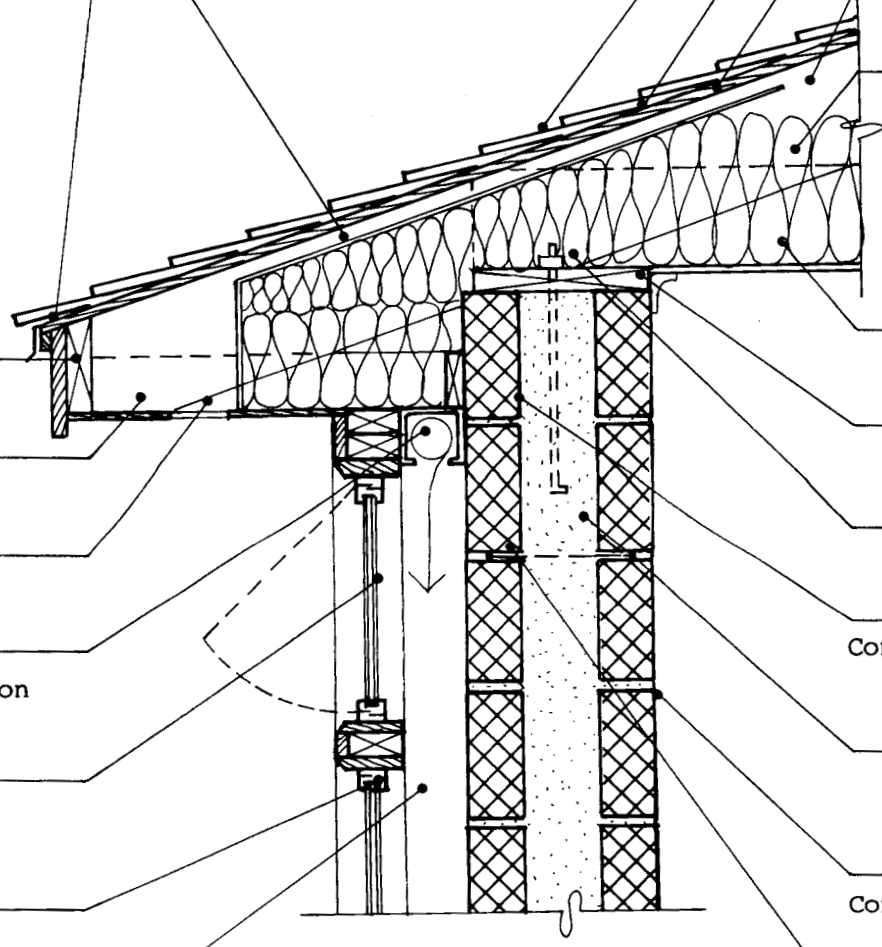
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
CMU/Cavity Wall
Roof

3.2234

Detail





Shingles
Roofing Felt
Sheathing
Roof Rafter
Insulation
Ceiling Joist
Top Plate
Anchor Bolt
Concrete Masonry Unit [see note 10]
Cavity [see note 10]
Concrete Masonry Unit [see note 10]
Metal Tie
Baffle [see note 5]
Edging
Fascia
Soffit
Screened Vent
Movable Insulation [see note 6]
Operable Vent [see note 7]
Collector [see note 8]
Airspace [see note 9]

[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections. Provide gutters and downspouts as required. Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.

[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.

[3] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.

[4] Insulation in ceiling must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[5] Provide baffles where necessary to maintain 1" minimum airspace for venting attic.

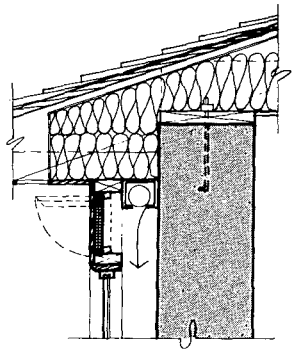
[6] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. For further information see Sections 3.2000 and 4.4300.

[7] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

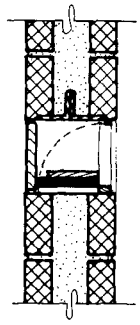
[8] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

[9] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.

[10] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2122.



Opaque Insulated Exterior Vent

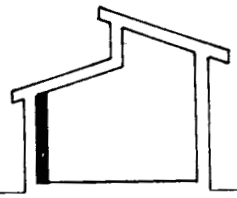


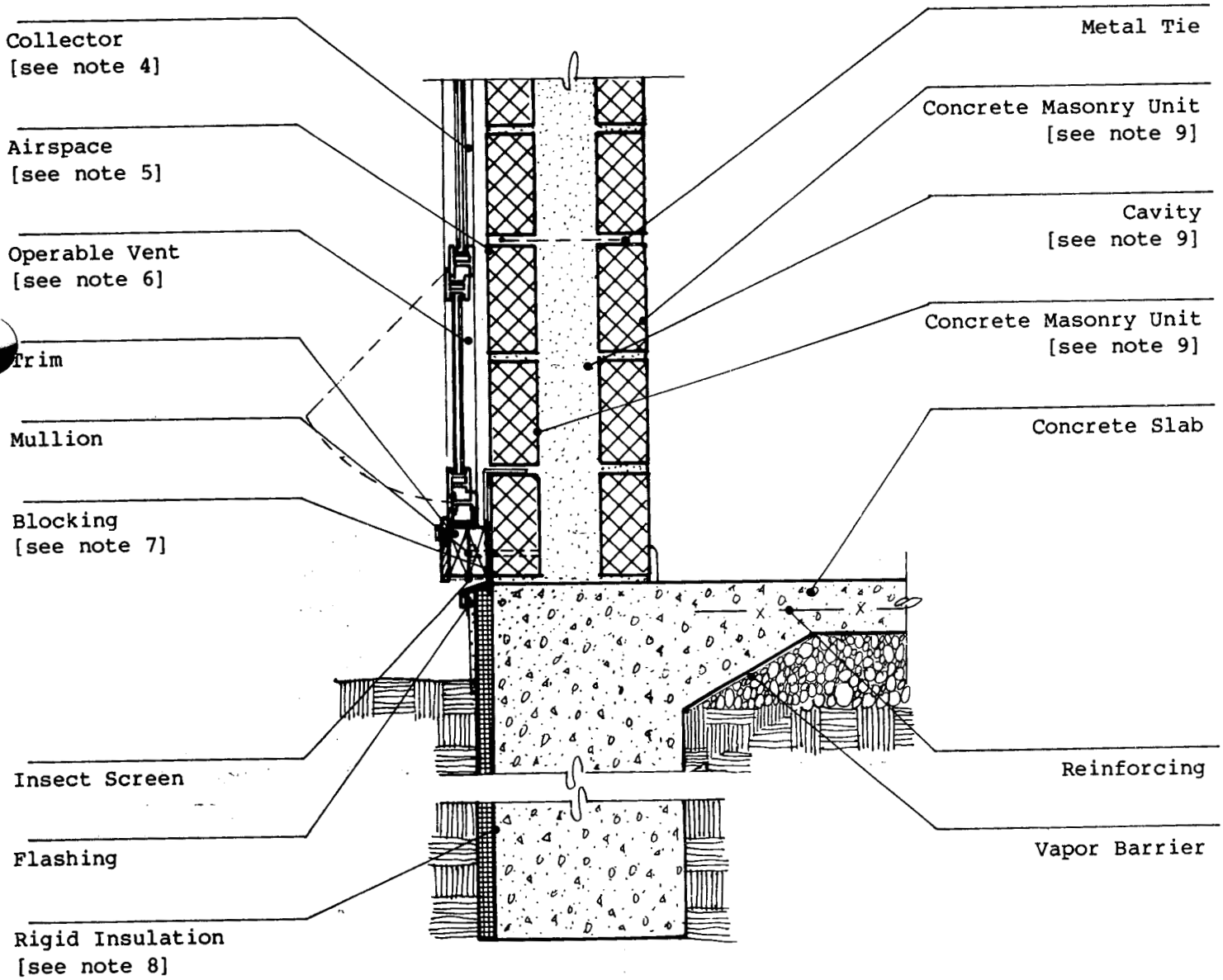
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
CMU/Cavity Wall
Concrete Slab-On-Grade

3.2236

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code. Where ground water problems exist, provide sufficient granular fill at haunch to prevent water penetration at slab.

[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code.

[3] Insulation levels at foundation/slab must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

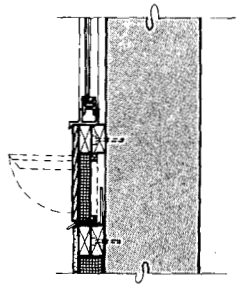
[5] Width of airspace may vary. For further information, see Key Page 3.2102.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

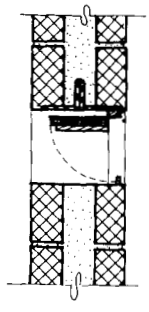
[7] Blocking can be discontinuous to provide weep holes where required. It is recommended that wood be pressure treated and insect screens (as shown) be provided at weep holes.

[8] Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

[9] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2122.



Opaque Insulated Exterior Vent

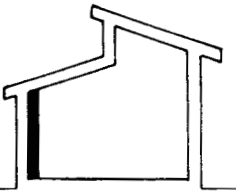


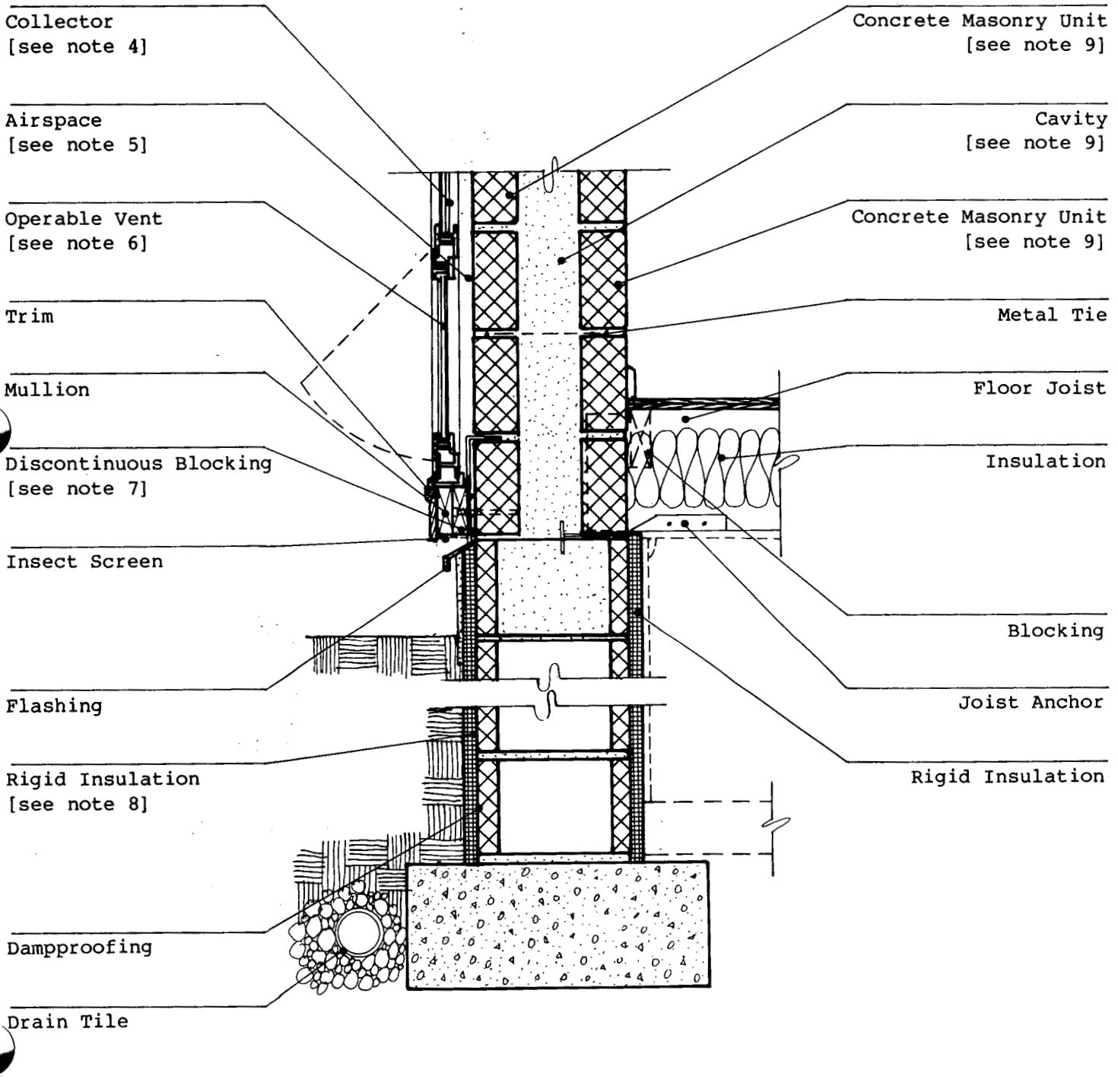
Operable Wall Vent

Thermal Storage Wall
CMU/Cavity Wall
Wood First Floor

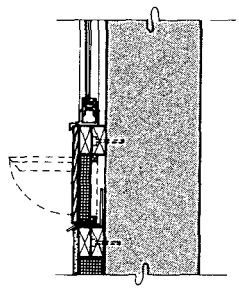
3.2238

Detail

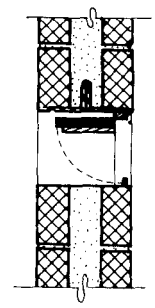




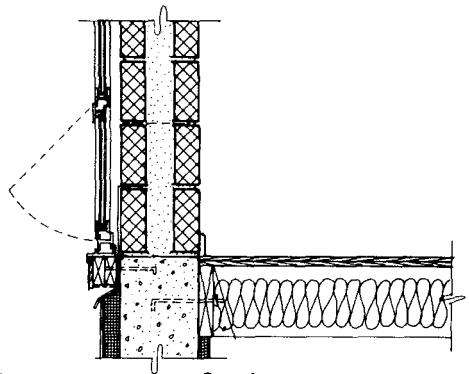
[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.
[2] Placement of reinforcing, metal ties, joist anchors, flashing and weep holes to be determined by local building codes and/or accepted practice. Floor joists must bear on solid masonry not less than 4" thick. Fire-cut joists as required.
[3] Insulation levels at floor must meet or exceed requirements of local building/ energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[5] Width of airspace may vary. For further information, see Key Page 3.2102.
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[7] Blocking can be discontinuous to provide weep holes where required. It is recommended that wood be pressure treated and insect screens (as shown) be provided at weep holes.
[8] It is recommended that the Thermal Storage Wall foundation be insulated on both sides to prevent heat losses to the outside and to the ground. In heated basements and crawl spaces insulation is not required on the inside. Insulation levels on both sides should be equal and should meet code requirements for foundation insulation. Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.
[9] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2122.



Opaque Insulated Exterior Vent



Operable Wall Vent

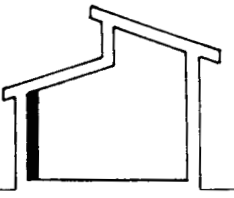


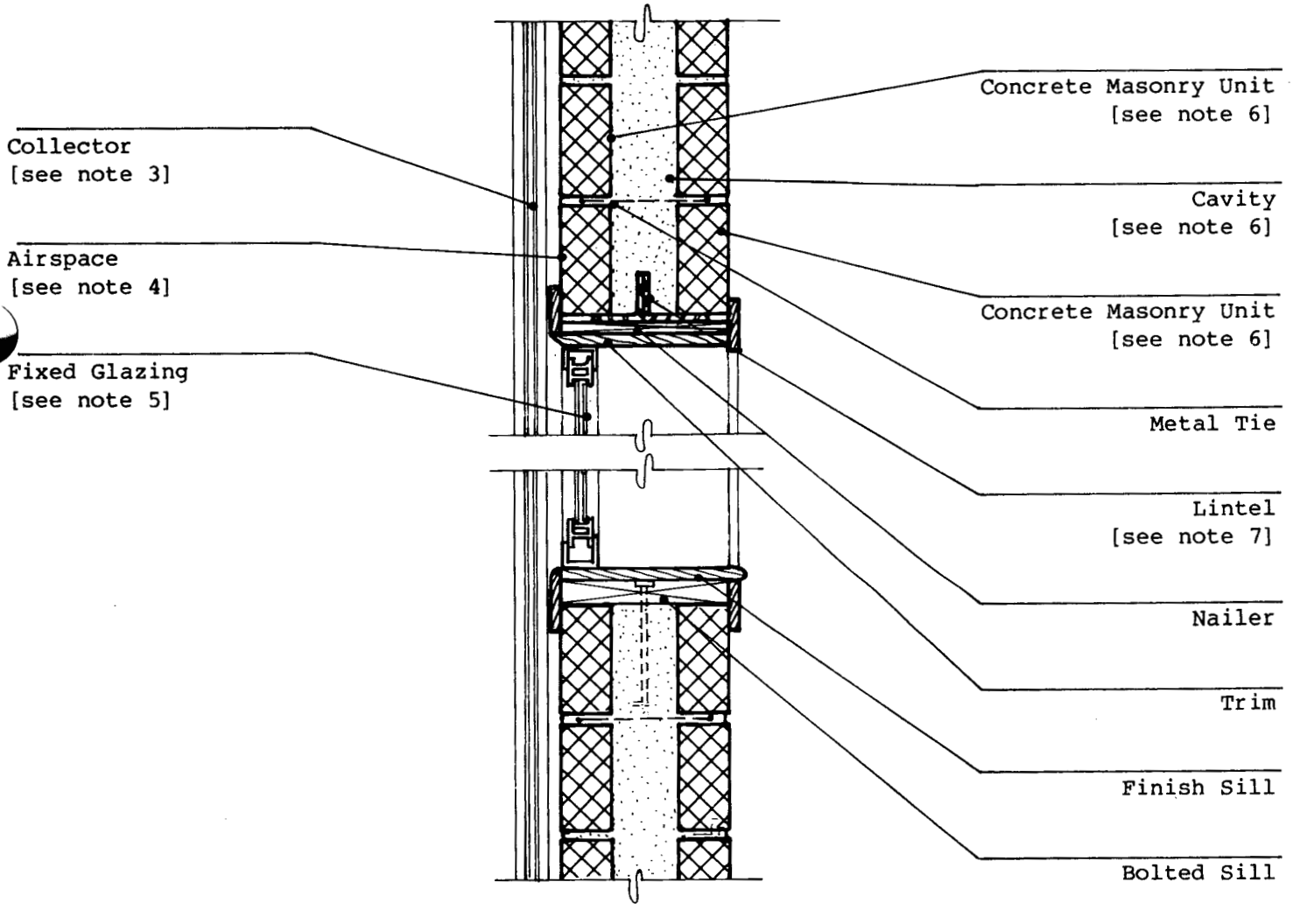
Concrete Foundation

Thermal Storage Wall
CMU/Cavity Wall
Direct Gain Window

3.2240

Detail





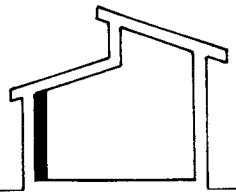
Construction Notes

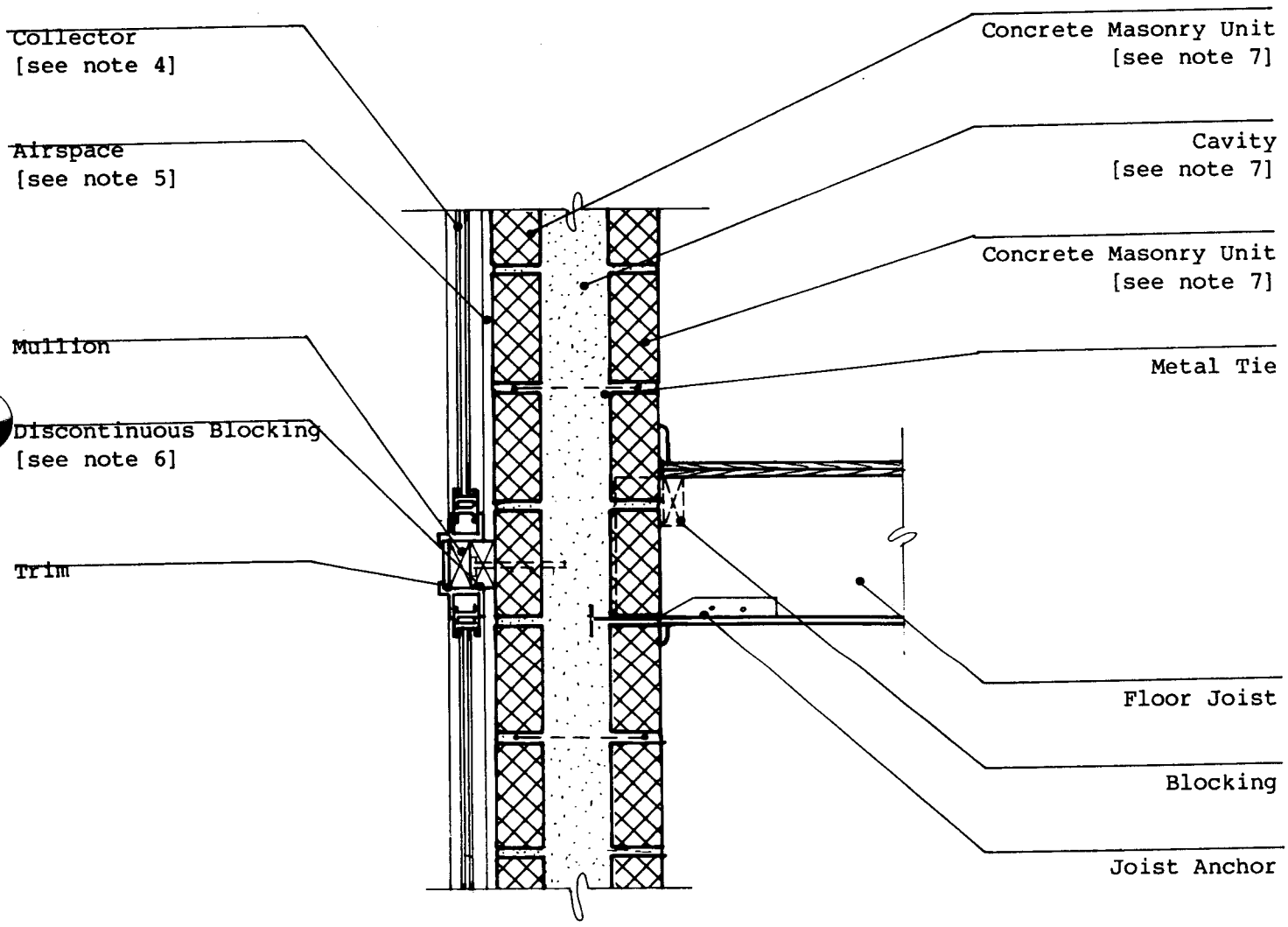
[1] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice.
[2] The storage mass should not be insulated. For further information, see Section 3.2000.
[3] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[4] Width of airspace may vary. For further information, see Key Page 3.2102.
[5] Conventional window for light, view and/or Direct Gain may be single or double glazed. For information on Direct Gain systems, see Section 3.1000.
[6] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2122.
[7] Lintel fabricated from steel angles designed for loading and clear span per local building codes and/or accepted practice. Provide 6" minimum bearing at each end. Alternate reinforced CMU or precast concrete lintel may be specified at builder's option.

Thermal Storage Wall
CMU/Cavity Wall
Wood Upper Floor

3.2242

Detail



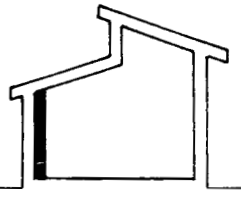


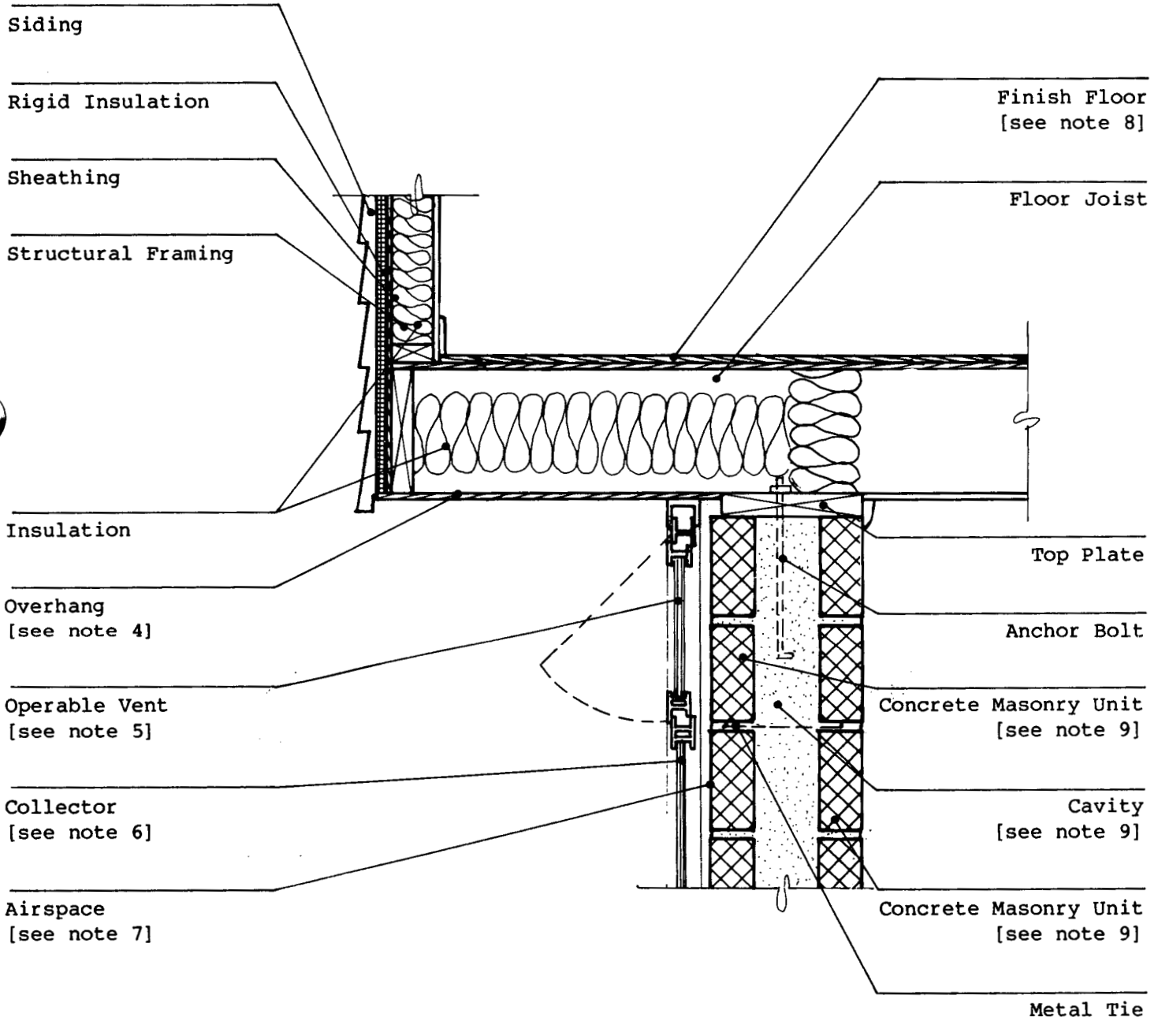
[1] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.
[2] Placement of reinforcing, metal ties and joist anchors to be determined by local building codes and/or accepted practice. Floor joists must bear on solid masonry not less than 4 inch thick. Fire-cut joists as required.
[3] The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[5] Width of airspace may vary. For further information, see Key Page 3.2102.
[6] Discontinuous blocking to allow for adequate air circulation in airspace.
[7] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2122.

Thermal Storage Wall
CMU/Cavity Wall
Wood Upper Floor Overhang

3.2244

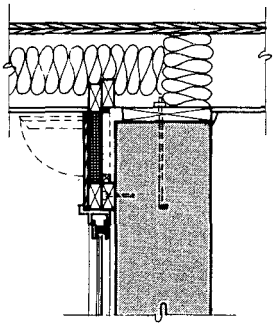
Detail



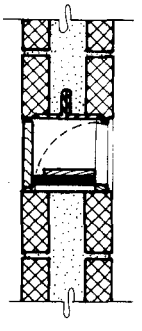


Construction Notes

[1] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.
[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.
[3] Insulation levels at frame wall and floor at overhang must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.
[5] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[6] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[7] Width of airspace may vary. For further information, see Key Page 3.2102.
[8] Direct Gain system may be incorporated into upper level design. For further information, see Section 3.1000.
[9] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2122.



Opaque Insulated Exterior Vent

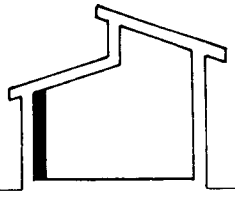


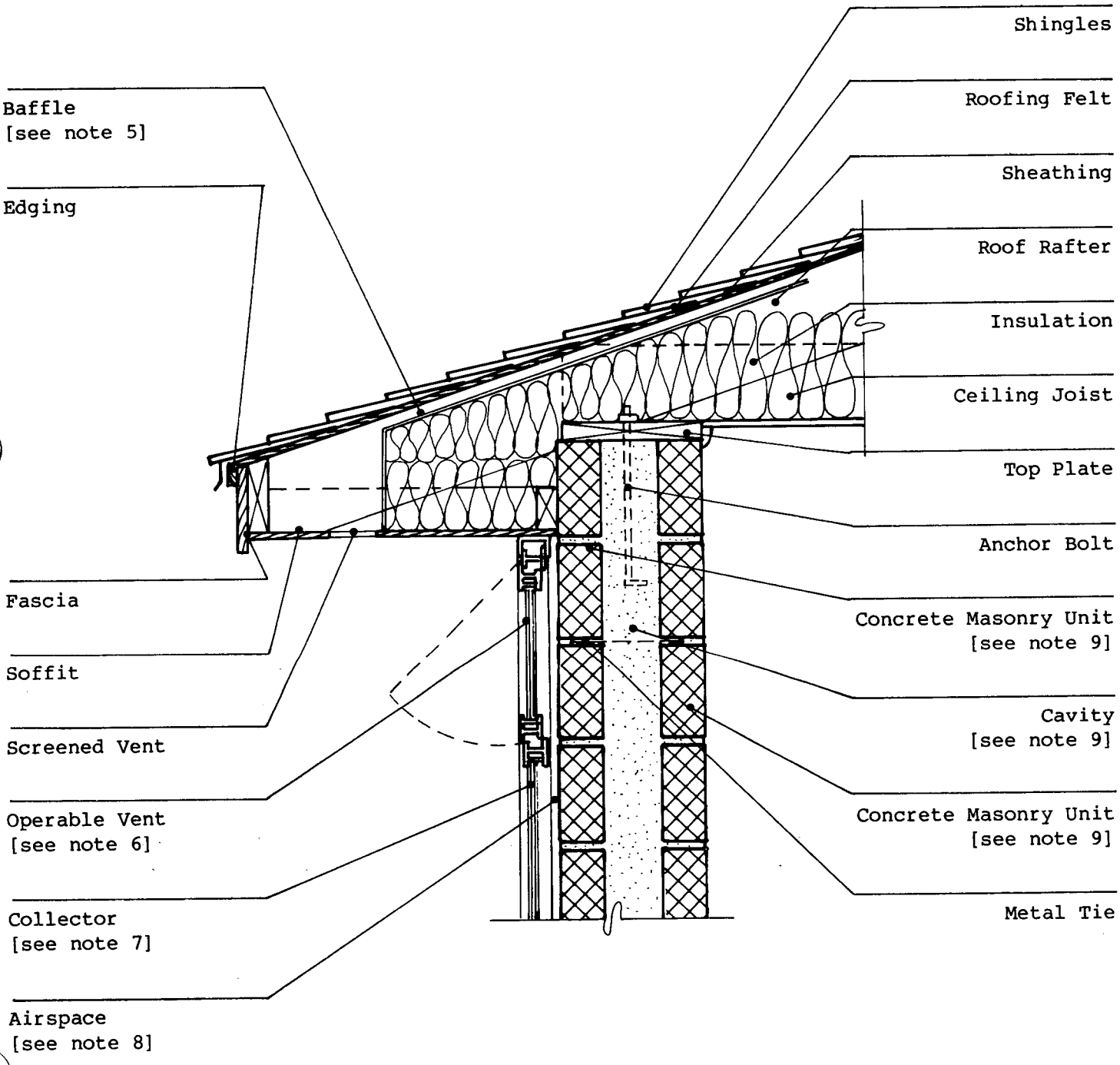
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
CMU/Cavity Wall
Roof

3.2246

Detail





[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections. Provide gutters and downspouts as required. Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.

[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.

[3] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.

[4] Insulation in ceiling must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

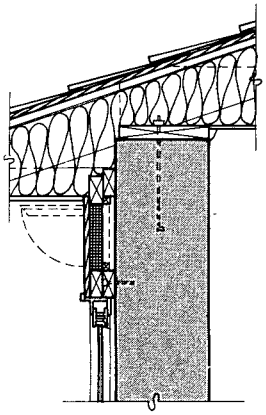
[5] Provide baffles where necessary to maintain 1" minimum airspace for venting attic.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

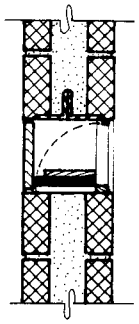
[7] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

[8] Width of airspace may vary. For further information, see Key Page 3.2102.

[9] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2122.



Opaque Insulated Exterior Vent

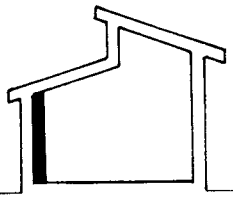


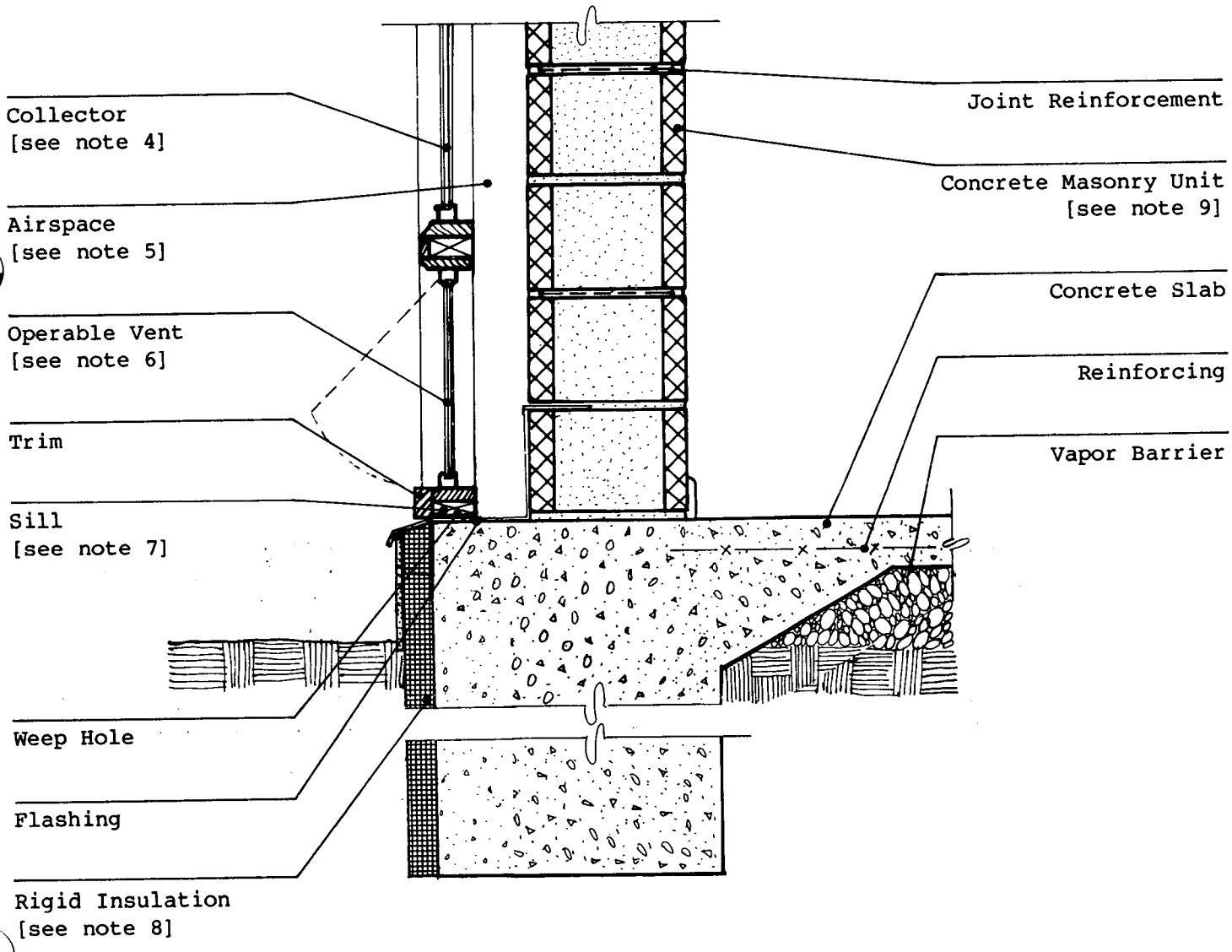
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Single Wythe CMU Wall
Concrete Slab-On-Grade

3.2248

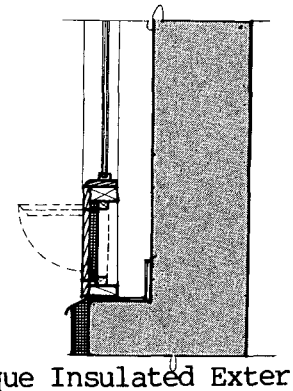
Detail



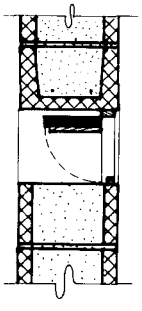


Thermal Storage Wall
Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code. Where ground water problems exist, provide sufficient granular fill at haunch to prevent water penetration at slab.
[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab is not recommended except where required by local conditions and/or code.
[3] Insulation levels at foundation/slab must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.
[5] Width of airspace may vary. For further information, see Key Page 3.2100.
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. For more information, see Section 3.2000.
[7] Sill can be wood or masonry at builder's option. Pressure treating should be specified if lumber is used. Sill to foundation and collector frame to foundation connections must meet local building codes.
[8] Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation.
[9] Single wythe Concrete Masonry Thermal Storage Wall must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2124.



Opaque Insulated Exterior Vent

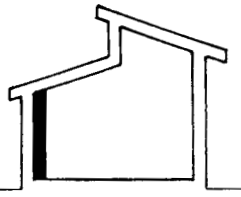


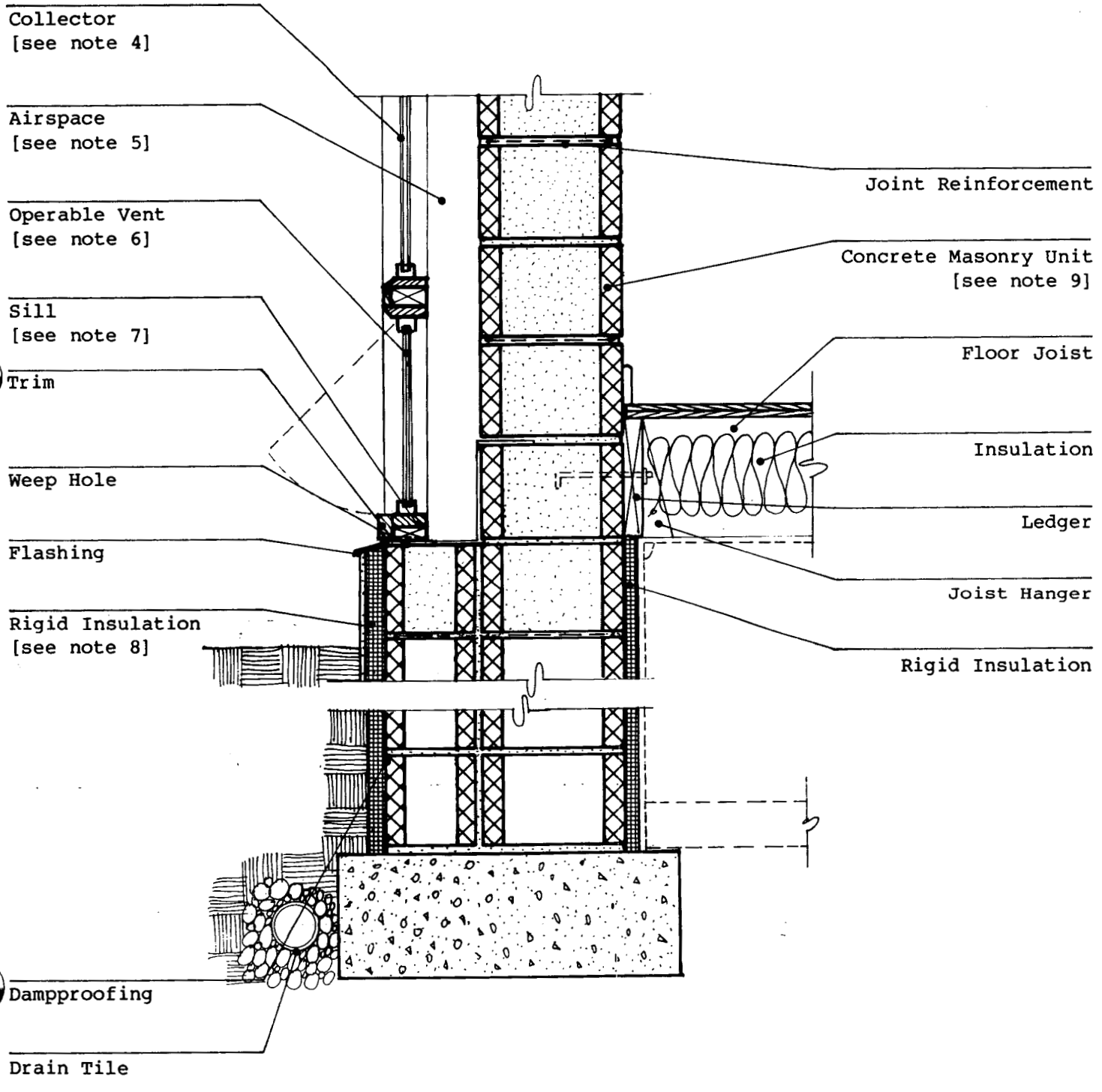
Operable Wall Vent

Thermal Storage Wall
Single Wythe CMU Wall
Wood First Floor

3.2250

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.

[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice.

[3] Insulation levels at floor must meet or exceed requirements of local building/ energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

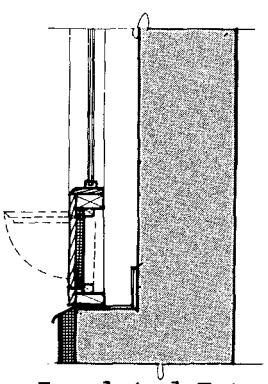
[5] Width of airspace may vary. For further information, see Key Page 3.2100.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

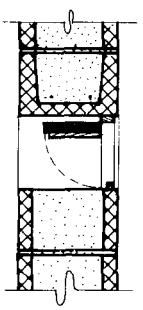
[7] Sill can be wood or masonry at builder's option. Pressure treating should be specified if lumber is used. Sill to foundation and collector frame to foundation connections must meet local building codes.

[8] It is recommended that the Thermal Storage Wall foundation be insulated on both sides to prevent heat losses to the outside and to the ground. In heated basements and heated crawl spaces insulation is not required on the inside. Insulation levels on both sides should be equal and should meet code requirements for foundation insulation. Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

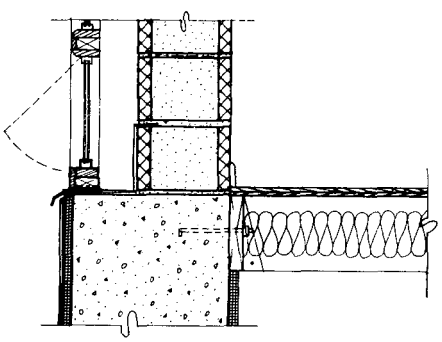
[9] Single wythe Concrete Masonry Thermal Storage Wall must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2124.



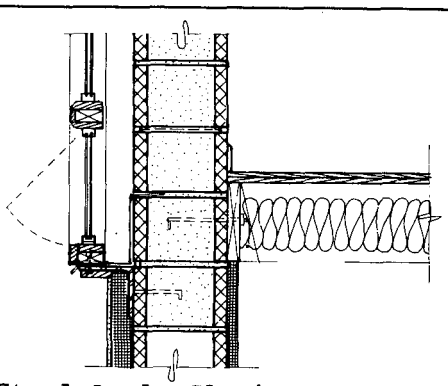
Opaque Insulated Exterior Vent



Operable Wall Vent



Concrete Foundation

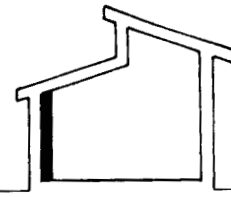


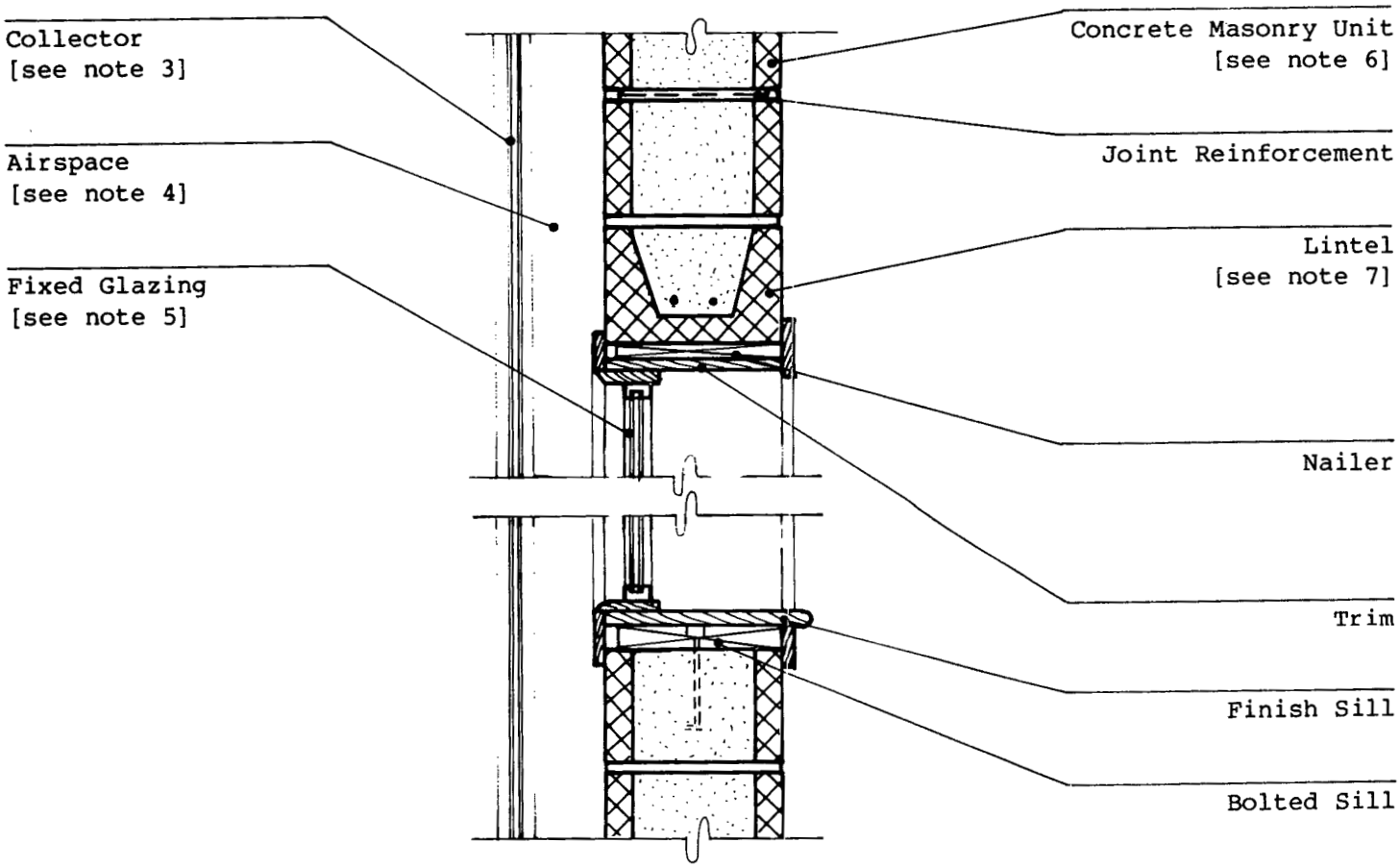
Steel Angle Glazing Support

Thermal Storage Wall
Single Wythe CMU Wall
Direct Gain Window

3.2252

Detail





Construction Notes

[1] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice.

[2] The storage mass should not be insulated. For further information, see Sections 2.2200 and 3.2000.

[3] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

[4] Width of airspace may vary. For further information, see Key Page 3.2100.

[5] Conventional window for light, view and/or Direct Gain may be single or double glazed. For information on Direct Gain systems see Section 3.1000.

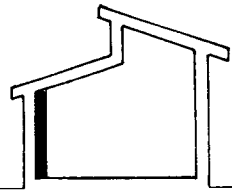
[6] Single wythe Concrete Masonry Thermal Storage Wall must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2124.

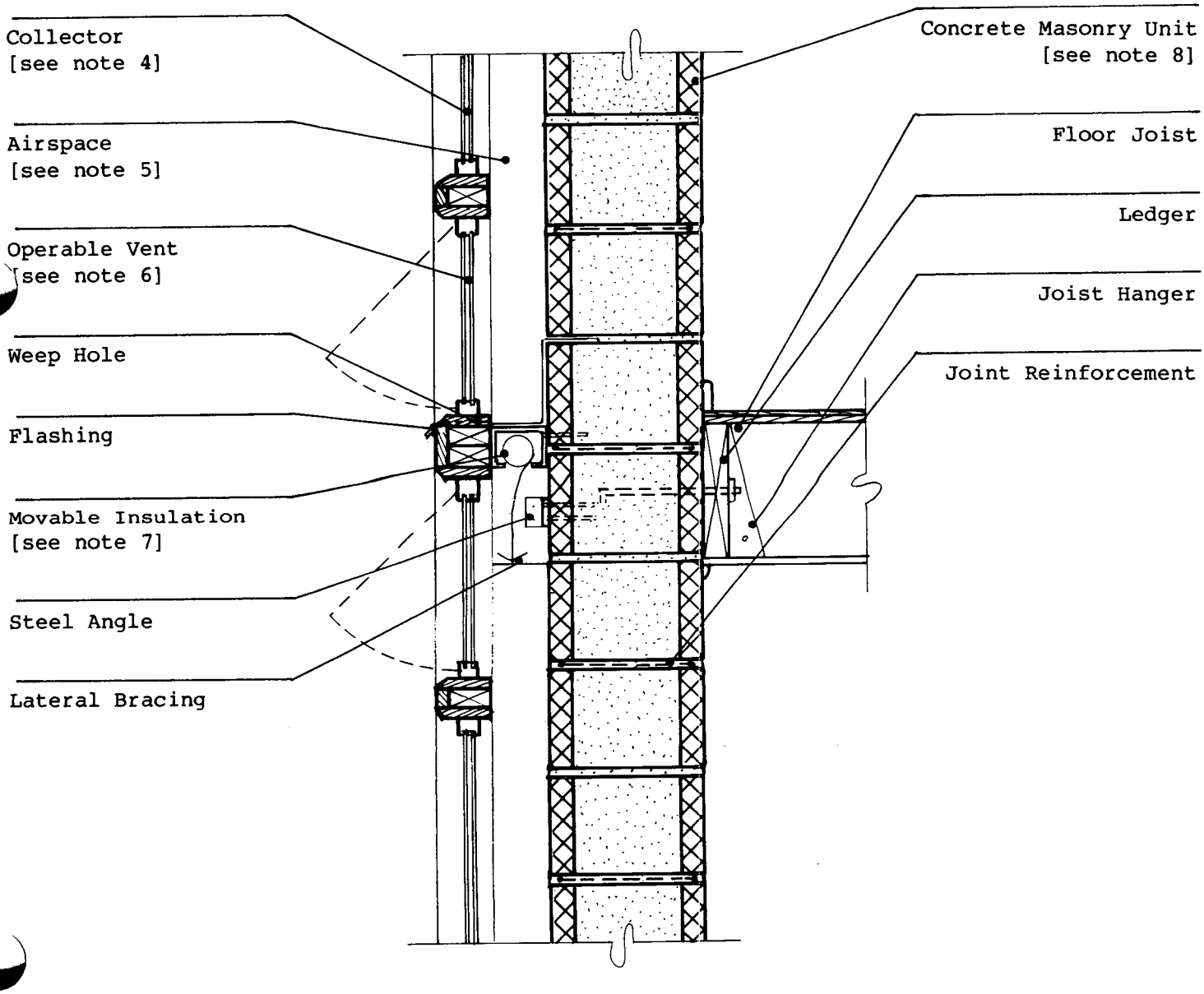
[7] Lintel may be bond-beam, lintel, or standard Concrete Masonry units with depressed, cut-out or grooved webs, or precast concrete. Provide 6" minimum bearing at each end. Reinforcing designed for loading and clear span per local building codes and/or accepted practice.

Thermal Storage Wall
Single Wythe CMU Wall
Wood Upper Floor

3.2254

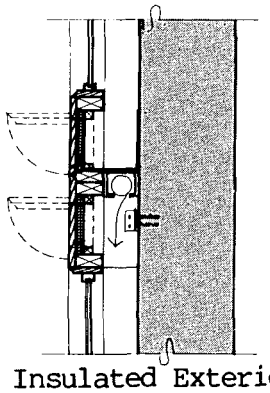
Detail



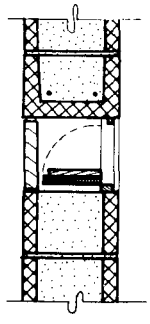


Thermal Storage Wall
Construction Notes

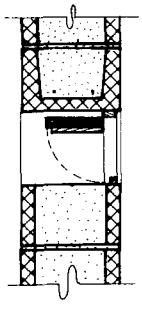
[1] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.
[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice.
[3] The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.
[5] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Where airspace is not continuous, top and bottom vents should be provided for each section. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[7] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. Where upper and lower portions of Thermal Storage Wall are separated, movable insulation must be installed in each section. For further information, see Sections 3.2000 and 4.4300.
[8] Single wythe Concrete Masonry Thermal Storage Wall must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2124.



Opaque Insulated Exterior Vents



Operable Wall Vent with Backdraft Damper

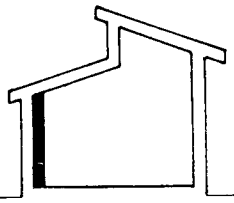


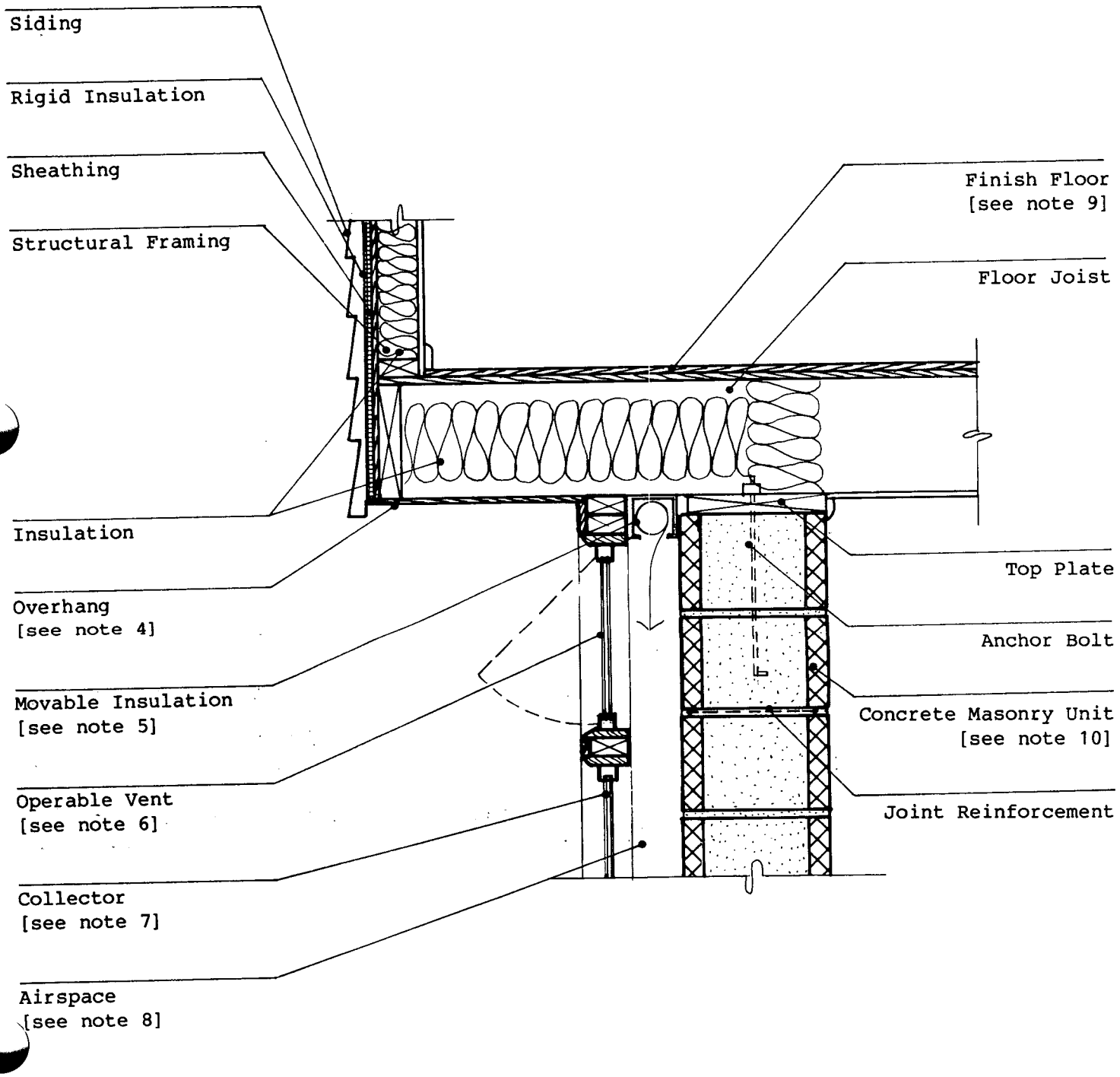
Operable Wall Vent

Thermal Storage Wall
Single Wythe CMU Wall
Wood Upper Floor Overhang

3.2256

Detail





Thermal Storage Wall
Construction Notes

[1] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.

[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.

[3] Insulation levels at frame wall and floor at overhang must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.

[5] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. For further information see Sections 3.2000 and 4.4300.

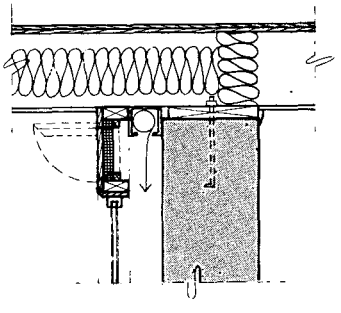
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

[7] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

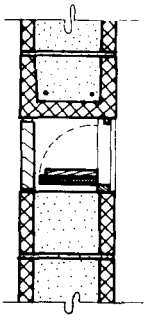
[8] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.

[9] Direct Gain system may be incorporated into upper level design. For further information, see Section 3.1000.

[10] Single wythe Concrete Masonry Thermal Storage Wall must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2124.



Opaque Insulated Exterior Vent

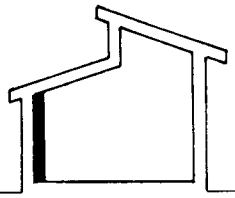


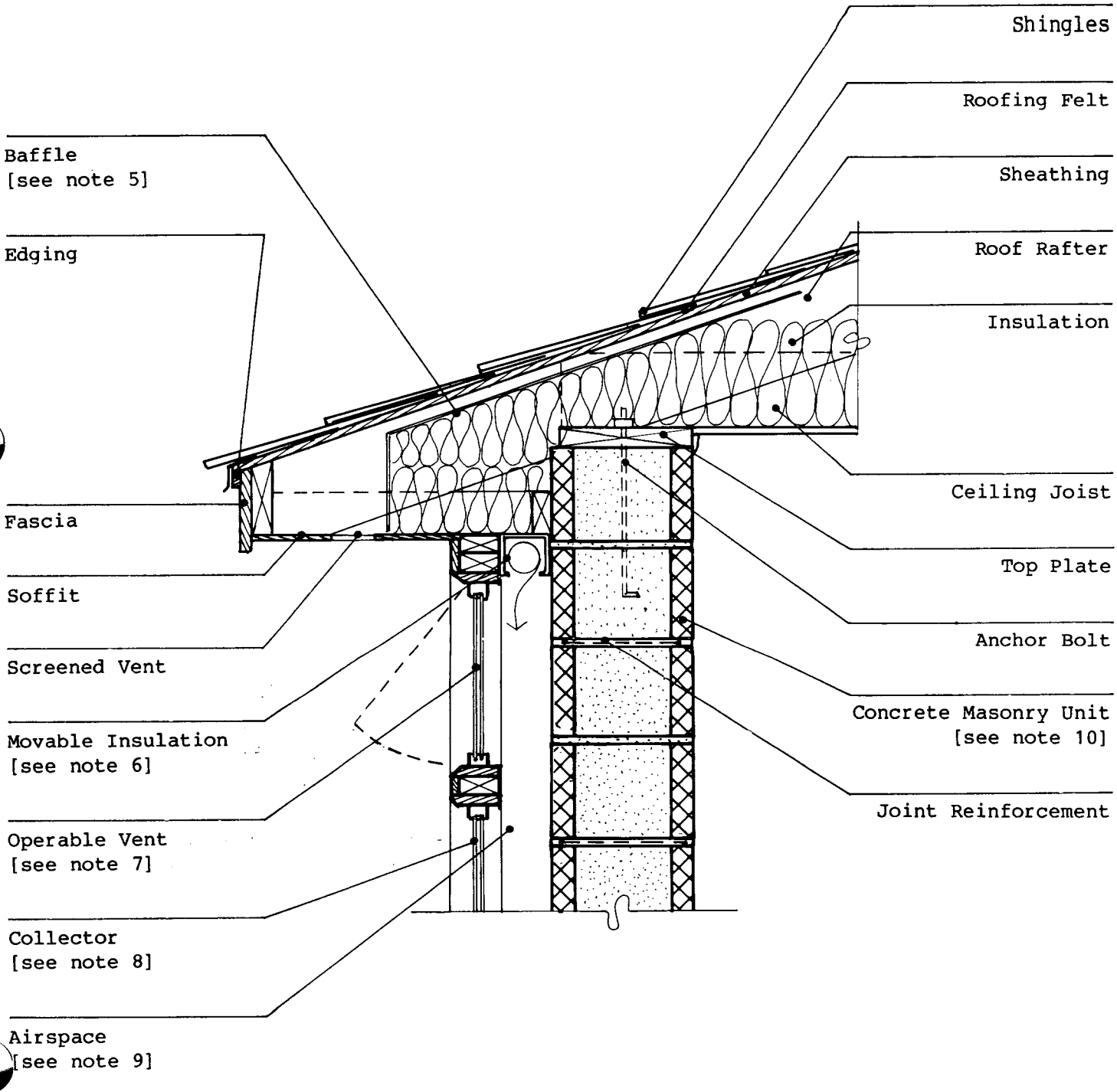
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Single Wythe CMU Wall
Roof

3.2258

Detail





Thermal Storage Wall
Construction Notes

[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections. Provide gutters and downspouts as required. Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.

[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.

[3] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.

[4] Insulation in ceiling must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[5] Provide baffles where necessary to maintain 1" minimum airspace for venting attic.

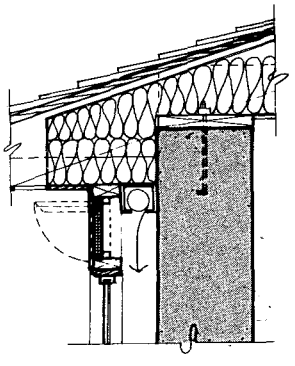
[6] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. For further information see Sections 3.2000 and 4.4300.

[7] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

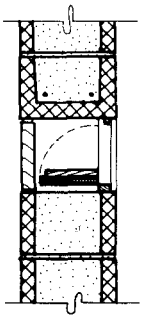
[8] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

[9] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.

[10] Single wythe Concrete Masonry Thermal Storage Wall must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2124.



Opaque Insulated Exterior Vent

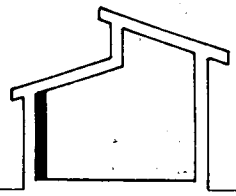


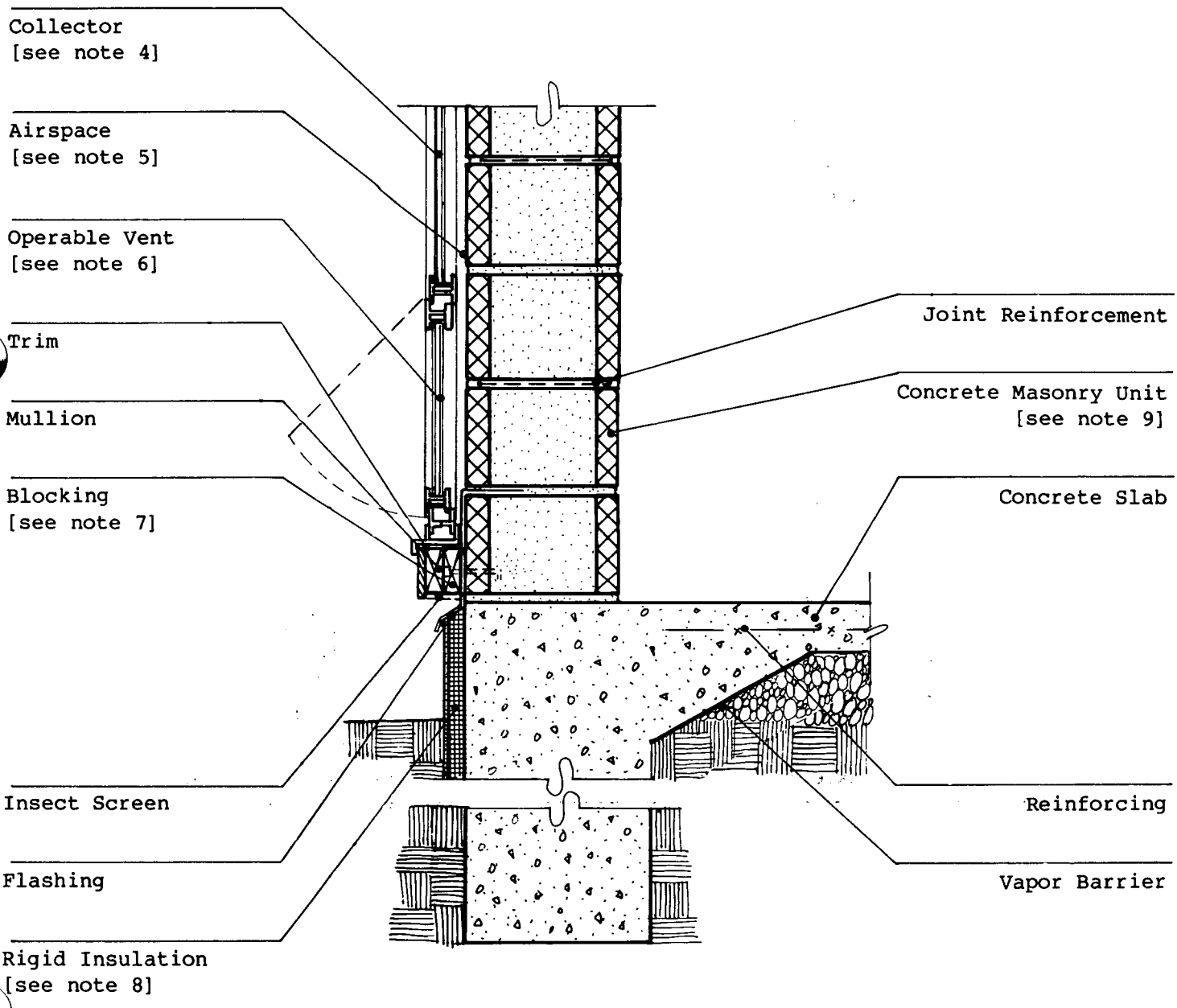
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Single Wythe CMU Wall
Concrete Slab-On-Grade

3.2260

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code. Where ground water problems exist, provide sufficient granular fill at haunch to prevent water penetration at slab.

[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code.

[3] Insulation levels at foundation/slab must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

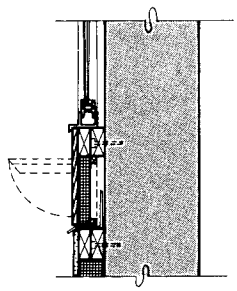
[5] Width of airspace may vary. For further information, see Key Page 3.2102.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

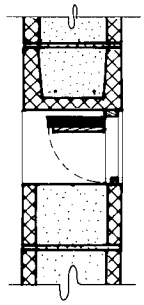
[7] Blocking can be discontinuous to provide weep holes where required. It is recommended that wood be pressure treated and insect screens (as shown) be provided at weep holes.

[8] Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

[9] Single wythe Concrete Masonry Thermal Storage Wall must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2124.



Opaque Insulated Exterior Vent

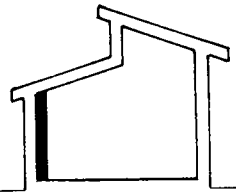


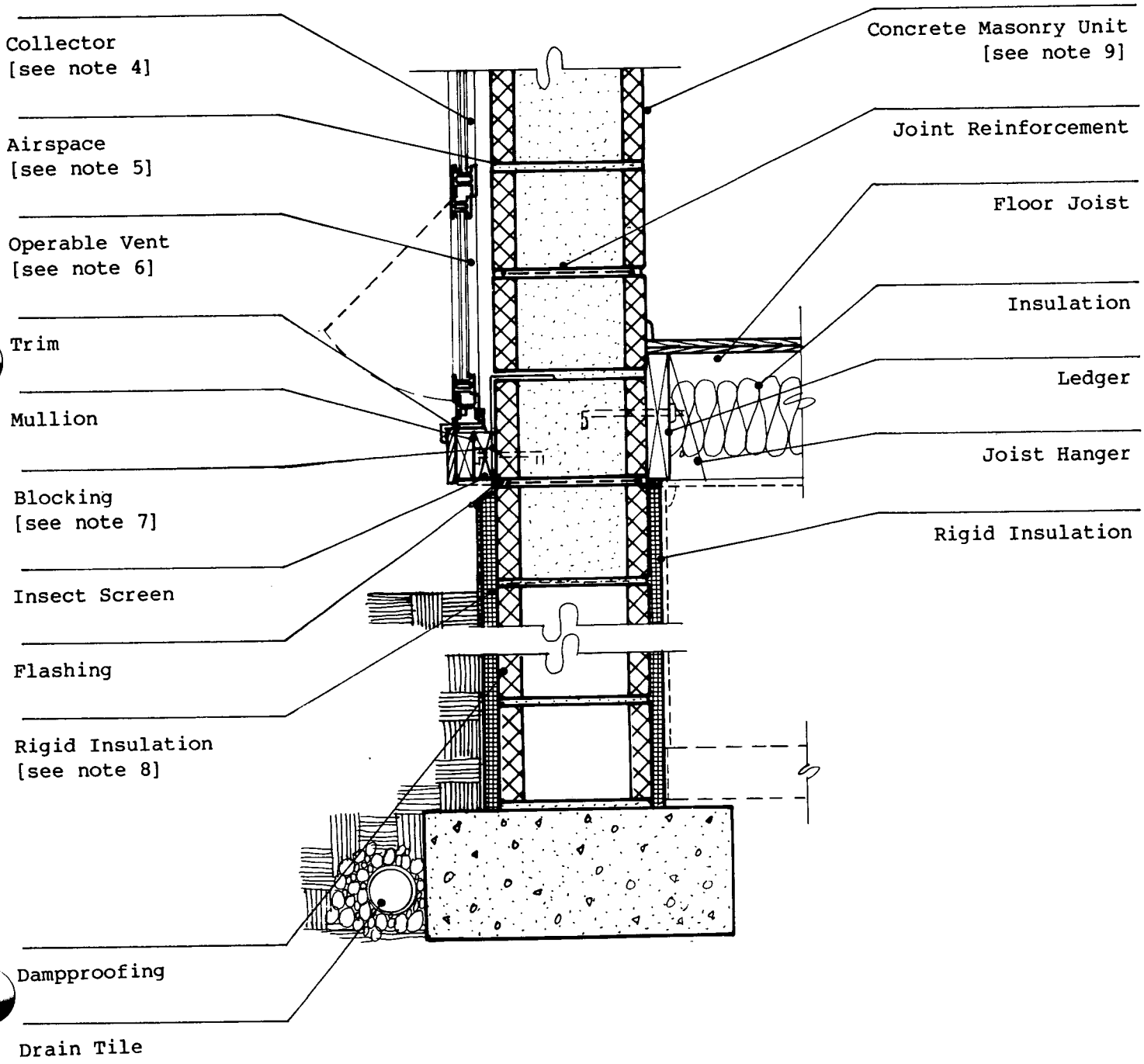
Operable Wall Vent

Thermal Storage Wall
Single Wythe CMU Wall
Wood First Floor

3.2262

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.

[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice.

[3] Insulation levels at floor must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

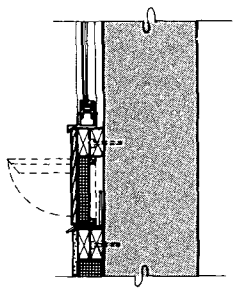
[5] Width of airspace may vary. For further information, see Key Page 3.2102.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

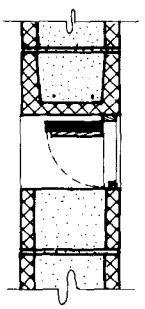
[7] Blocking can be discontinuous to provide weep holes where required. It is recommended that wood be pressure treated and insect screens (as shown) be provided at weep holes.

[8] It is recommended that the Thermal Storage Wall foundation be insulated on both sides to prevent heat losses to the outside and to the ground. In heated basements and heated crawl spaces insulation is not required on the inside. Insulation levels on both sides should be equal and should meet code requirements for foundation insulation. Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

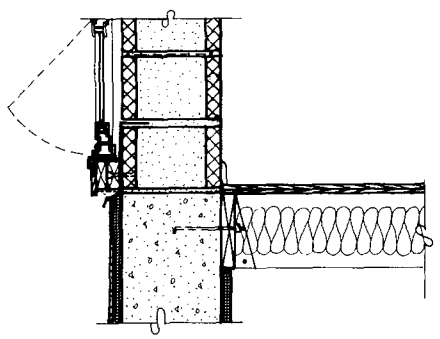
[9] Single wythe Concrete Masonry Thermal Storage Wall must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2124.



Opaque Insulated Exterior Vent



Operable Wall Vent

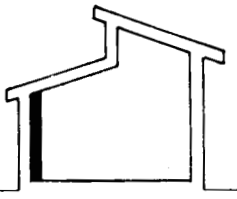


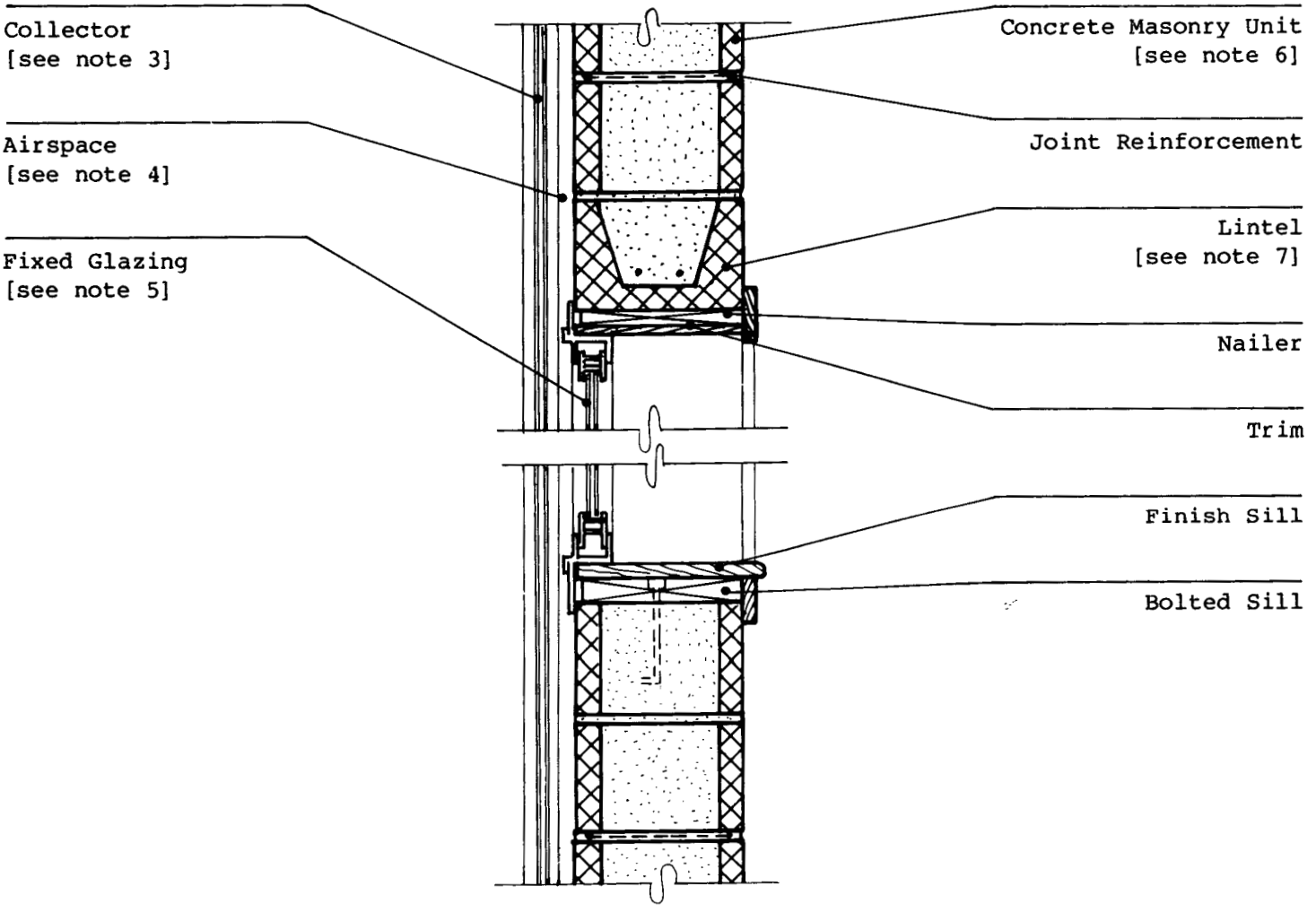
Concrete Foundation

Thermal Storage Wall
Single Wythe CMU Wall
Direct Gain Window

3.2264

Detail





Construction Notes

[1] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice.

[2] The storage mass should not be insulated. For further information, see Section 3.2000.

[3] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

[4] Width of airspace may vary. For further information, see Key Page 3.2102.

[5] Conventional window for light, view and/or Direct Gain may be single or double glazed. For information on Direct Gain systems, see Section 3.1000.

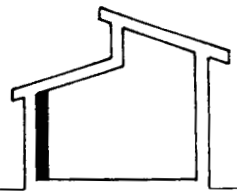
[6] Single wythe Concrete Masonry Thermal Storage Wall must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2124.

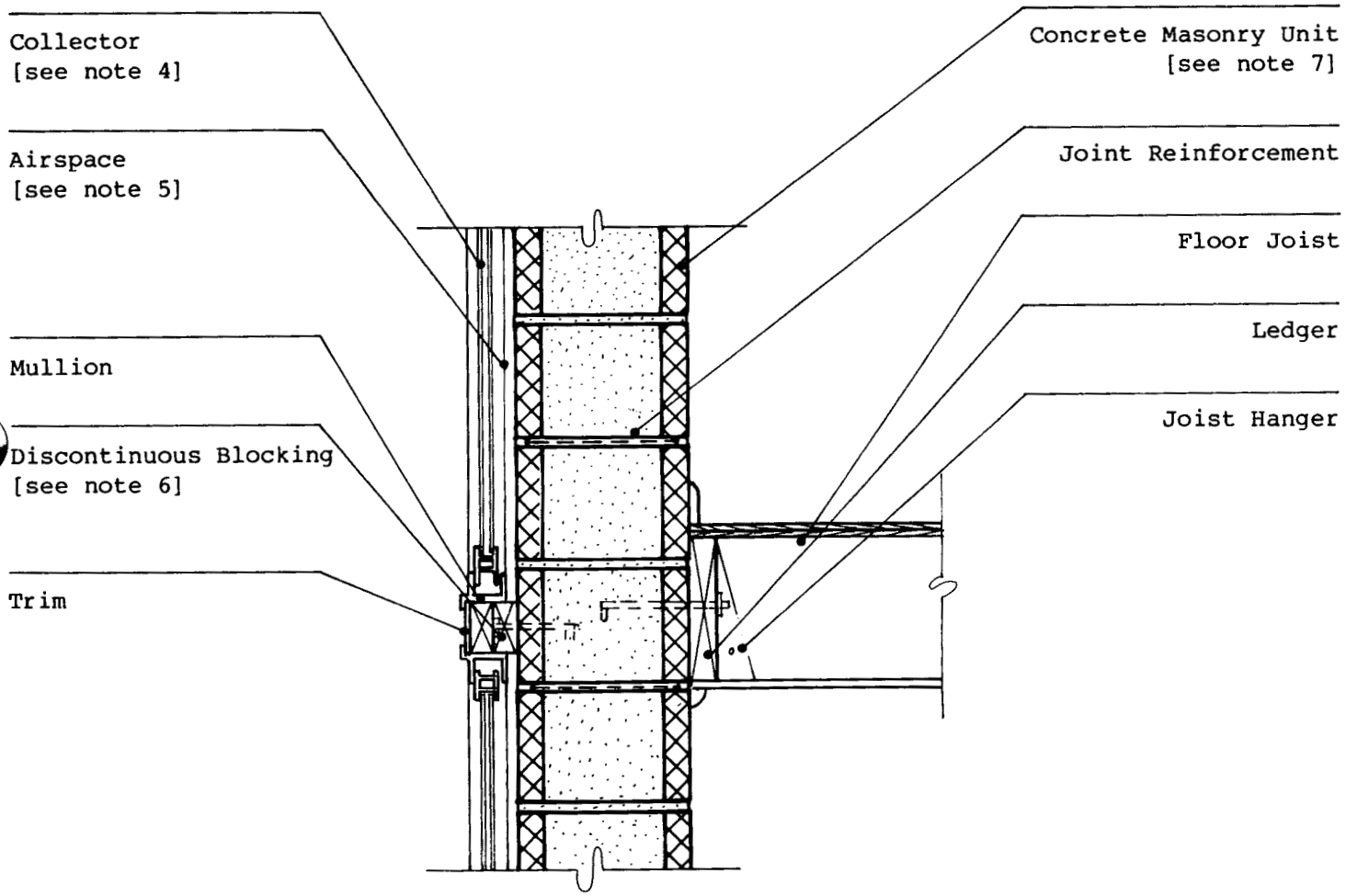
[7] Lintel may be bond-beam, lintel, or standard Concrete Masonry units with depressed, cut-out or grooved webs, or precast concrete. Provide 6" minimum bearing at each end. Reinforcing designed for loading and clear span per local building codes and/or accepted practice.

Thermal Storage Wall
Single Wythe CMU Wall
Wood Upper Floor

3.2266

Detail



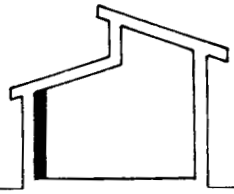


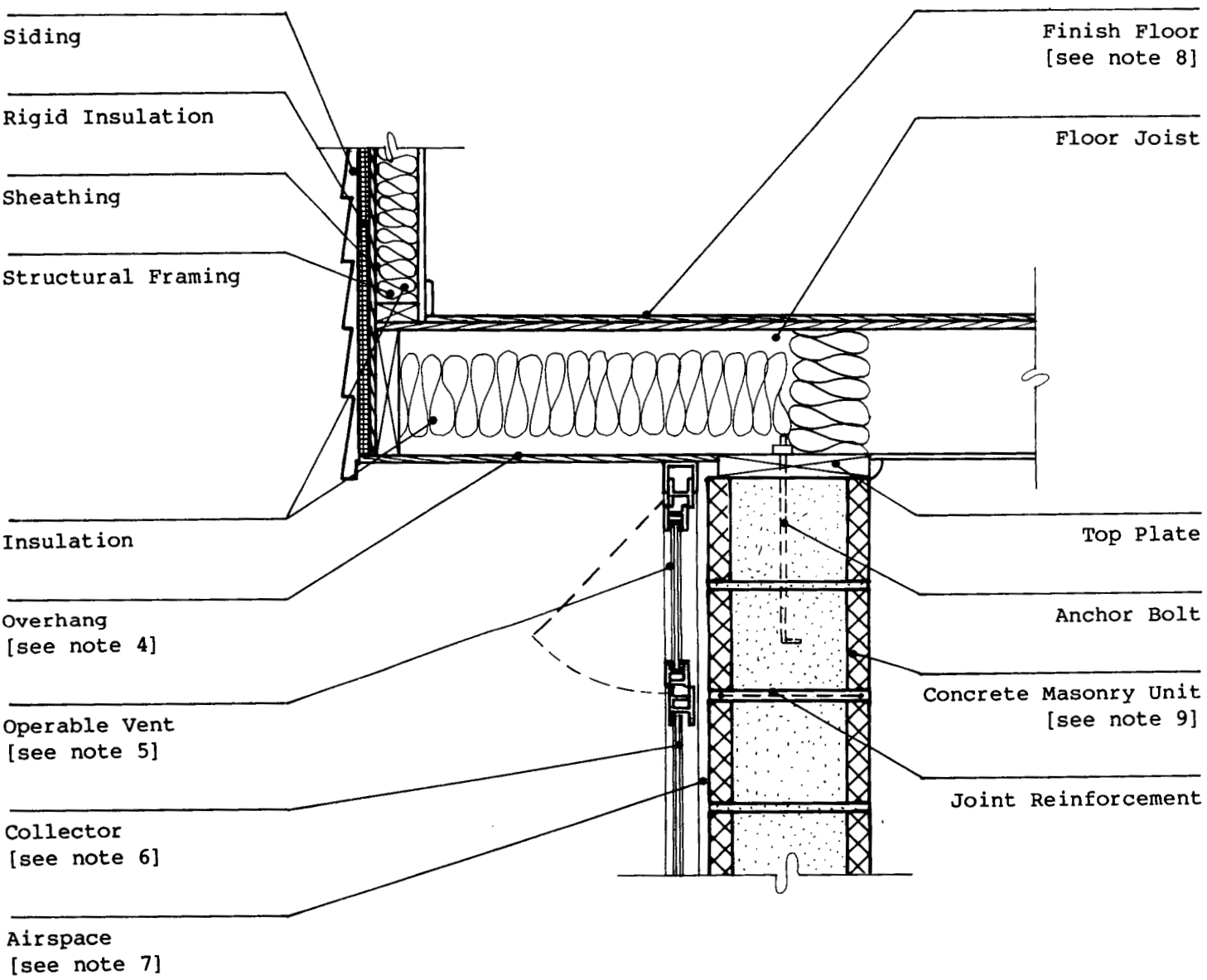
[1] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.
[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice.
[3] The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[5] Width of airspace may vary. For further information, see Key Page 3.2102.
[6] Discontinuous blocking to allow for adequate air circulation in airspace.
[7] Single wythe Concrete Masonry Thermal Storage Wall must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2124.

Thermal Storage Wall
Single Wythe CMU Wall
Wood Upper Floor Overhang

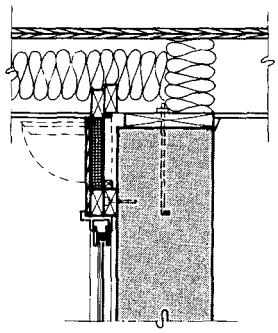
3.2268

Detail

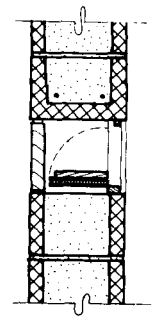




[1] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.
[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.
[3] Insulation levels at frame wall and floor at overhang must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.
[5] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[6] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[7] Width of airspace may vary. For further information, see Key Page 3.2102.
[8] Direct Gain system may be incorporated into upper level design. For further information, see Section 3.1000.
[9] Single wythe Concrete Masonry Thermal Storage Wall must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2124.



Opaque Insulated Exterior Vent

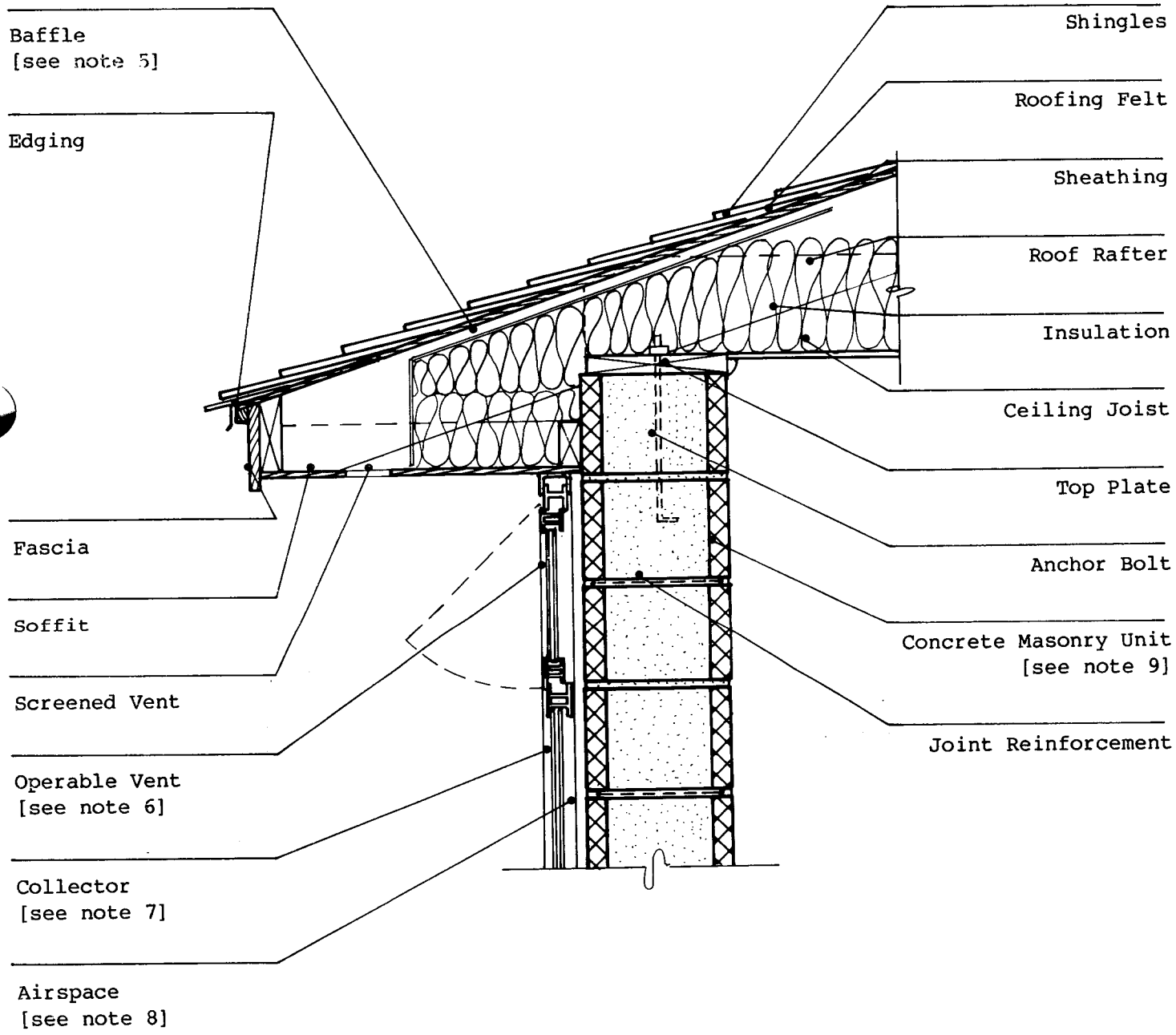


Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Single Wythe CMU Wall
Roof

3.2270

Detail



Thermal Storage Wall
Construction Notes

[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections. Provide gutters and downspouts as required. Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.

[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.

[3] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.

[4] Insulation in ceiling must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

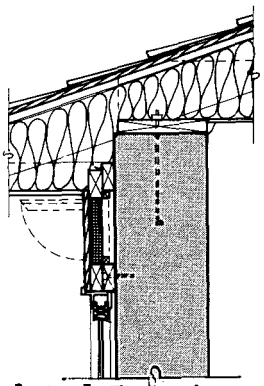
[5] Provide baffles where necessary to maintain 1" minimum airspace for venting attic.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

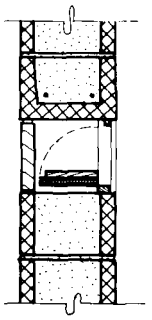
[7] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

[8] Width of airspace may vary. For further information, see Key Page 3.2102.

[9] Single wythe Concrete Masonry Thermal Storage Wall must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2124.



Opaque Insulated Exterior Vent

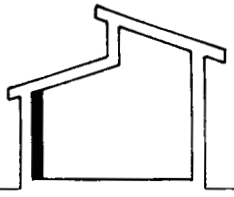


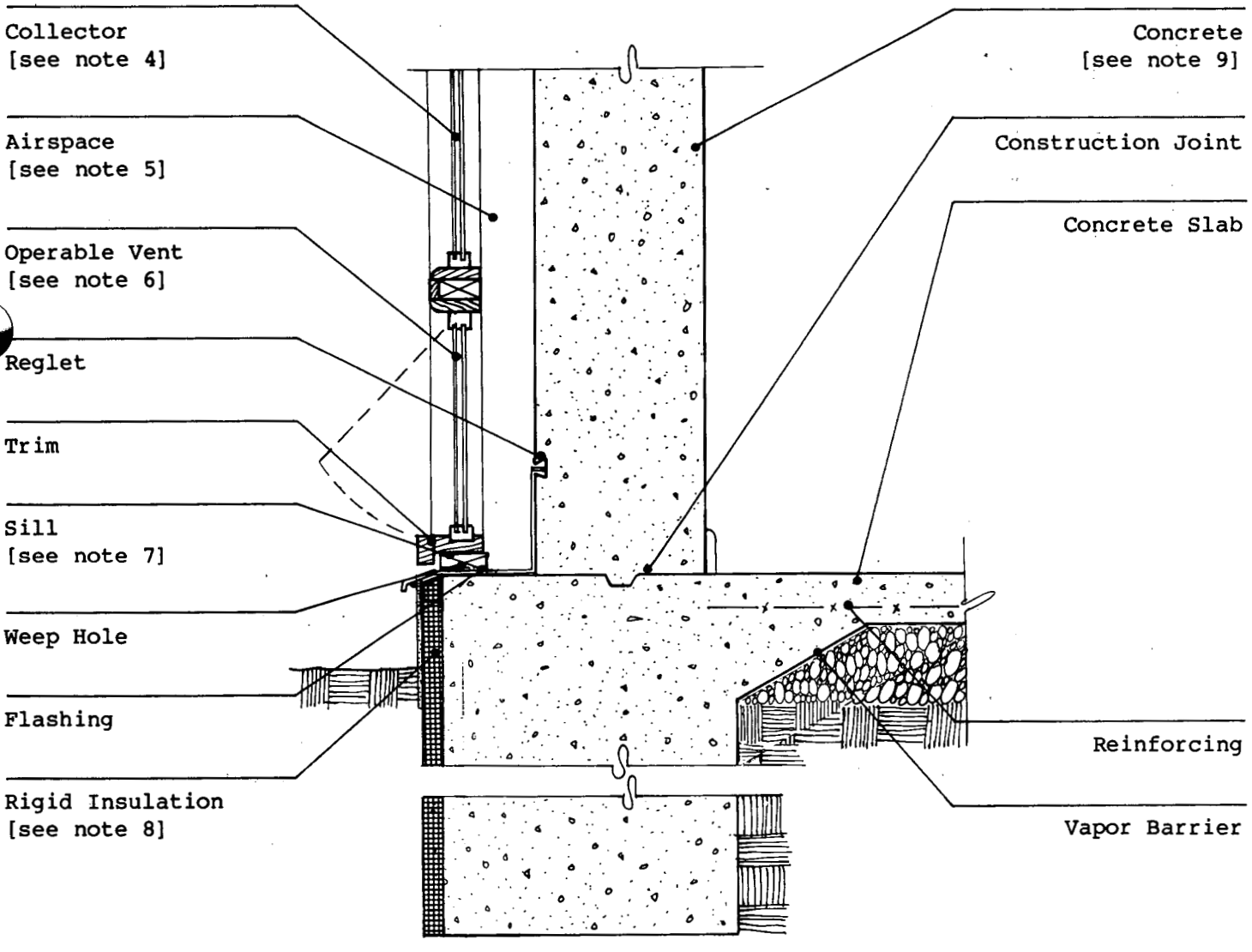
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Concrete Wall
Concrete Slab-On-Grade

3.2272

Detail





Thermal Storage Wall
Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code. Where ground water problems exist, provide sufficient granular fill at haunch to prevent water penetration at slab.

[2] Placement of reinforcing, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab is not recommended except where required by local conditions and/or code.

[3] Insulation levels at foundation/slab must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

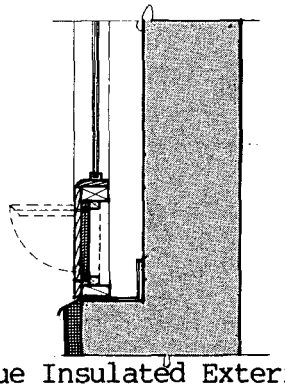
[5] Width of airspace may vary. For further information, see Key Page 3.2100.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. For more information, see Section 3.2000.

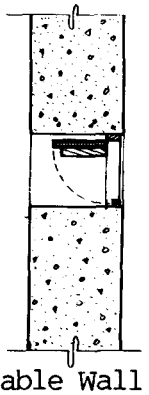
[7] Sill can be wood or masonry at builder's option. Pressure treating should be specified if lumber is used. Sill to foundation and collector frame to foundation connections must meet local building codes.

[8] Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation.

[9] Concrete Thermal Storage Wall. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2126.



Opaque Insulated Exterior Vent

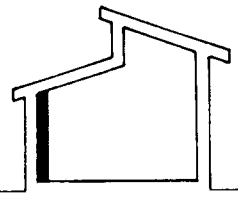


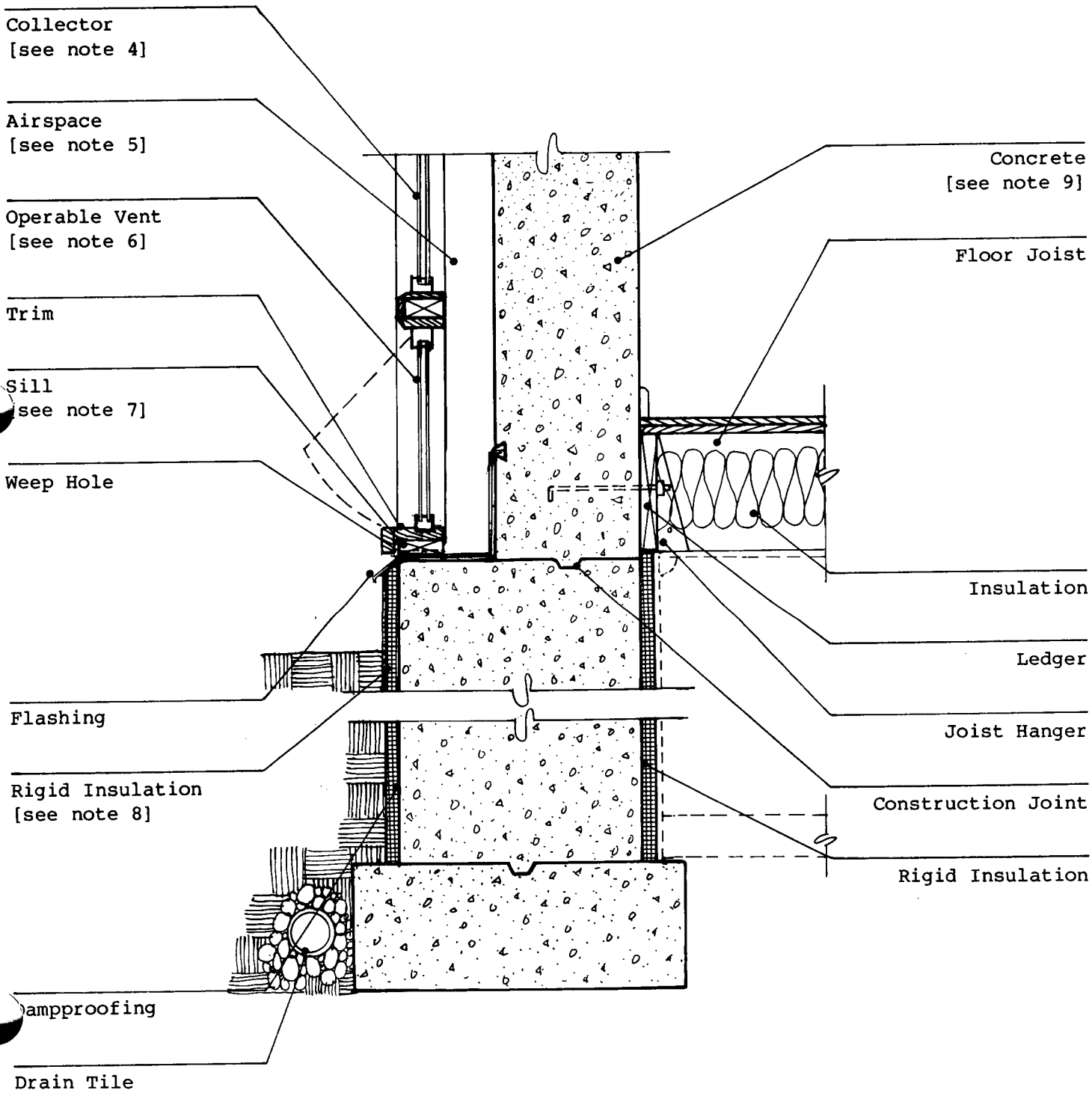
Operable Wall Vent

Thermal Storage Wall
Concrete Wall
Wood First Floor

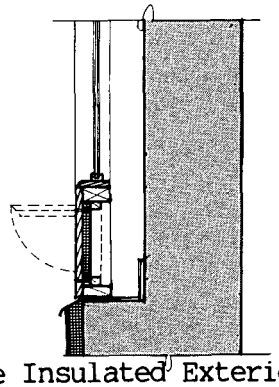
3.2274

Detail

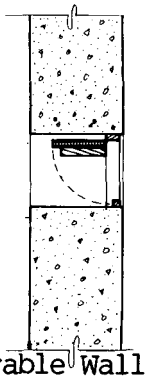




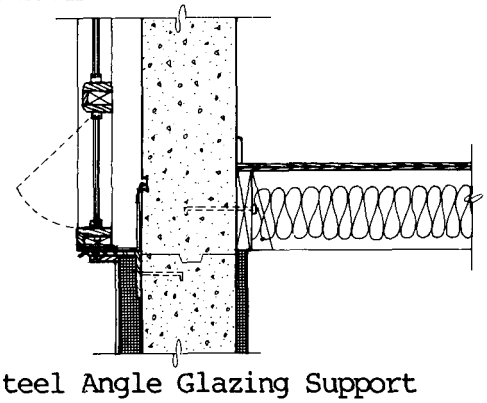
[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.
[2] Placement of reinforcing, flashing and weep holes to be determined by local building codes and/or accepted practice.
[3] Insulation levels at floor must meet or exceed requirements of local building/ energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.
[5] Width of airspace may vary. For further information, see Key Page 3.2100.
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[7] Sill can be wood or masonry at builder's option. Pressure treating should be specified if lumber is used. Sill to foundation and collector frame to foundation connections must meet local building codes.
[8] It is recommended that the Thermal Storage Wall foundation be insulated on both sides to prevent heat losses to the outside and to the ground. In heated basements and heated crawl spaces insulation is not required on the inside. Insulation levels on both sides should be equal and should meet code requirements for foundation insulation. Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.
[9] Concrete Thermal Storage Wall. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2126.



Opaque Insulated Exterior Vent



Operable Wall Vent

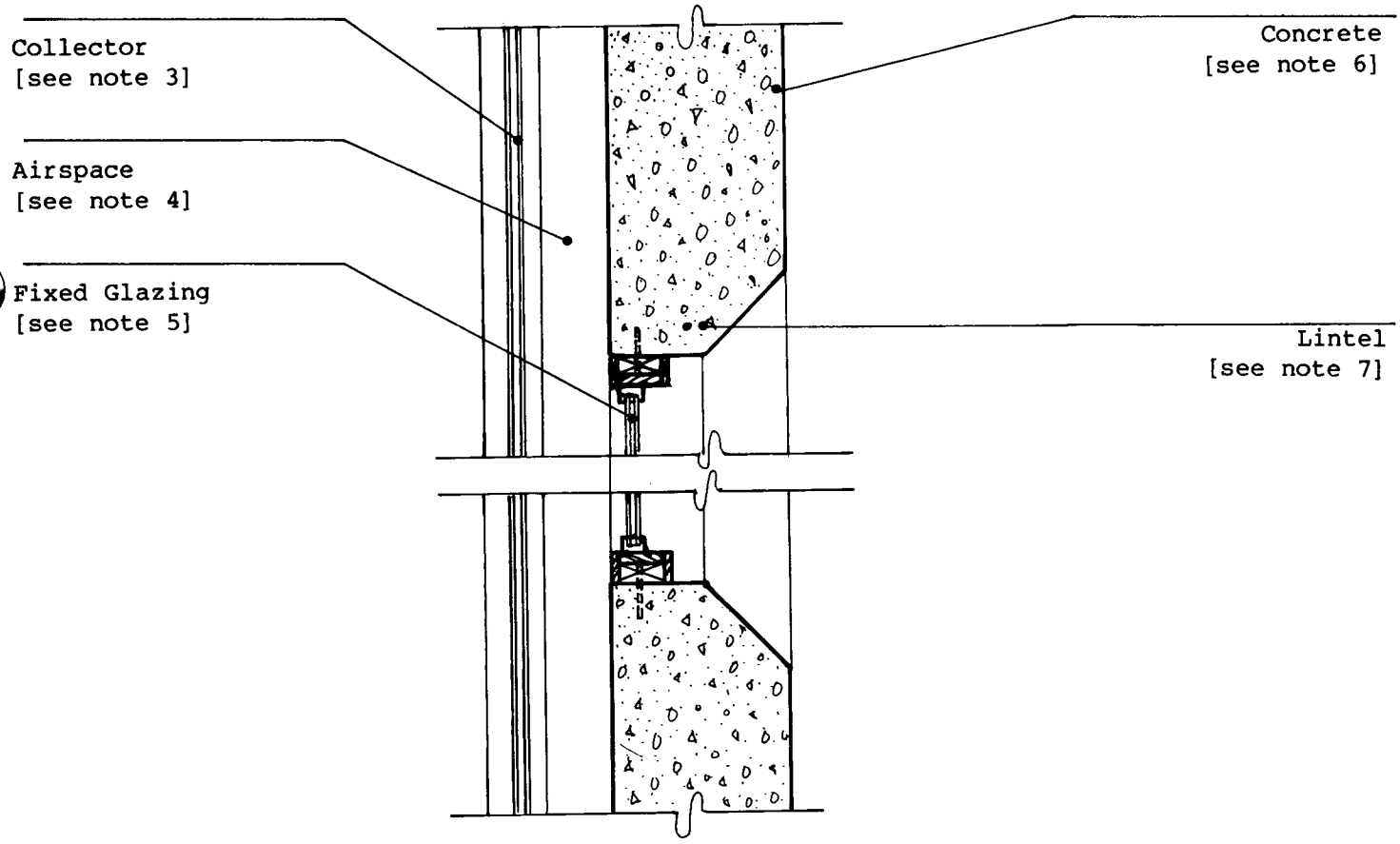


Steel Angle Glazing Support

Thermal Storage Wall
Concrete Wall
Direct Gain Window

3.2276

Detail



Construction Notes

[1] Placing of reinforcing to be determined by local building codes and/or accepted practice.

[2] The storage mass should not be insulated. For further information, see Section 3.2000.

[3] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

[4] Width of airspace may vary. For further information, see Key Page 3.2100.

[5] Conventional window for light, view and/or Direct Gain may be single or double glazed. For information on Direct Gain systems see Section 3.1000.

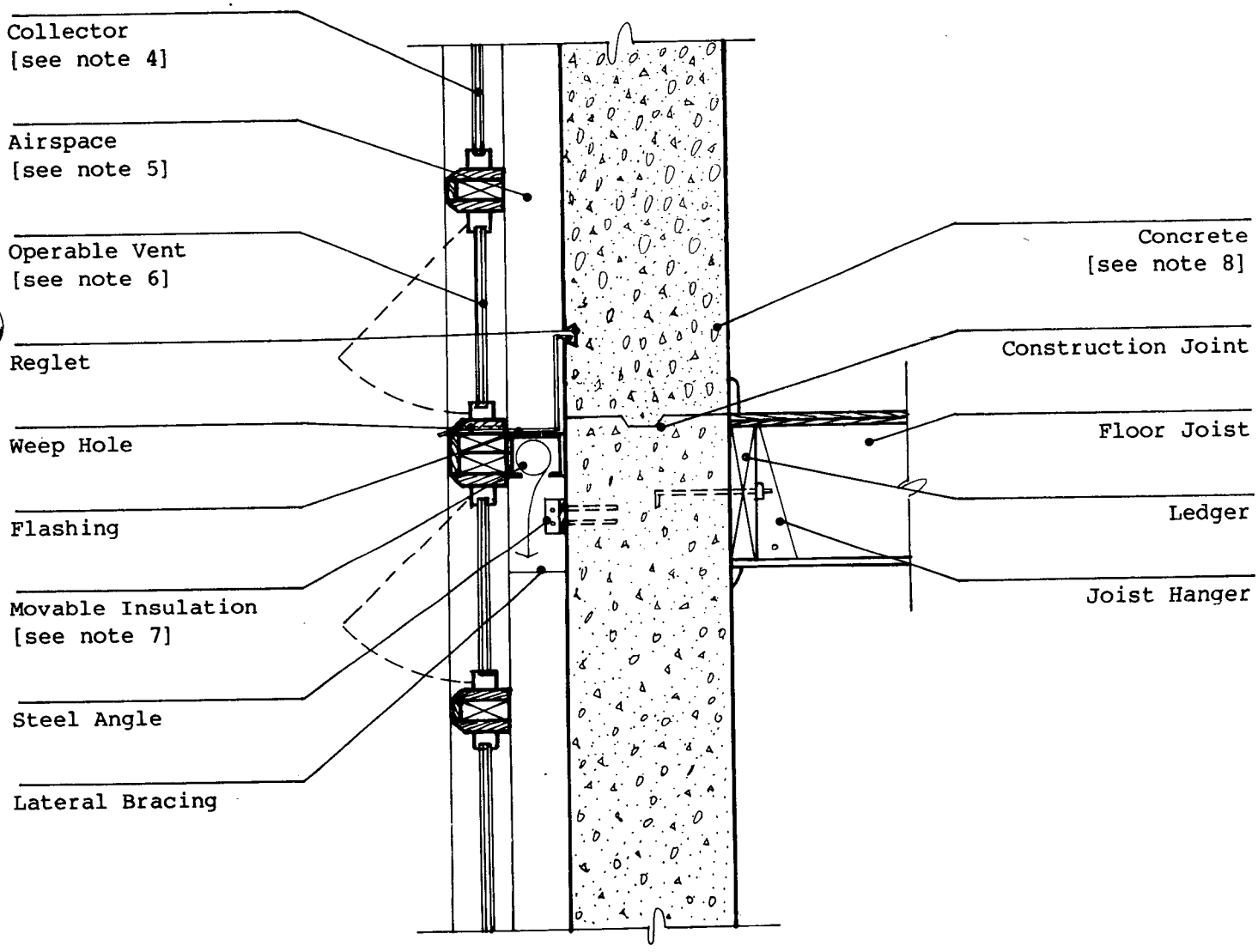
[6] Concrete Thermal Storage Wall. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2126.

[7] Opening may be beveled, providing more even distribution of light to space. Steel reinforcing designed for loading and clear span per local building codes and/or accepted practice. Alternate precast concrete lintel may be specified at builder's option.

Thermal Storage Wall
Concrete Wall
Wood Upper Floor

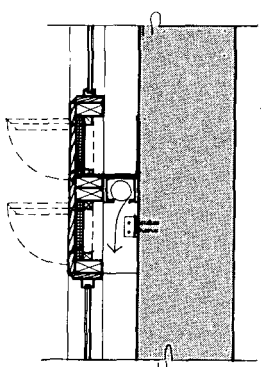
3.2278

Detail

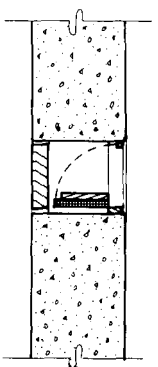


Thermal Storage Wall
Construction Notes

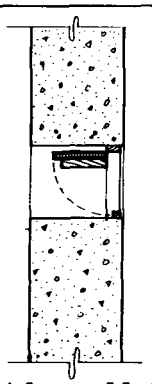
[1] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.
[2] Placement of reinforcing, flashing and weep holes to be determined by local building codes and/or accepted practice.
[3] The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.
[5] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Where airspace is not continuous, top and bottom vents should be provided for each section. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[7] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. Where upper and lower portions of Thermal Storage Wall are separated, movable insulation must be installed in each section. For further information, see Sections 3.2000 and 4.4300.
[8] Concrete Thermal Storage Wall. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2126.



Opaque Insulated Exterior Vents



Operable Wall Vent with Backdraft Damper

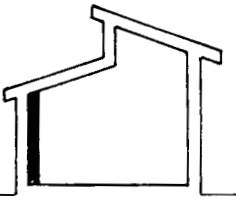


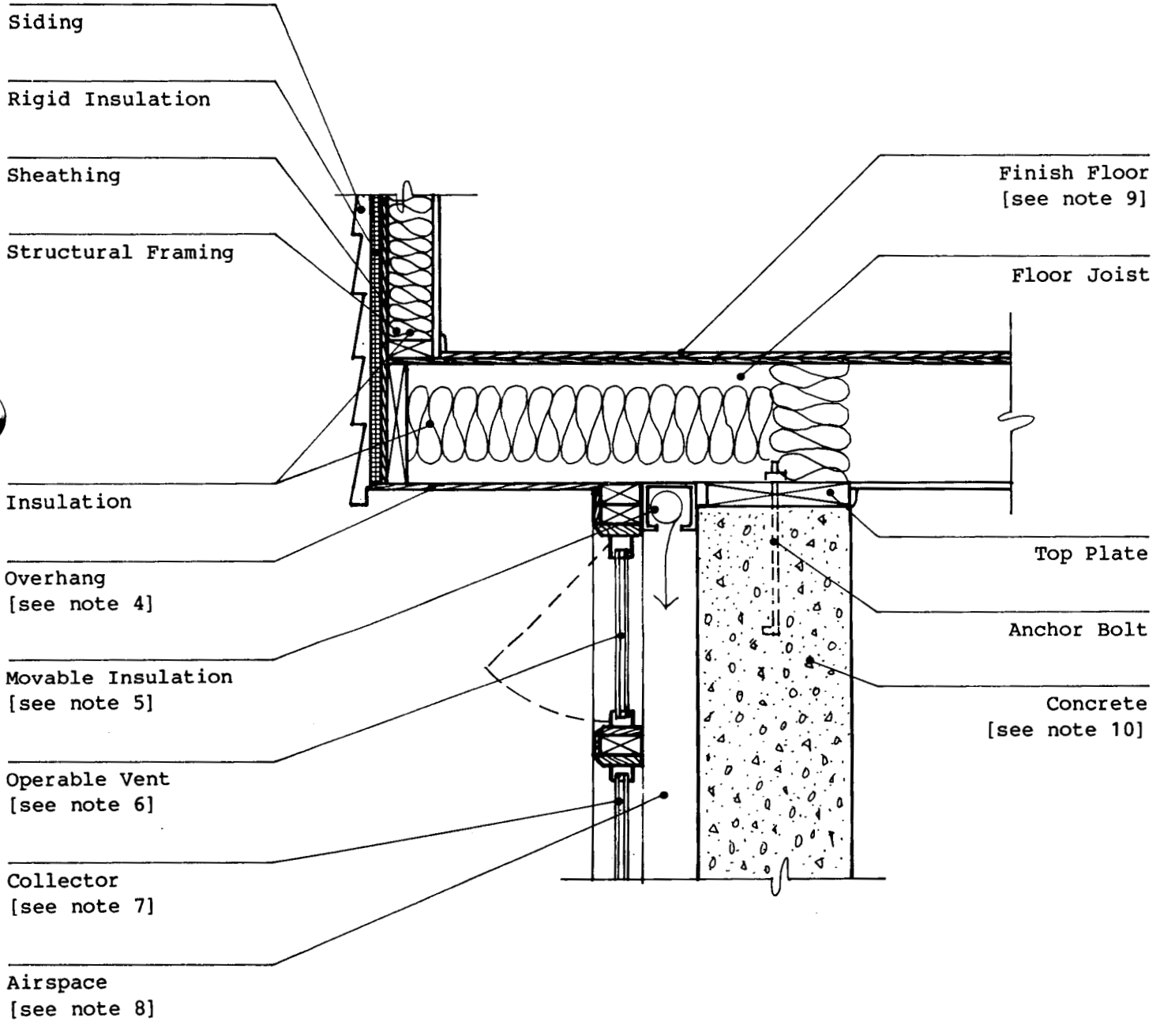
Operable Wall Vent

Thermal Storage Wall
Concrete Wall
Wood Upper Floor Overhang

3.2280

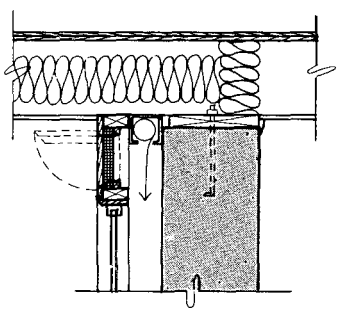
Detail



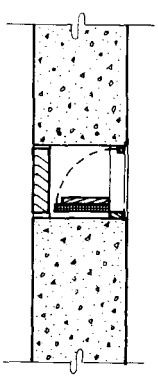


Thermal Storage Wall
Construction Notes

[1] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.
[2] Placement of reinforcing and anchor bolts to be determined by local building codes and/or accepted practice.
[3] Insulation levels at frame wall and floor at overhang must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.
[5] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. For further information see Sections 3.2000 and 4.4300.
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[7] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.
[8] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.
[9] Direct Gain system may be incorporated into upper level design. For further information, see Section 3.1000.
[10] Concrete Thermal Storage Wall. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2126.



Opaque Insulated Exterior Vent

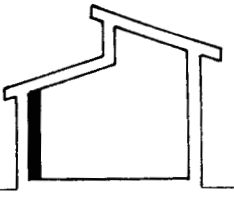


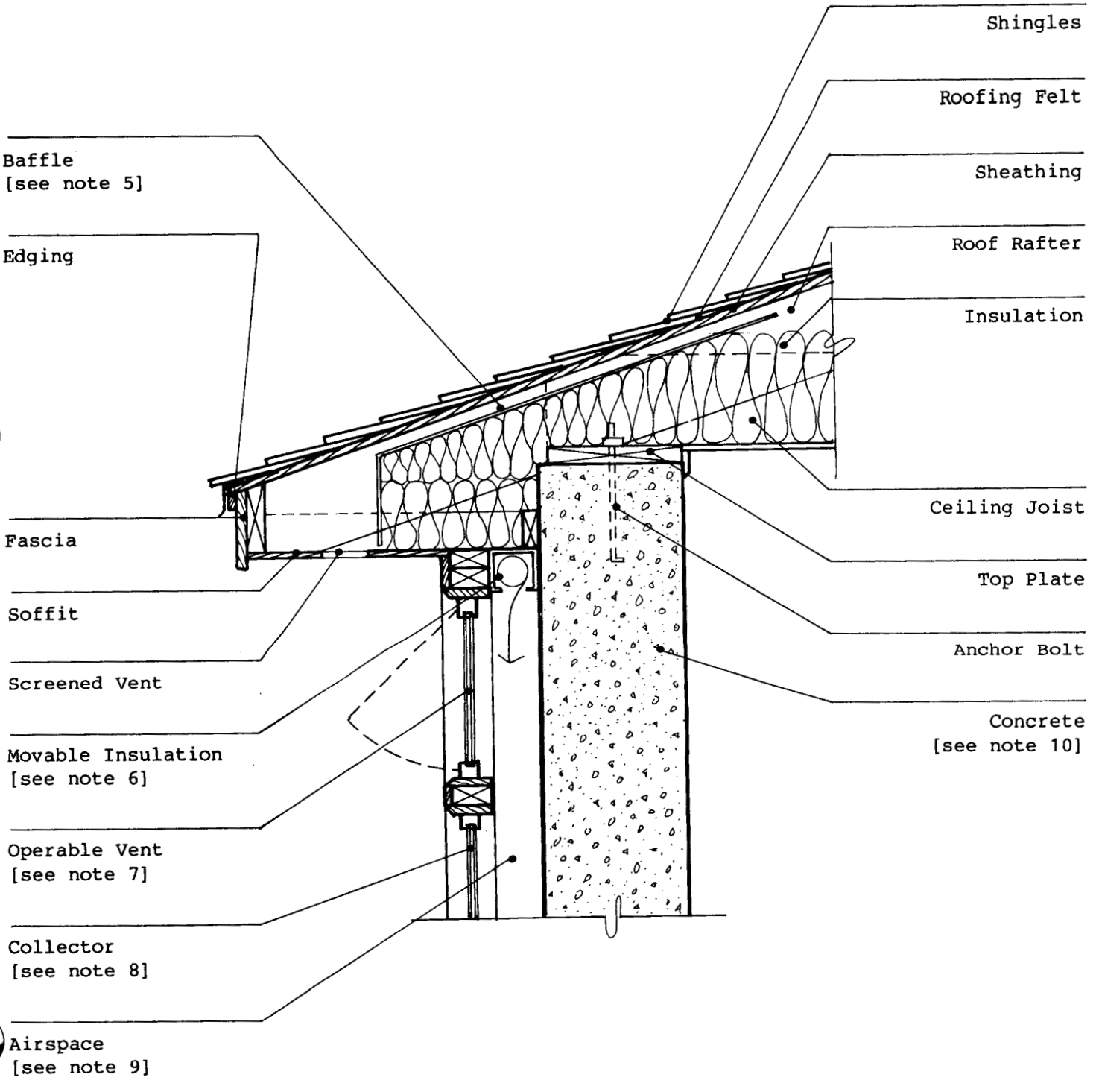
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Concrete Wall
Roof

3.2282

Detail





Construction Notes

[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections. Provide gutters and downspouts as required. Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.

[2] Placement of reinforcing and anchor bolts to be determined by local building codes and/or accepted practice.

[3] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.

[4] Insulation in ceiling must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[5] Provide baffles where necessary to maintain 1" minimum airspace for venting attic.

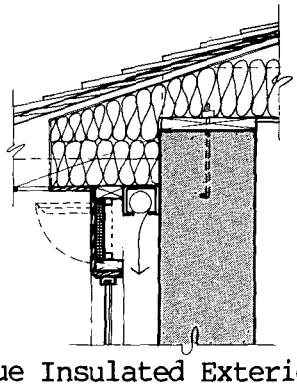
[6] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. For further information see Sections 3.2000 and 4.4300.

[7] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

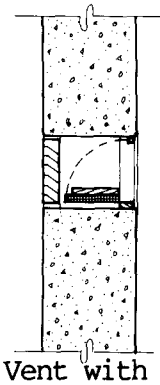
[8] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

[9] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.

[10] Concrete Thermal Storage Wall. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2126.



Opaque Insulated Exterior Vent

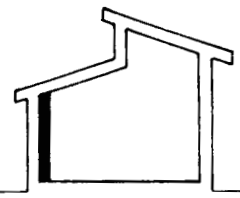


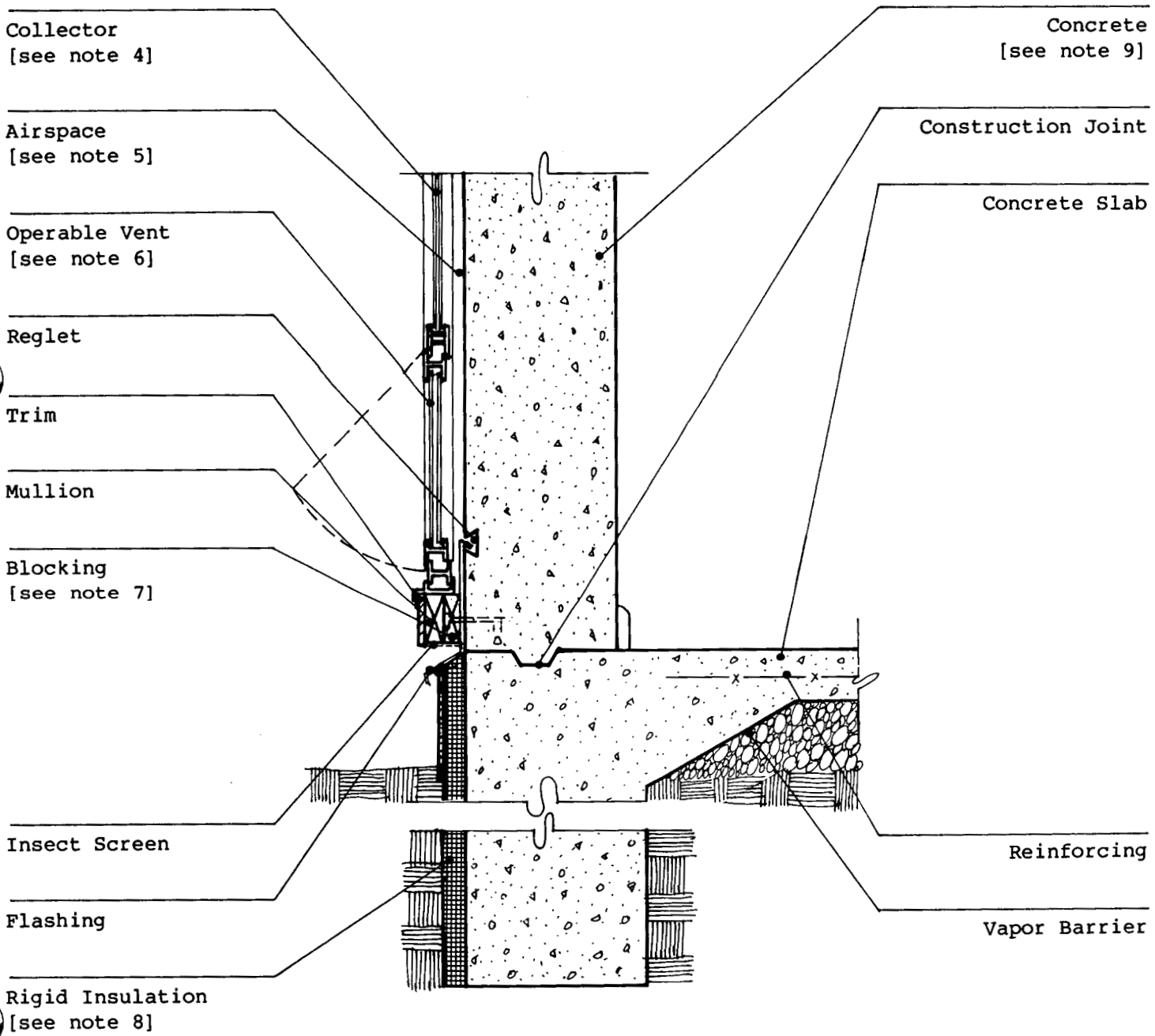
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Concrete Wall
Concrete Slab-On-Grade

3.2284

Detail





Thermal Storage Wall
Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code. Where ground water problems exist, provide sufficient granular fill at haunch to prevent water penetration at slab.

[2] Placement of reinforcing, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code.

[3] Insulation levels at foundation/slab must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

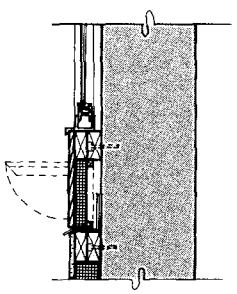
[5] Width of airspace may vary. For further information, see Key Page 3.2102.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

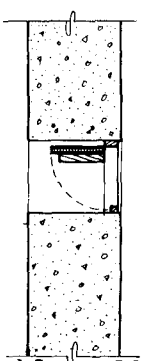
[7] Blocking can be discontinuous to provide weep holes where required. It is recommended that wood be pressure treated and insect screens (as shown) be provided at weep holes.

[8] Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

[9] Concrete Thermal Storage Wall. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2126.



Opaque Insulated Exterior Vent

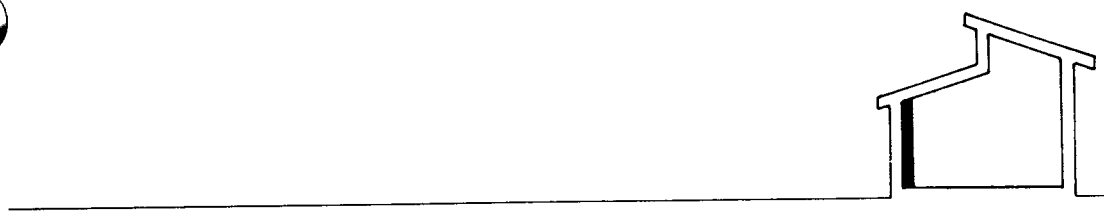


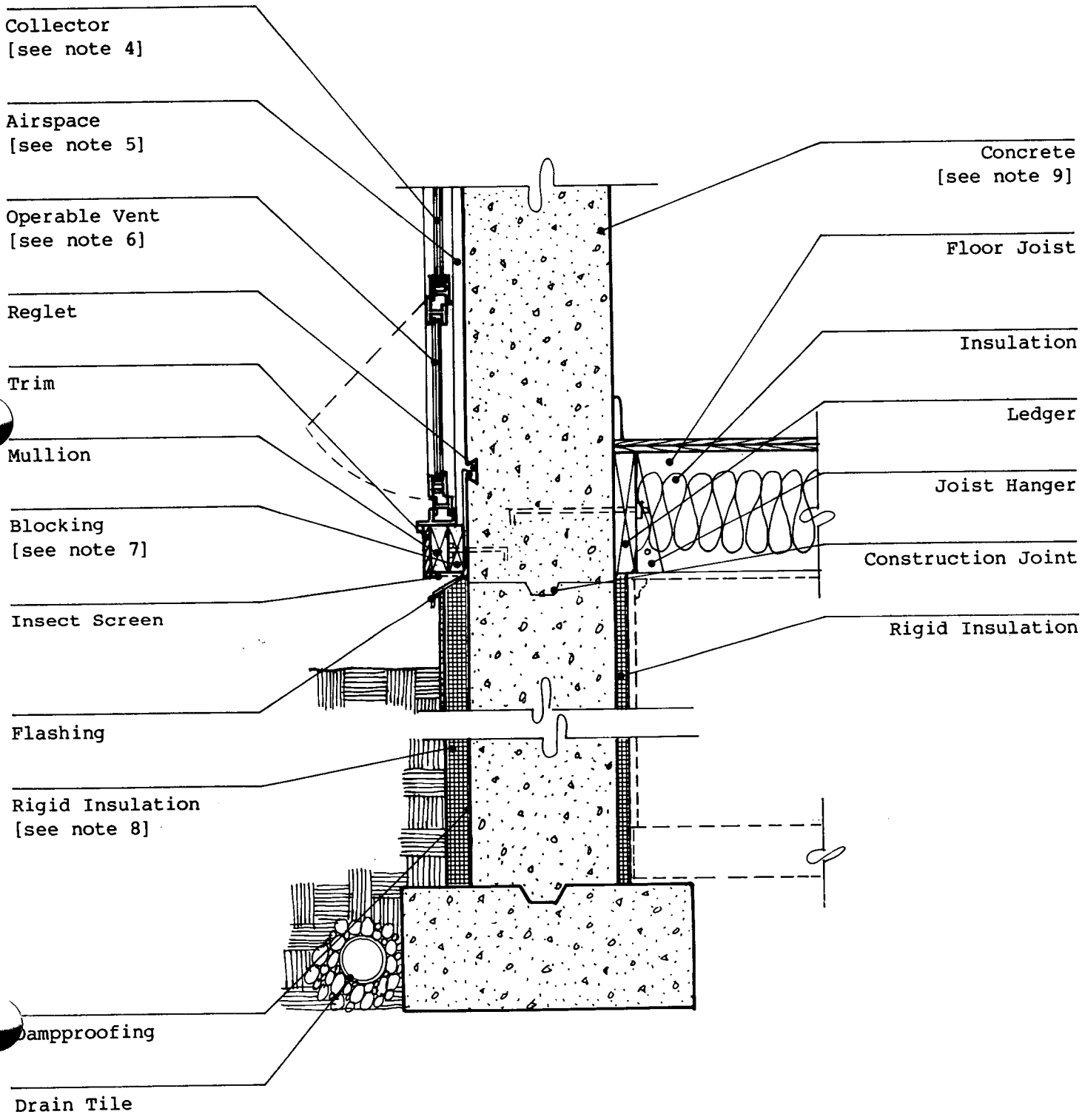
Operable Wall Vent

Thermal Storage Wall
Concrete Wall
Wood First Floor

3.2286

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.

[2] Placement of reinforcing, flashing and weep holes to be determined by local building codes and/or accepted practice.

[3] Insulation levels at floor must meet or exceed requirements of local building/ energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

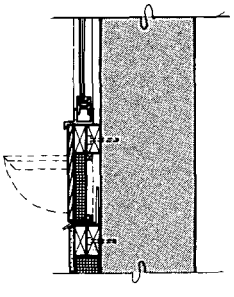
[5] Width of airspace may vary. For further information, see Key Page 3.2102.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

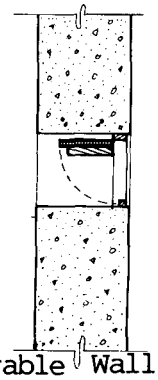
[7] Blocking can be discontinuous to provide weep holes where required. It is recommended that wood be pressure treated and insect screens (as shown) be provided at weep holes.

[8] It is recommended that the Thermal Storage Wall foundation be insulated on both sides to prevent heat losses to the outside and to the ground. In heated basements and heated crawl spaces insulation is not required on the inside. Insulation levels on both sides should be equal and should meet code requirements for foundation insulation. Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

[9] Concrete Thermal Storage Wall. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2126.



Opaque Insulated Exterior Vent

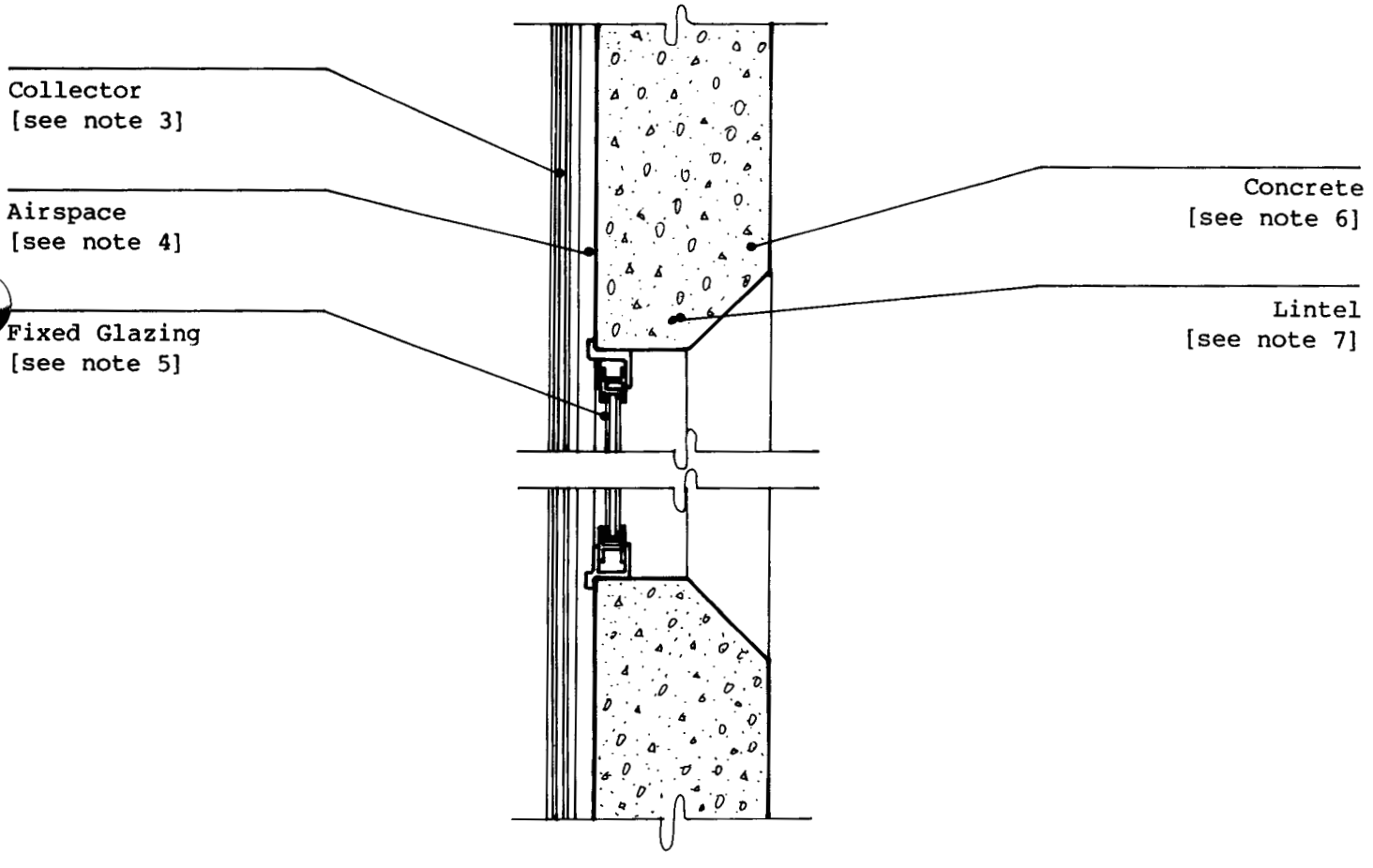


Operable Wall Vent

Thermal Storage Wall
Concrete Wall
Direct Gain Window

3.2288

Detail



Construction Notes

[1] Placing of reinforcing to be determined by local building codes and/or accepted practice.

[2] The storage mass should not be insulated. For further information, see Section 3.2000.

[3] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

[4] Width of airspace may vary. For further information, see Key Page 3.2102.

[5] Conventional window for light, view and/or Direct Gain may be single or double glazed. For information on Direct Gain systems, see Section 3.1000.

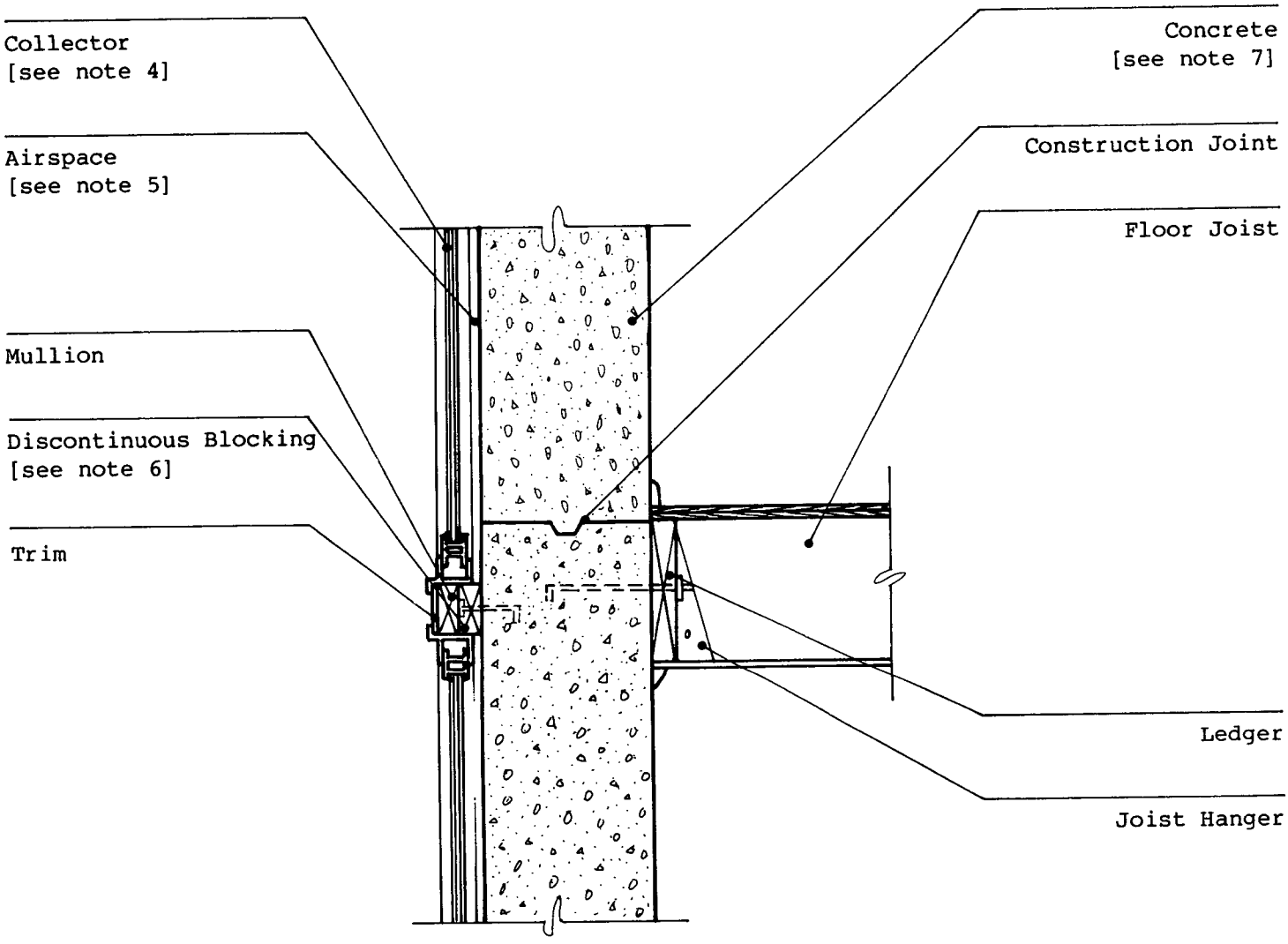
[6] Concrete Thermal Storage Wall. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2126.

[7] Opening may be beveled, providing more even distribution of light to space. Steel reinforcing designed for loading and clear span per local building codes and/or accepted practice. Alternate precast concrete lintel may be specified at builder's option.

Thermal Storage Wall
Concrete Wall
Wood Upper Floor

3.2290

Detail

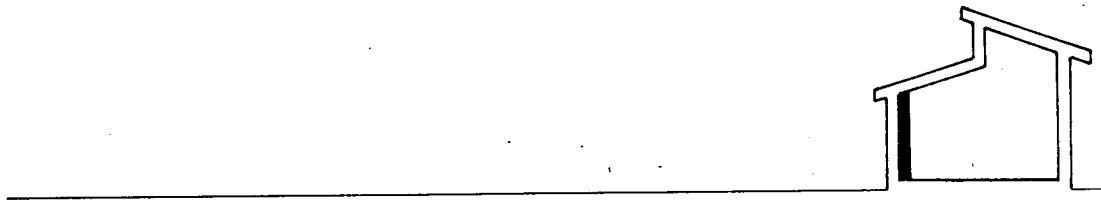


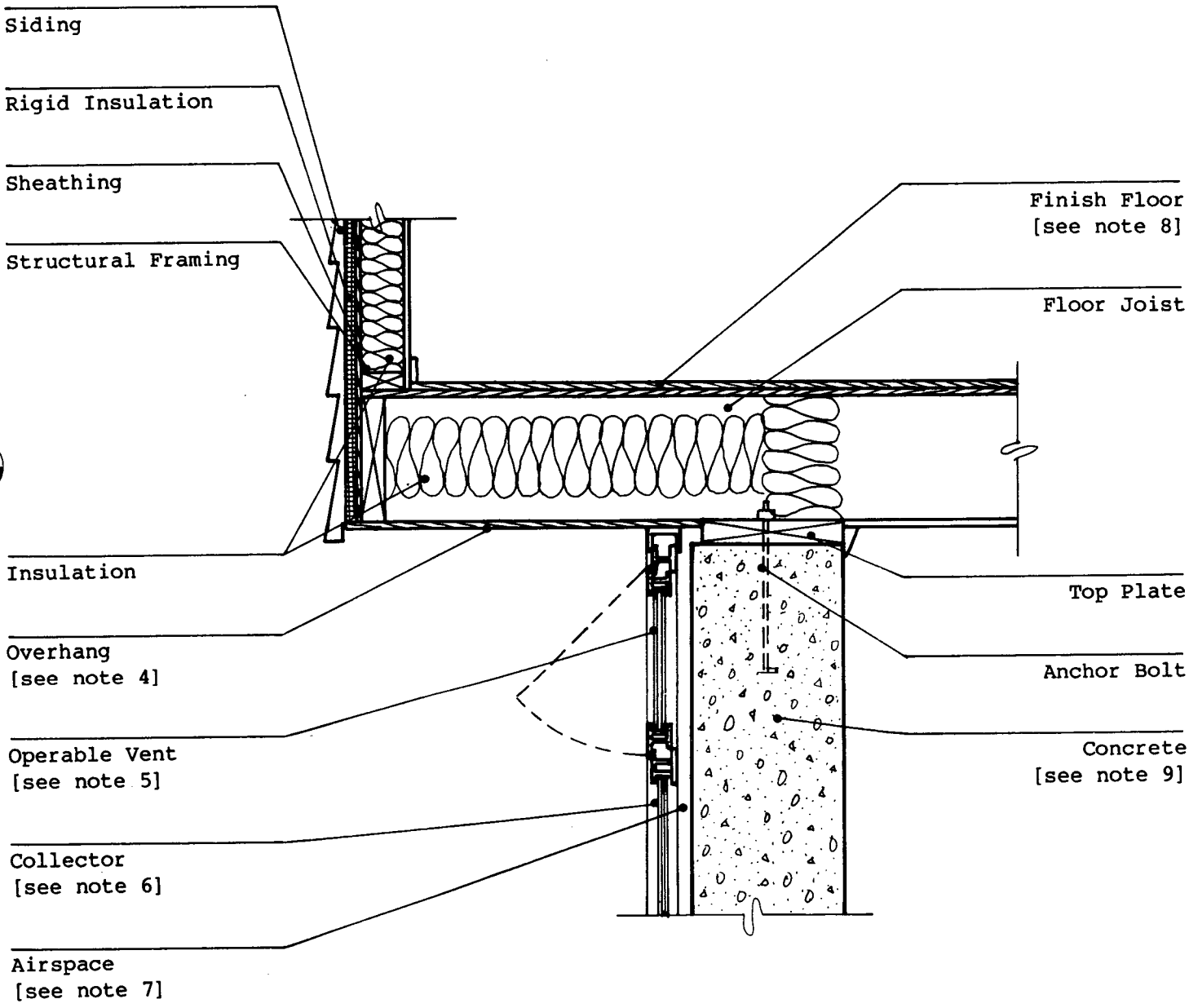
[1] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.
[2] Placing of reinforcing to be determined by local building codes and/or accepted practice.
[3] The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[5] Width of airspace may vary. For further information, see Key Page 3.2102.
[6] Discontinuous blocking to allow for adequate air circulation in airspace.
[7] Concrete Thermal Storage Wall. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2126.

Thermal Storage Wall
Concrete Wall
Wood Upper Floor Overhang

3.2292

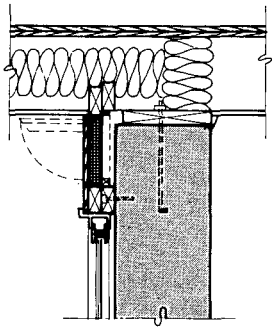
Detail



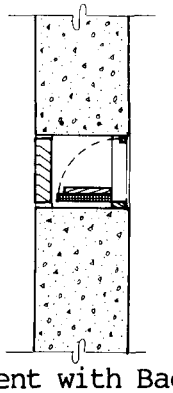


Thermal Storage Wall
Construction Notes

[1] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.
[2] Placement of reinforcing and anchor bolts to be determined by local building codes and/or accepted practice.
[3] Insulation levels at frame wall and floor at overhang must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.
[5] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[6] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[7] Width of airspace may vary. For further information, see Key Page 3.2102.
[8] Direct Gain system may be incorporated into upper level design. For further information, see Section 3.1000.
[9] Concrete Thermal Storage Wall. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2126.



Opaque Insulated Exterior Vent

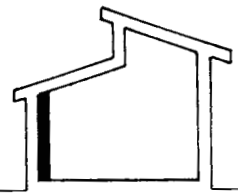


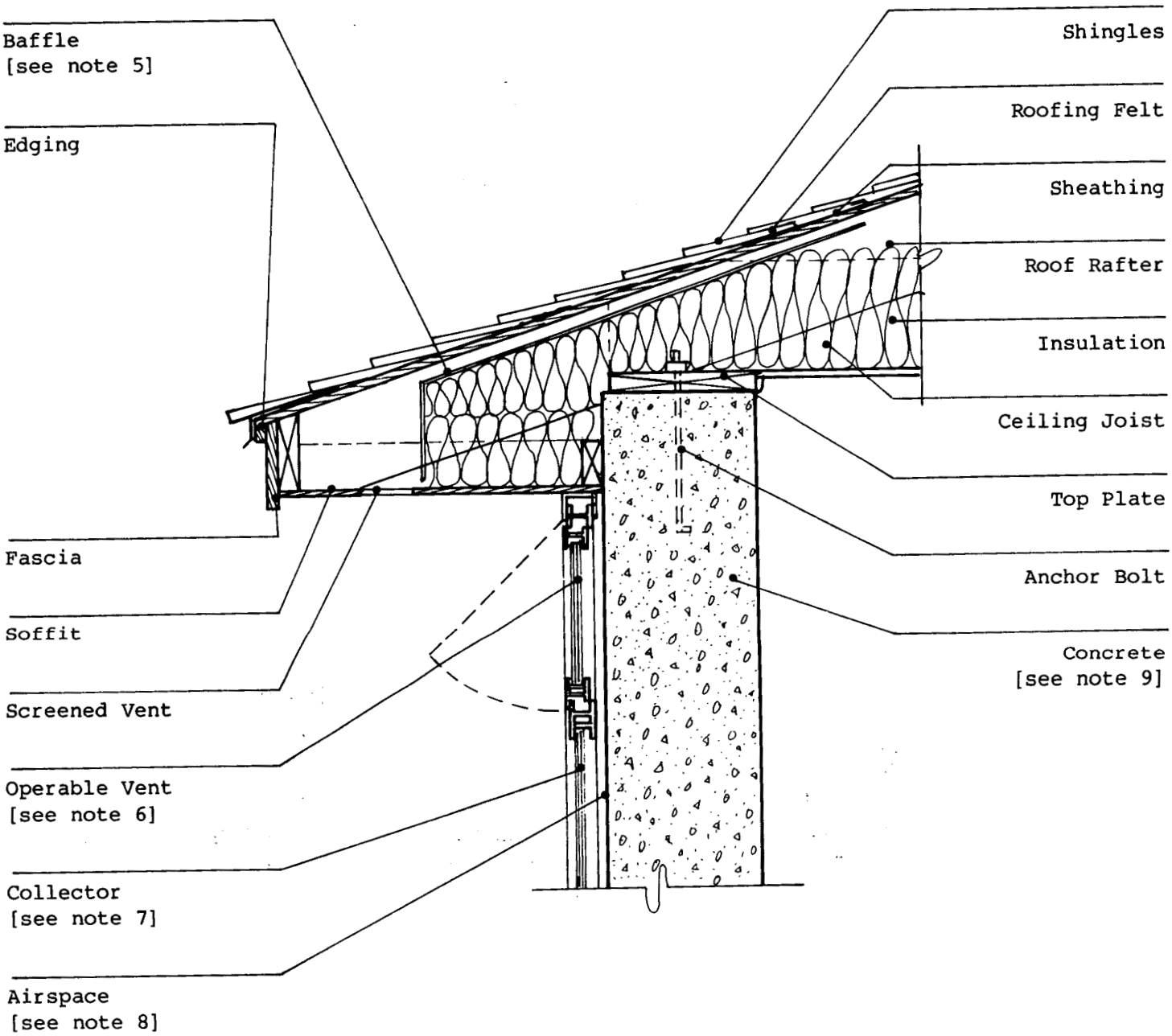
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Concrete Wall
Roof

3.2294

Detail





[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections. Provide gutters and downspouts as required. Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.

[2] Placement of reinforcing and anchor bolts to be determined by local building codes and/or accepted practice.

[3] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.

[4] Insulation in ceiling must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

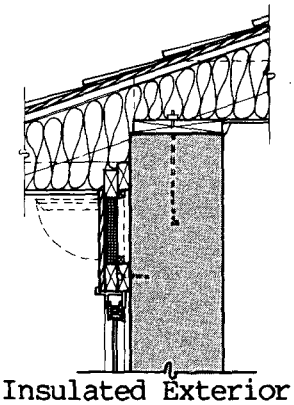
[5] Provide baffles where necessary to maintain 1" minimum airspace for venting attic.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

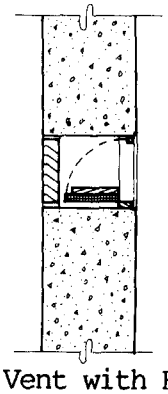
[7] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

[8] Width of airspace may vary. For further information, see Key Page 3.2102.

[9] Concrete Thermal Storage Wall. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2126.



Opaque Insulated Exterior Vent

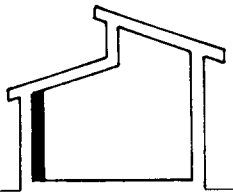


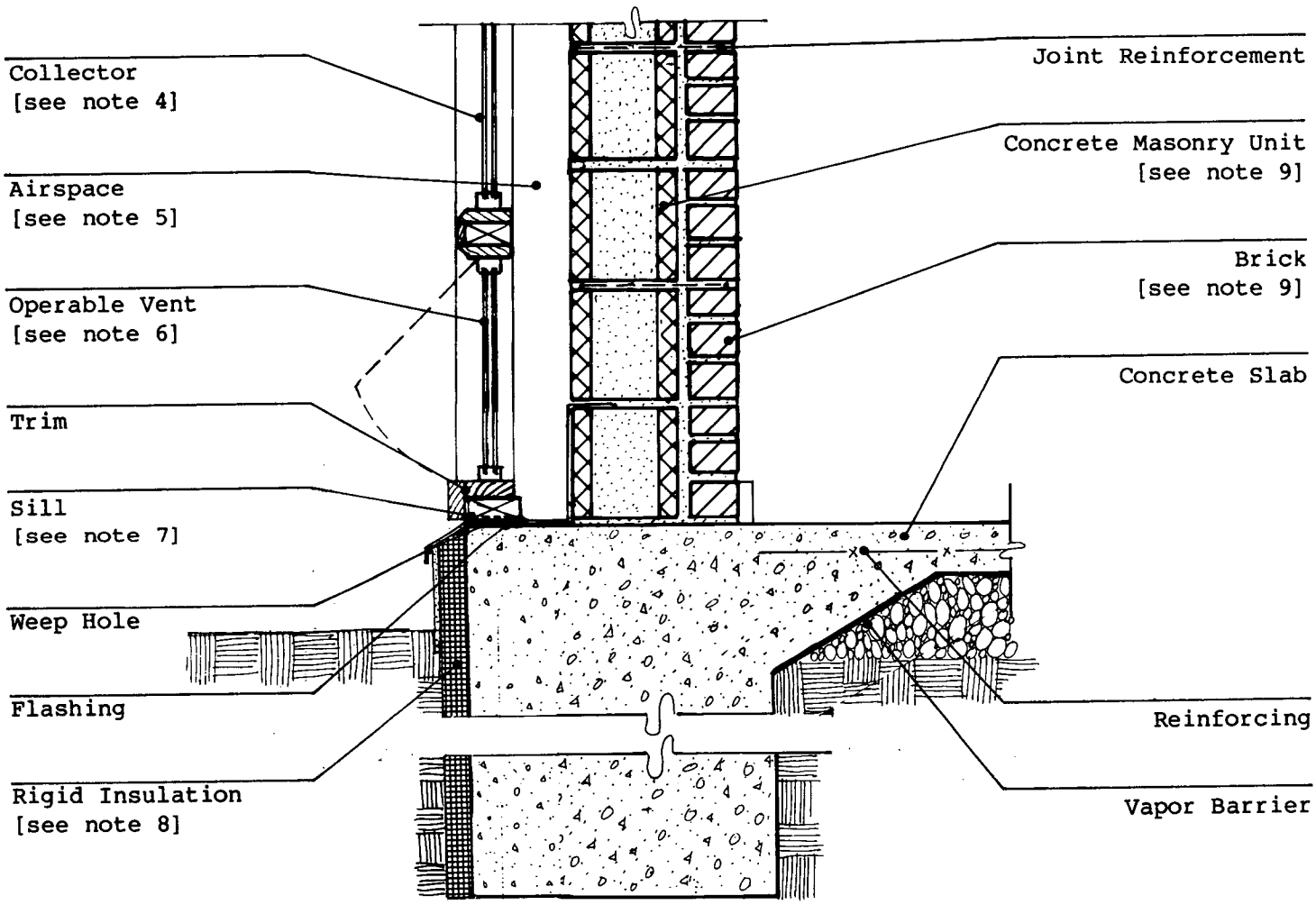
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Brick/CMU Composite Wall
Concrete Slab-On-Grade

3.2296

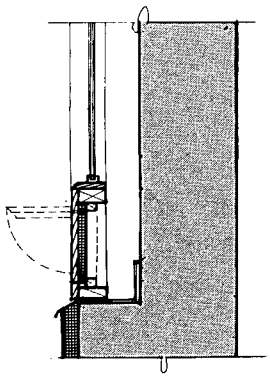
Detail



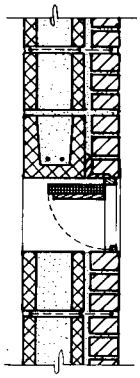


Thermal Storage Wall
Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code. Where ground water problems exist, provide sufficient granular fill at haunch to prevent water penetration at slab.
[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab is not recommended except where required by local conditions and/or code.
[3] Insulation levels at foundation/slab must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.
[5] Width of airspace may vary. For further information, see Key Page 3.2100.
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. For more information, see Section 3.2000.
[7] Sill can be wood or masonry at builder's option. Pressure treating should be specified if lumber is used. Sill to foundation and collector frame to foundation connections must meet local building codes.
[8] Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation.
[9] Brick facing and Concrete Masonry back-up unit must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2128.



Opaque Insulated Exterior Vent

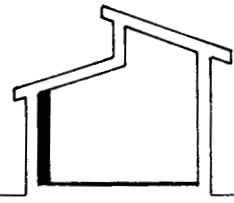


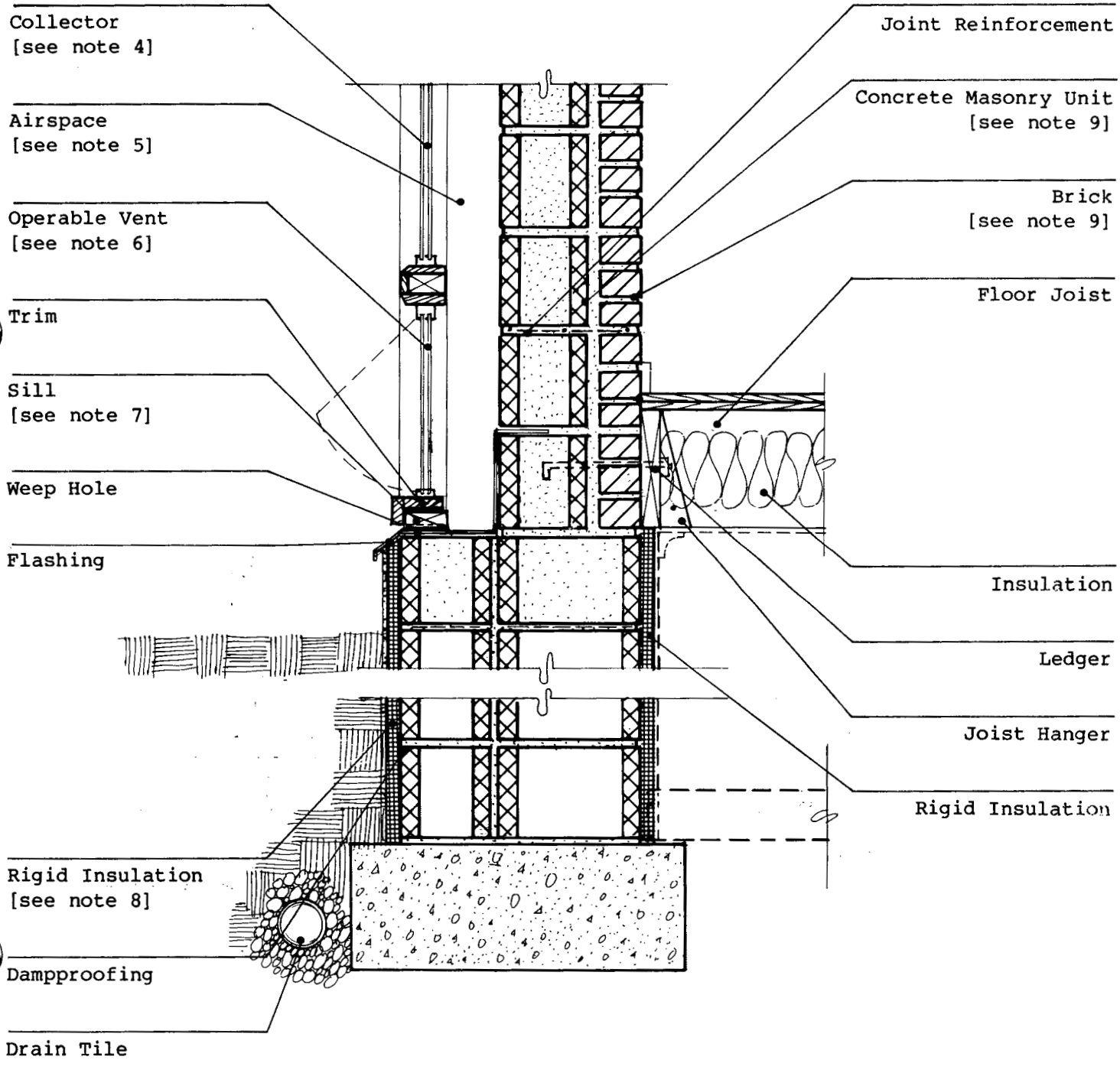
Operable Wall Vent

Thermal Storage Wall
Brick/CMU Composite Wall
Wood First Floor

3.2298

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.

[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice.

[3] Insulation levels at floor must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

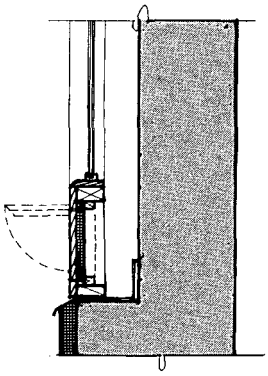
[5] Width of airspace may vary. For further information, see Key Page 3.2100.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

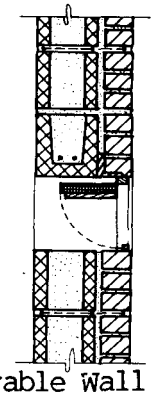
[7] Sill can be wood or masonry at builder's option. Pressure treating should be specified if lumber is used. Sill to foundation and collector frame to foundation connections must meet local building codes.

[8] It is recommended that the Thermal Storage Wall foundation be insulated on both sides to prevent heat losses to the outside and to the ground. In heated basements and heated crawl spaces insulation is not required on the inside. Insulation levels on both sides should be equal and should meet code requirements for foundation insulation. Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

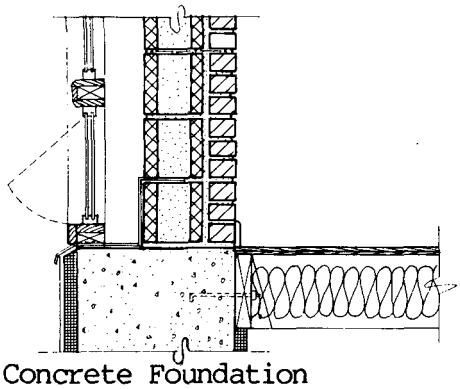
[9] Brick facing and Concrete Masonry back-up unit must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2128.



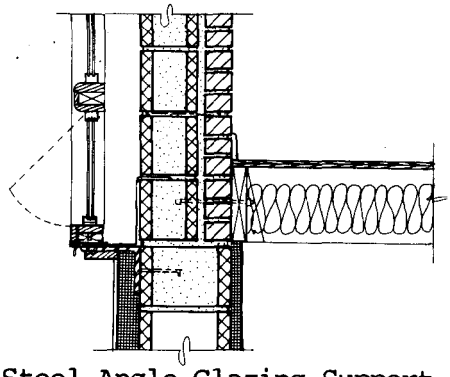
Opaque Insulated Exterior Vent



Operable Wall Vent



Concrete Foundation

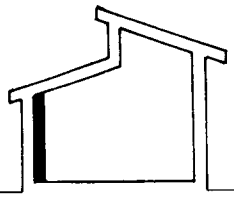


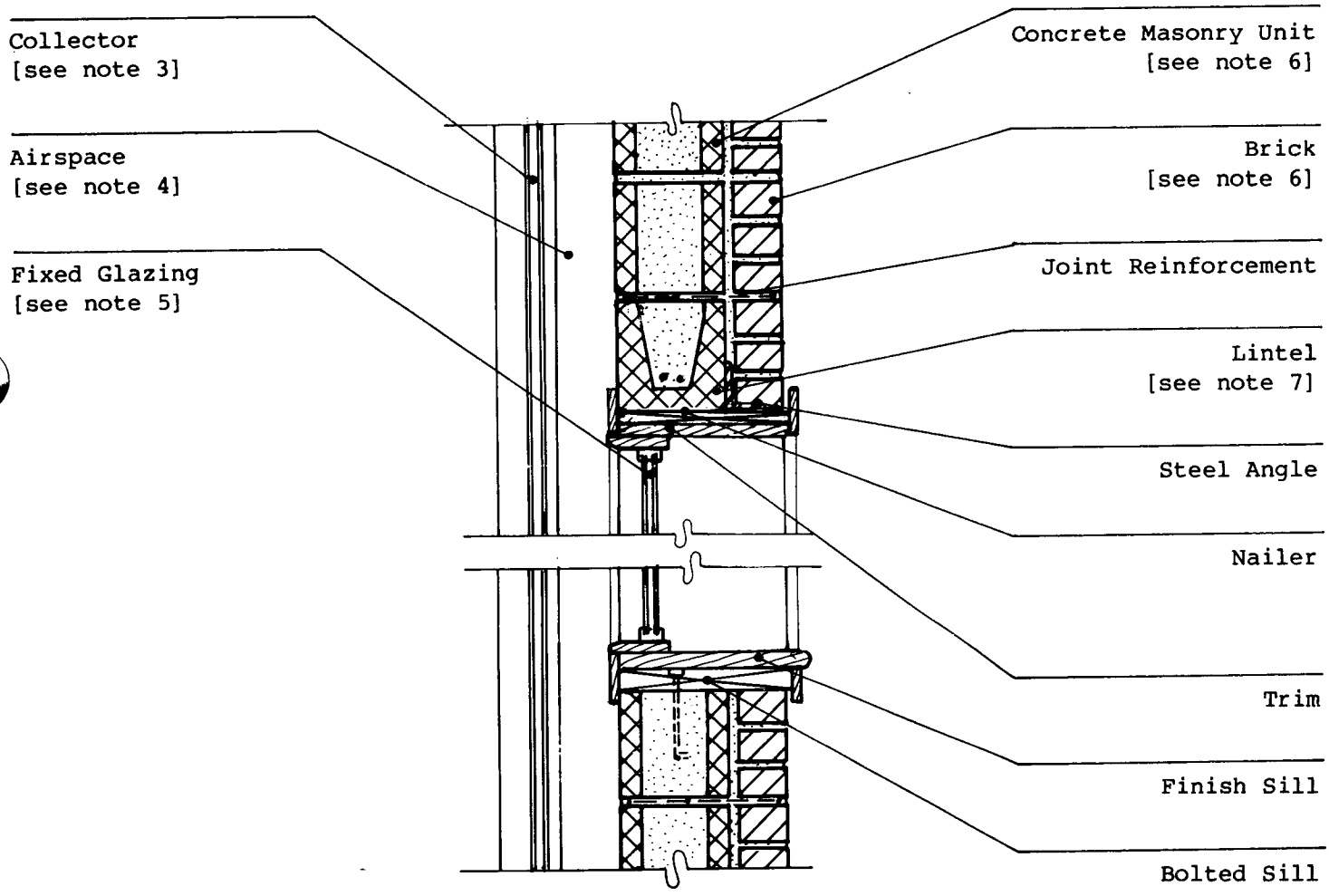
Steel Angle Glazing Support

Thermal Storage Wall
Brick/CMU Composite Wall
Direct Gain Window

3.2300

Detail

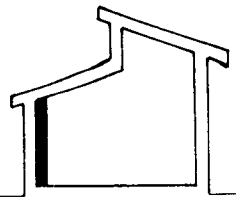


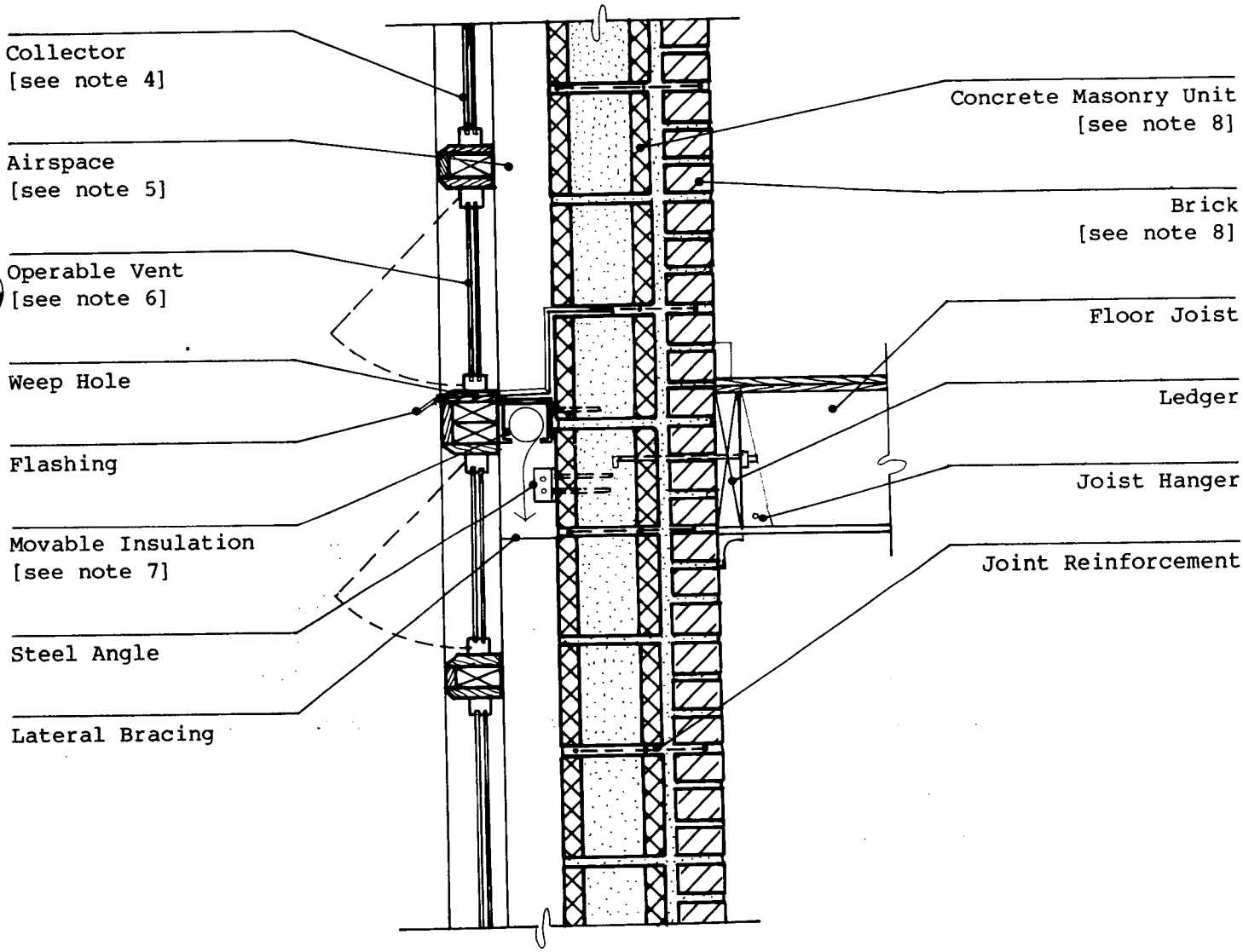


[1] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice.
[2] The storage mass should not be insulated. For further information, see Section 3.2000.
[3] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.
[4] Width of airspace may vary. For further information, see Key Page 3.2100.
[5] Conventional window for light, view and/or Direct Gain may be single or double glazed. For information on Direct Gain systems see Section 3.1000.
[6] Brick facing and Concrete Masonry back-up unit must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2128.
[7] Lintel may be bond-beam, lintel, or standard Concrete Masonry units with depressed, cut-out or grooved webs, or precast concrete. Provide 6" minimum bearing at each end. Reinforcing designed for loading and clear span per local building codes and/or accepted practice. Facing unit is supported by steel angle.

Thermal Storage Wall
Brick/CMU Composite Wall
Wood Upper Floor

Detail





Construction Notes

[1] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.

[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice.

[3] The storage mass should not be insulated. For further information, see Section 3.2000.

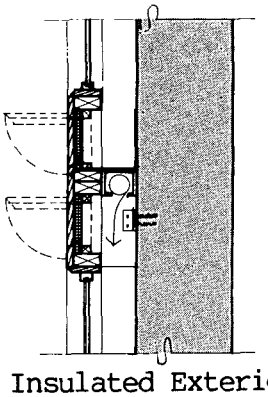
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

[5] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.

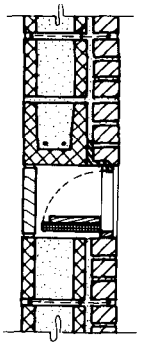
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Where airspace is not continuous, top and bottom vents should be provided for each section. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

[7] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. Where upper and lower portions of Thermal Storage Wall are separated, movable insulation must be installed in each section. For further information, see Sections 3.2000 and 4.4300.

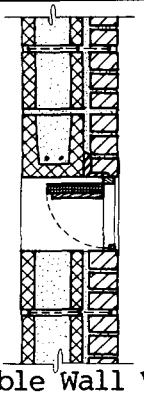
[8] Brick facing and Concrete Masonry back-up unit must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2128.



Opaque Insulated Exterior Vents



Operable Wall Vent with Backdraft Damper

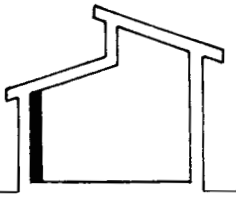


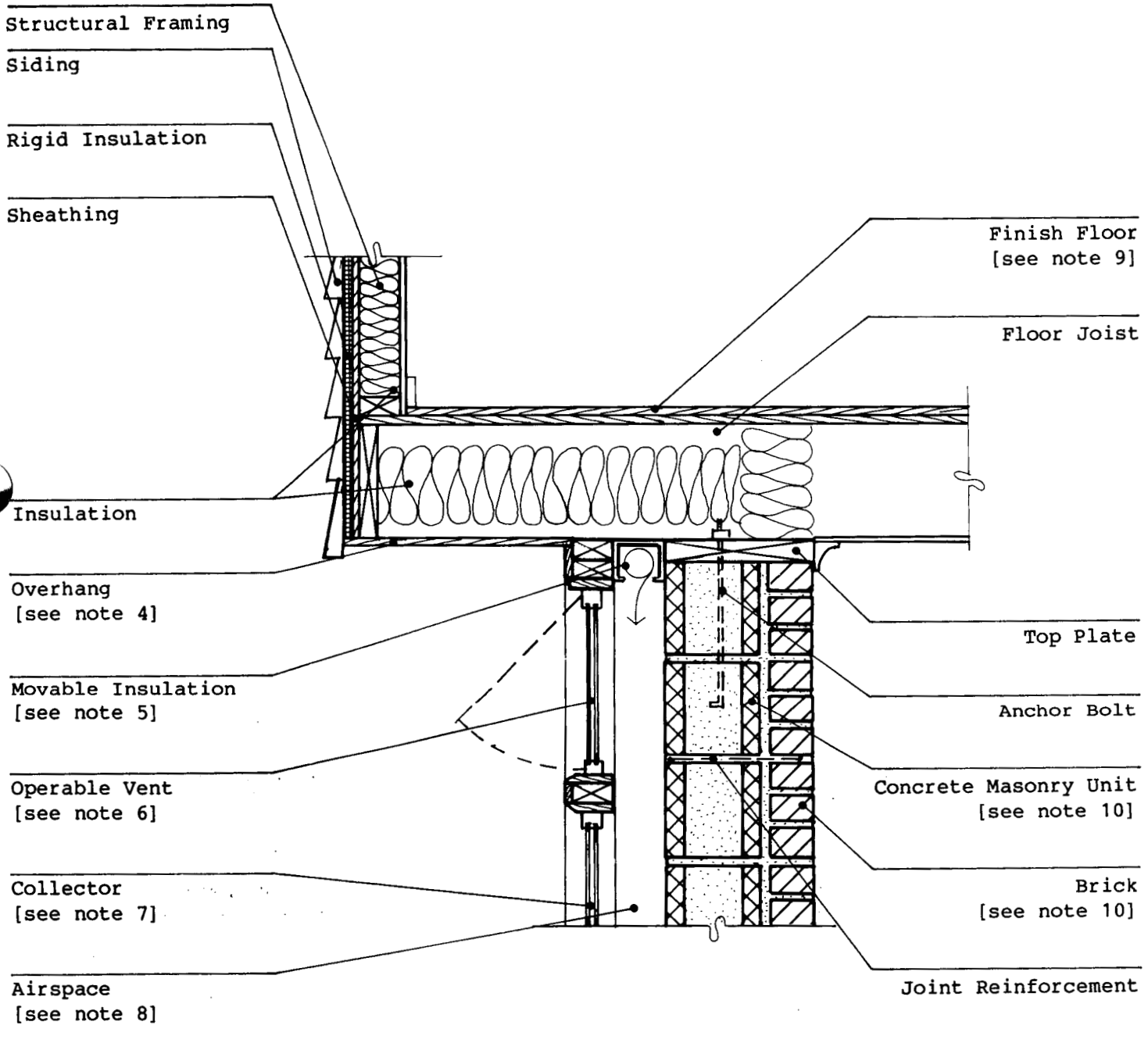
Operable Wall Vent

Thermal Storage Wall
Brick/CMU Composite Wall
Wood Upper Floor Overhang

3.2304

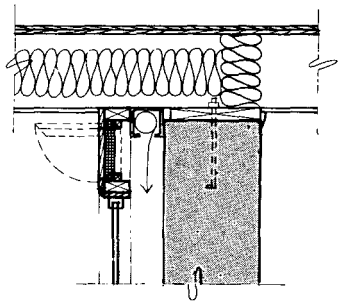
Detail



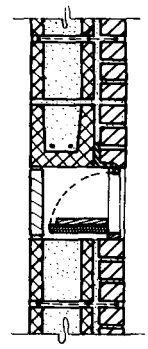


Thermal Storage Wall
Construction Notes

[1] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.
[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.
[3] Insulation levels at frame wall and floor at overhang must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.
[5] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. For further information see Sections 3.2000 and 4.4300.
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[7] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.
[8] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.
[9] Direct Gain system may be incorporated into upper level design. For further information, see Section 3.1000.
[10] Brick facing and Concrete Masonry back-up unit must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2128.



Opaque Insulated Exterior Vent

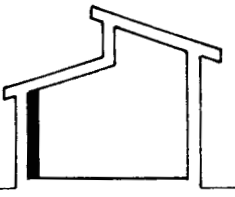


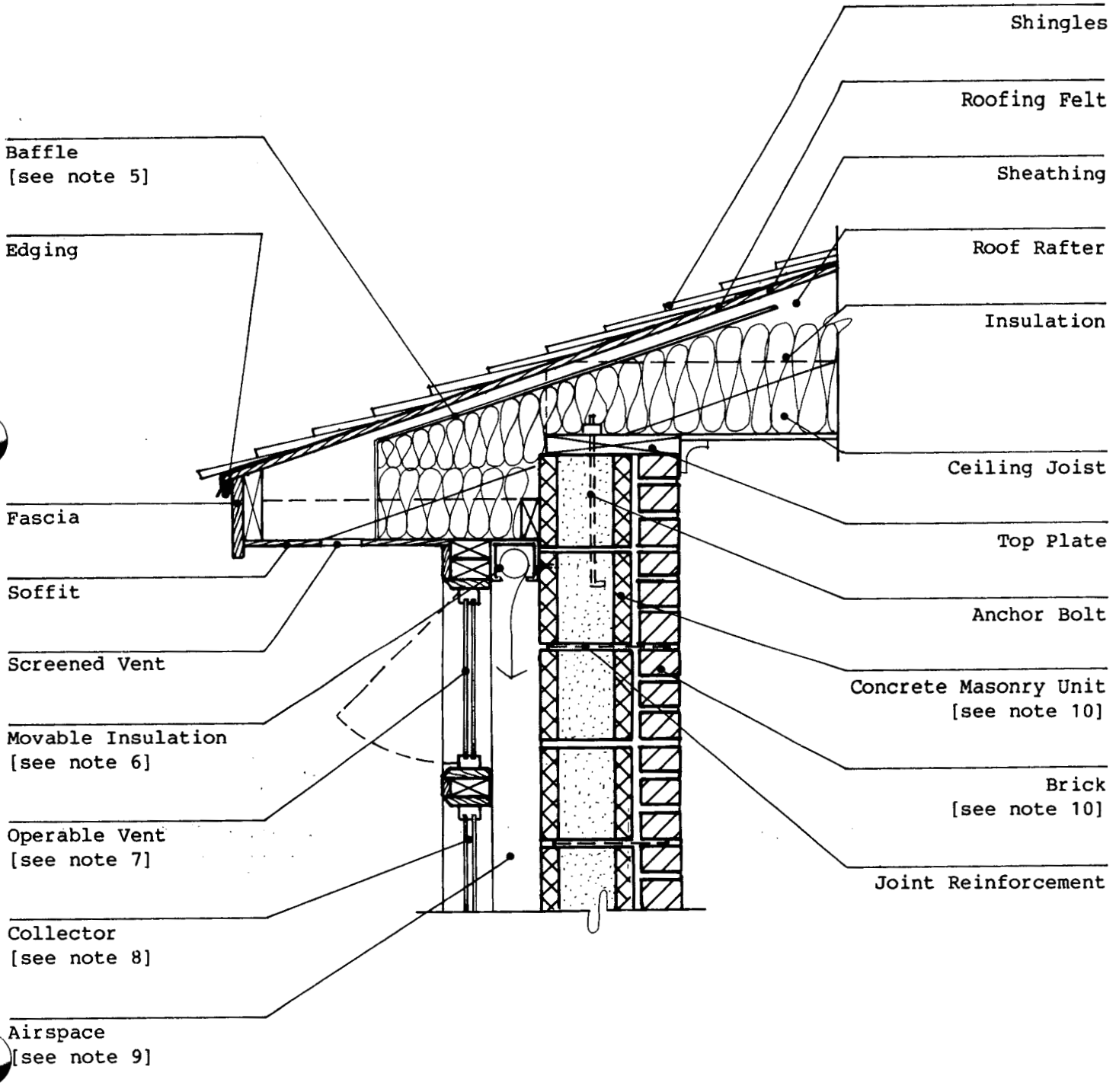
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Brick/CMU Composite Wall
Roof

3.2306

Detail





[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections. Provide gutters and downspouts as required. Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.

[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.

[3] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.

[4] Insulation in ceiling must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[5] Provide baffles where necessary to maintain 1" minimum airspace for venting attic.

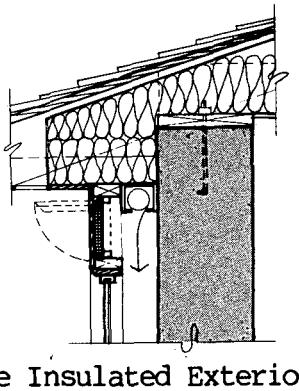
[6] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. For further information see Sections 3.2000 and 4.4300.

[7] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

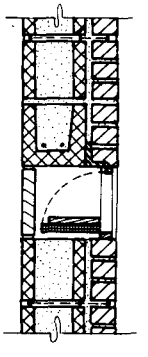
[8] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

[9] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.

[10] Brick facing and Concrete Masonry back-up unit must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2128.



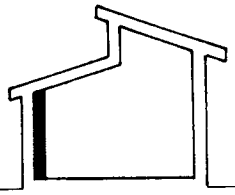
Opaque Insulated Exterior Vent

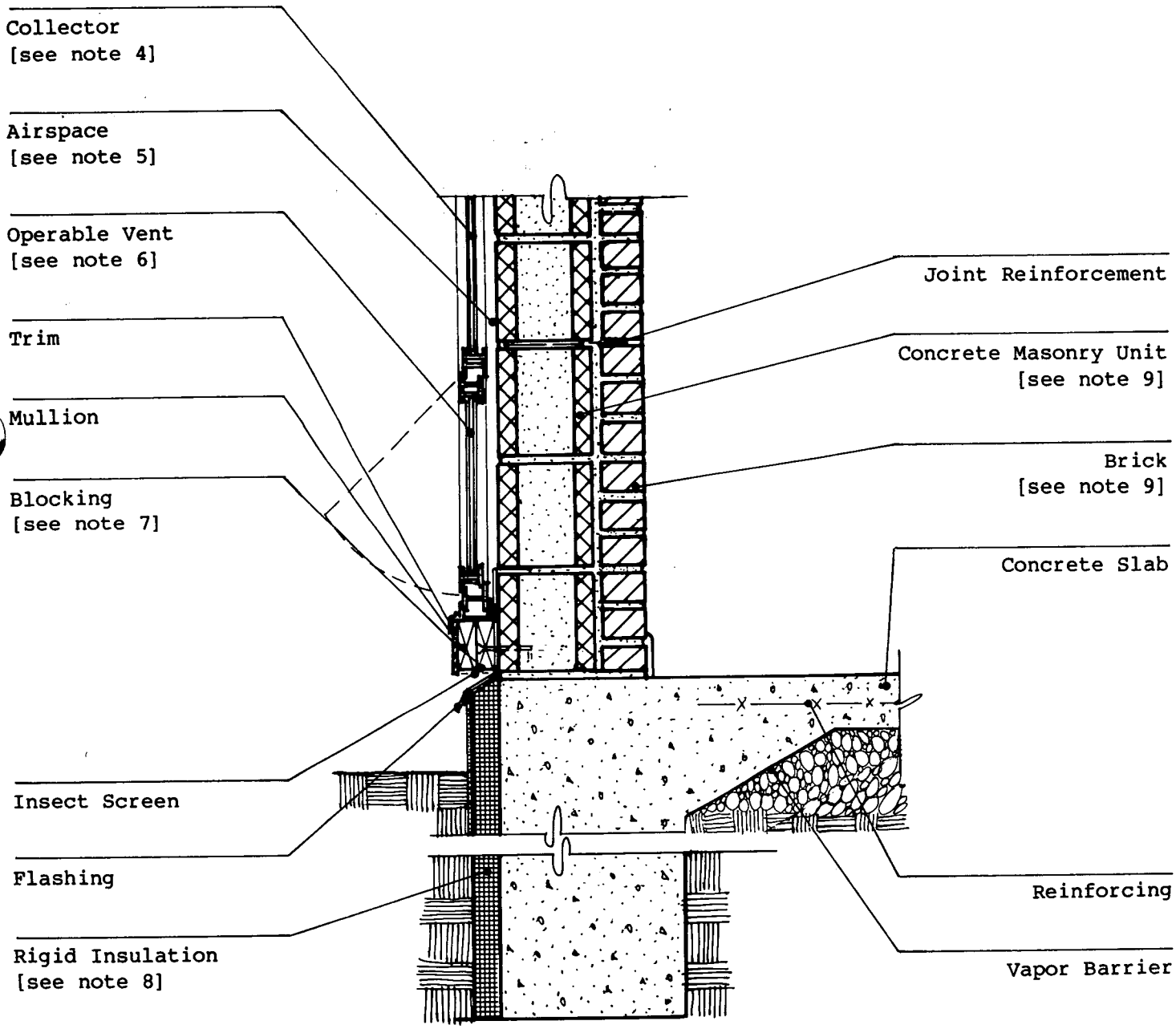


Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Brick/CMU Composite Wall
Concrete Slab-On-Grade

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code. Where ground water problems exist, provide sufficient granular fill at haunch to prevent water penetration at slab.

[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code.

[3] Insulation levels at foundation/slab must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

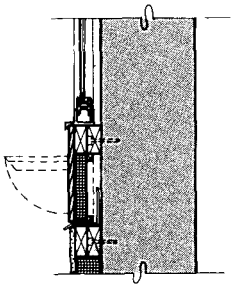
[5] Width of airspace may vary. For further information, see Key Page 3.2102.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

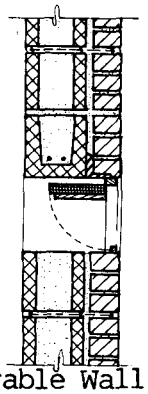
[7] Blocking can be discontinuous to provide weep holes where required. It is recommended that wood be pressure treated and insect screens (as shown) be provided at weep holes.

[8] Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

[9] Brick facing and Concrete Masonry back-up unit must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2128.



Opaque Insulated Exterior Vent

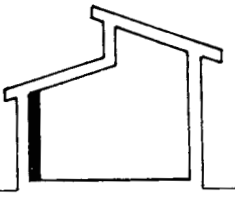


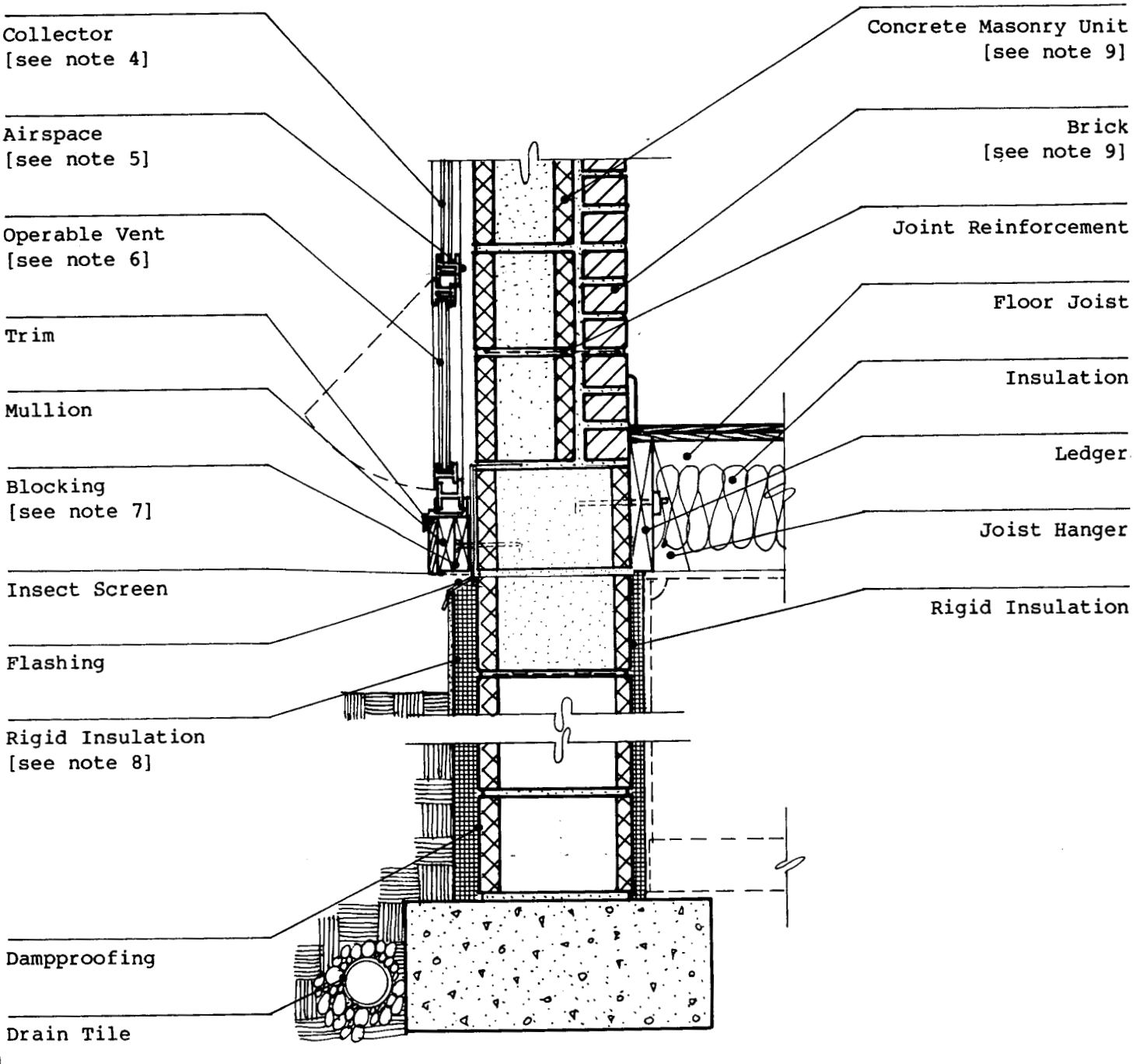
Operable Wall Vent

Thermal Storage Wall
Brick/CMU Composite Wall
Wood First Floor

3.2310

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.

[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice.

[3] Insulation levels at floor must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

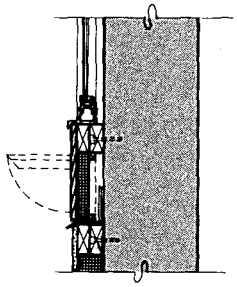
[5] Width of airspace may vary. For further information, see Key Page 3.2102.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

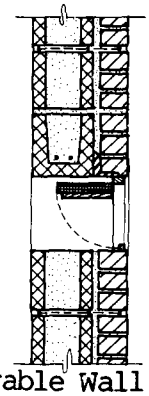
[7] Blocking can be discontinuous to provide weep holes where required. It is recommended that wood be pressure treated and insect screens (as shown) be provided at weep holes.

[8] It is recommended that the Thermal Storage Wall foundation be insulated on both sides to prevent heat losses to the outside and to the ground. In heated basements and heated crawl spaces insulation is not required on the inside. Insulation levels on both sides should be equal and should meet code requirements for foundation insulation. Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

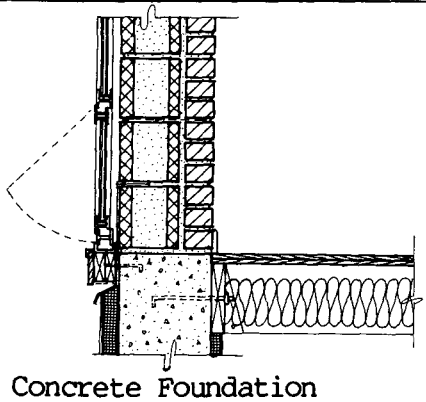
[9] Brick facing and Concrete Masonry back-up unit must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2128.



Opaque Insulated Exterior Vent



Operable Wall Vent

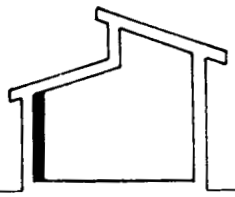


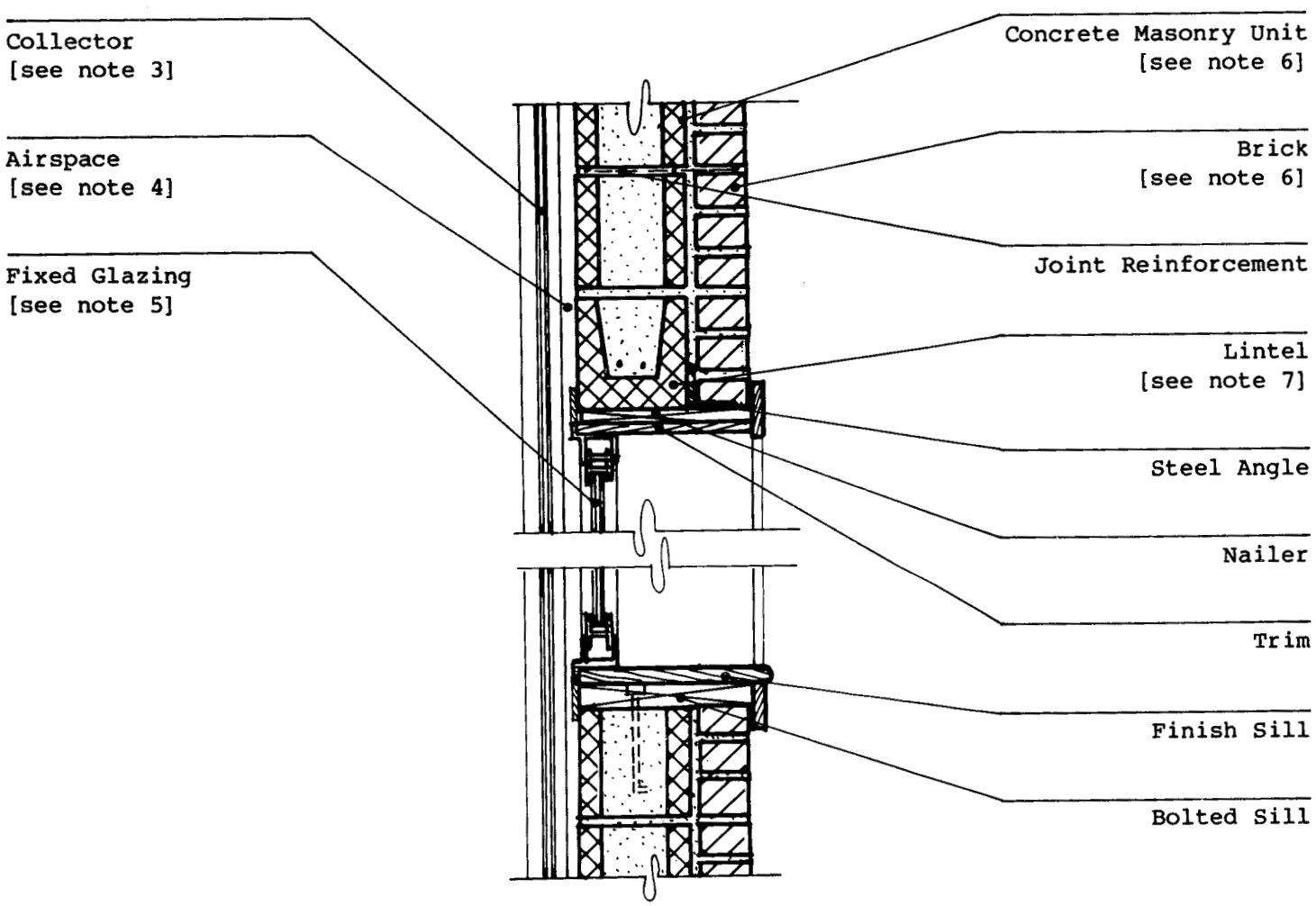
Concrete Foundation

Thermal Storage Wall
Brick/CMU Composite Wall
Direct Gain Window

3.2312

Detail





Construction Notes

[1] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice.

[2] The storage mass should not be insulated. For further information, see Section 3.2000.

[3] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

[4] Width of airspace may vary. For further information, see Key Page 3.2102.

[5] Conventional window for light, view and/or Direct Gain may be single or double glazed. For information on Direct Gain systems, see Section 3.1000.

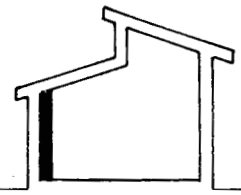
[6] Brick facing and Concrete Masonry back-up unit must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2128.

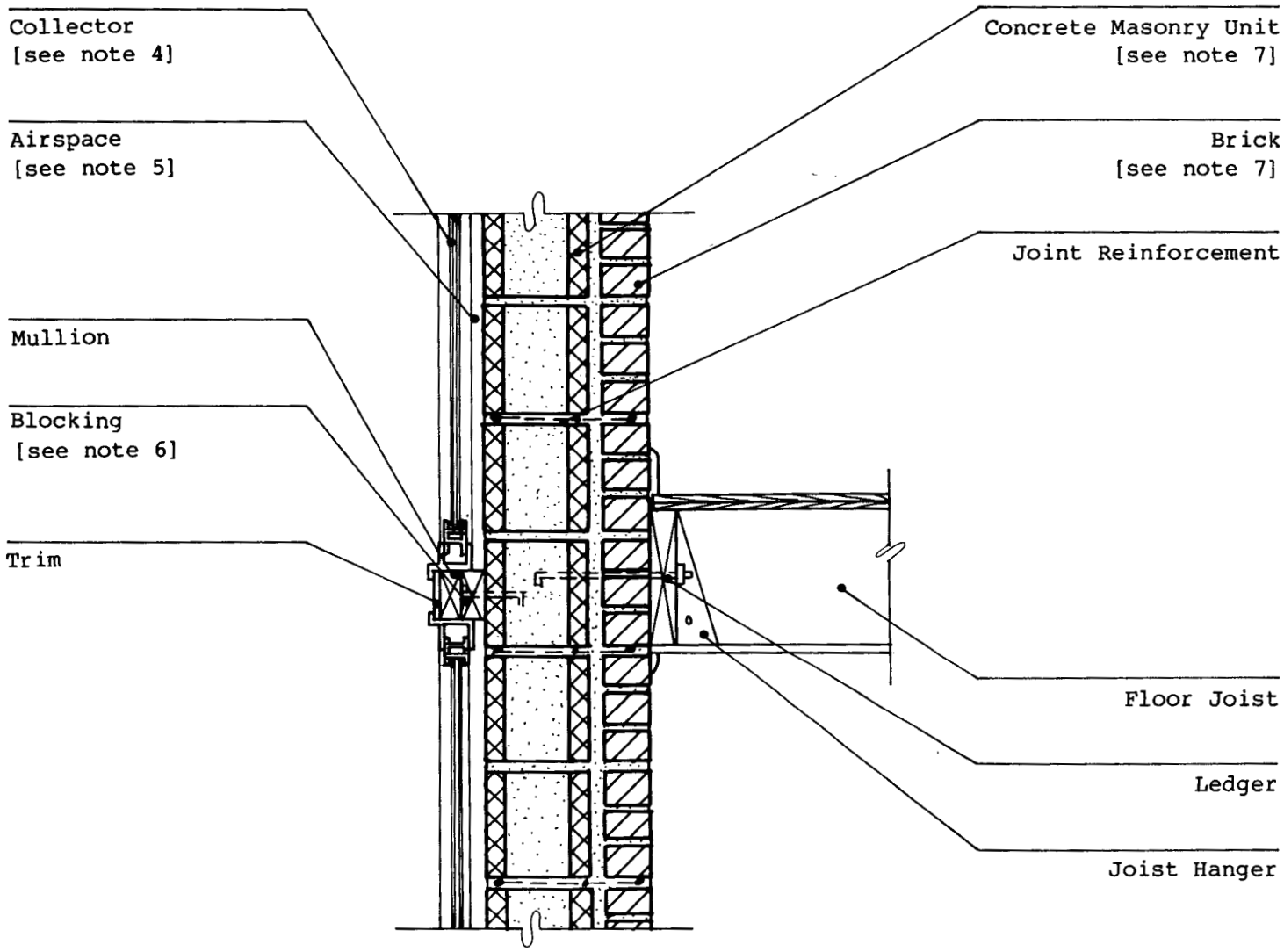
[7] Lintel may be bond-beam, lintel, or standard Concrete Masonry units with depressed, cut-out or grooved webs, or precast concrete. Provide 6" minimum bearing at each end. Reinforcing designed for loading and clear span per local building codes and/or accepted practice. Facing unit is supported by steel angle.

Thermal Storage Wall
Brick/CMU Composite Wall
Wood Upper Floor

3.2314

Detail





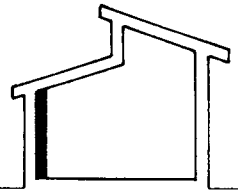
Construction Notes

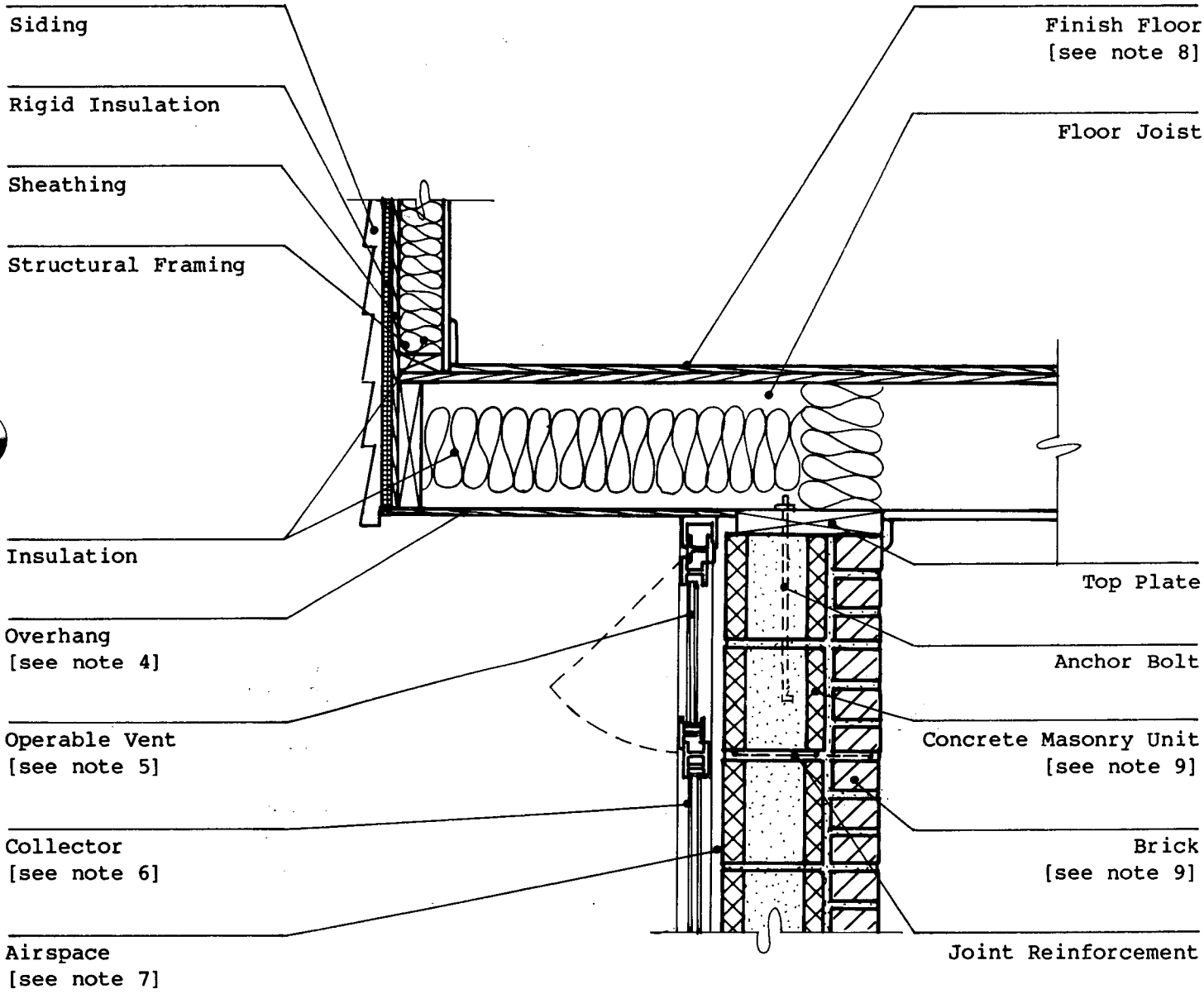
[1] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.
[2] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice.
[3] The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[5] Width of airspace may vary. For further information, see Key Page 3.2102.
[6] Discontinuous blocking to allow for adequate air circulation in airspace.
[7] Brick facing and Concrete Masonry back-up unit must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2128.

Thermal Storage Wall
Brick/CMU Composite Wall
Wood Upper Floor Overhang

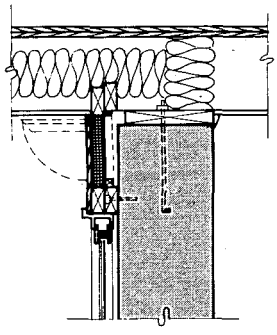
3.2316

Detail

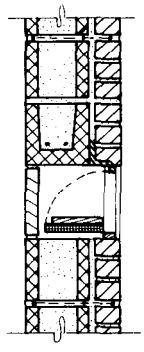




[1] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.
[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.
[3] Insulation levels at frame wall and floor at overhang must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.
[5] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[6] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[7] Width of airspace may vary. For further information, see Key Page 3.2102.
[8] Direct Gain system may be incorporated into upper level design. For further information, see Section 3.1000.
[9] Brick facing and Concrete Masonry back-up unit must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2128.



Opaque Insulated Exterior Vent

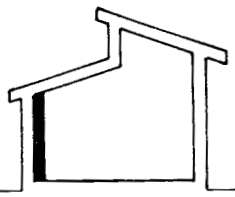


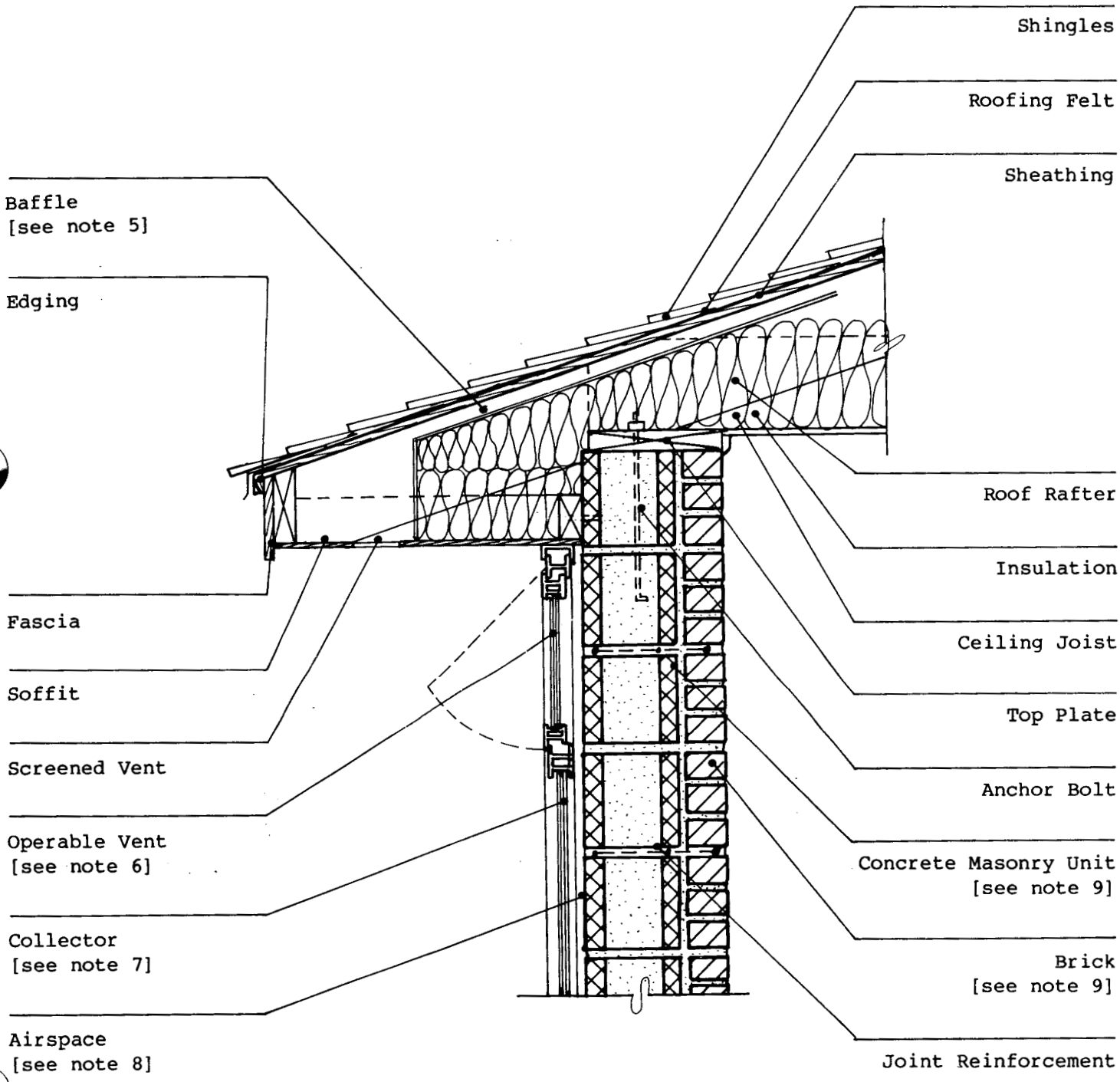
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Brick/CMU Composite Wall
Roof

3.2318

Detail





[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections. Provide gutters and downspouts as required. Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.

[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.

[3] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.

[4] Insulation in ceiling must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

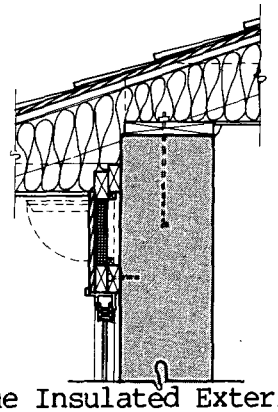
[5] Provide baffles where necessary to maintain 1" minimum airspace for venting attic.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

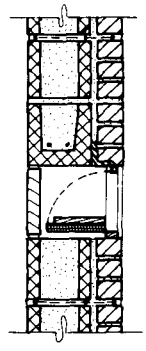
[7] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

[8] Width of airspace may vary. For further information, see Key Page 3.2102.

[9] Brick facing and Concrete Masonry back-up unit must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2128.



Opaque Insulated Exterior Vent

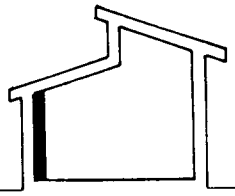


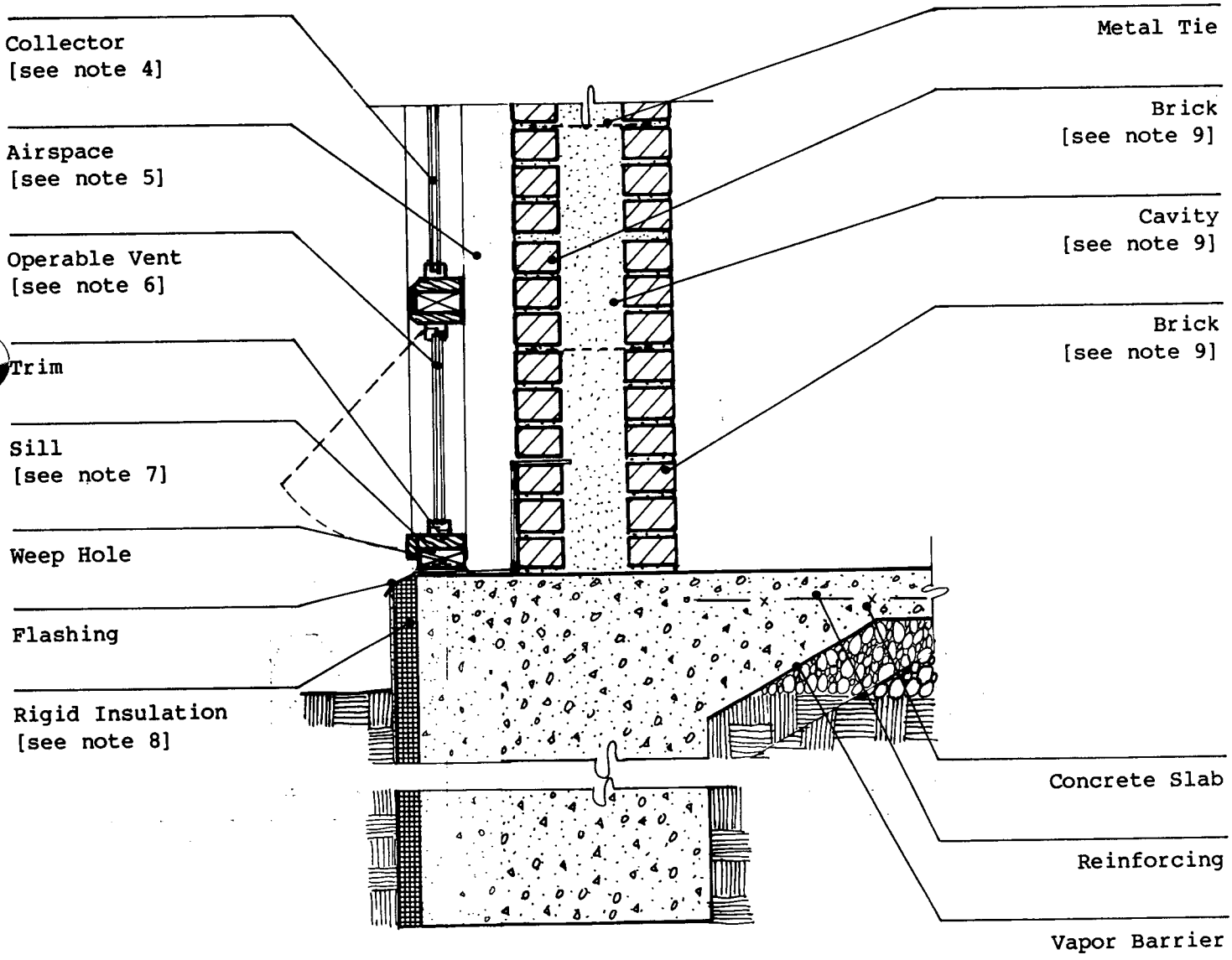
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Brick Cavity Wall
Concrete Slab-On-Grade

3.2320

Detail





Thermal Storage Wall
Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code. Where ground water problems exist, provide sufficient granular fill at haunch to prevent water penetration at slab.

[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab is not recommended except where required by local conditions and/or code.

[3] Insulation levels at foundation/slab must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

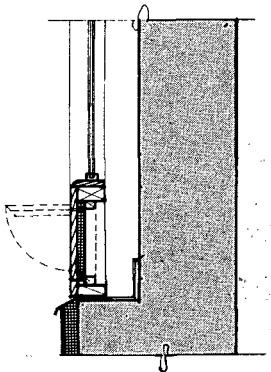
[5] Width of airspace may vary. For further information, see Key Page 3.2100.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. For more information, see Section 3.2000.

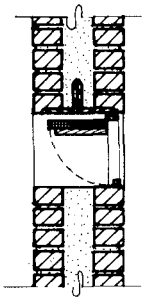
[7] Sill can be wood or masonry at builder's option. Pressure treating should be specified if lumber is used. Sill to foundation and collector frame to foundation connections must meet local building codes.

[8] Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation.

[9] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2130.



Opaque Insulated Exterior Vent

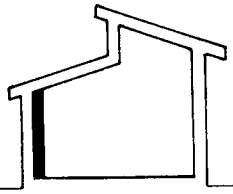


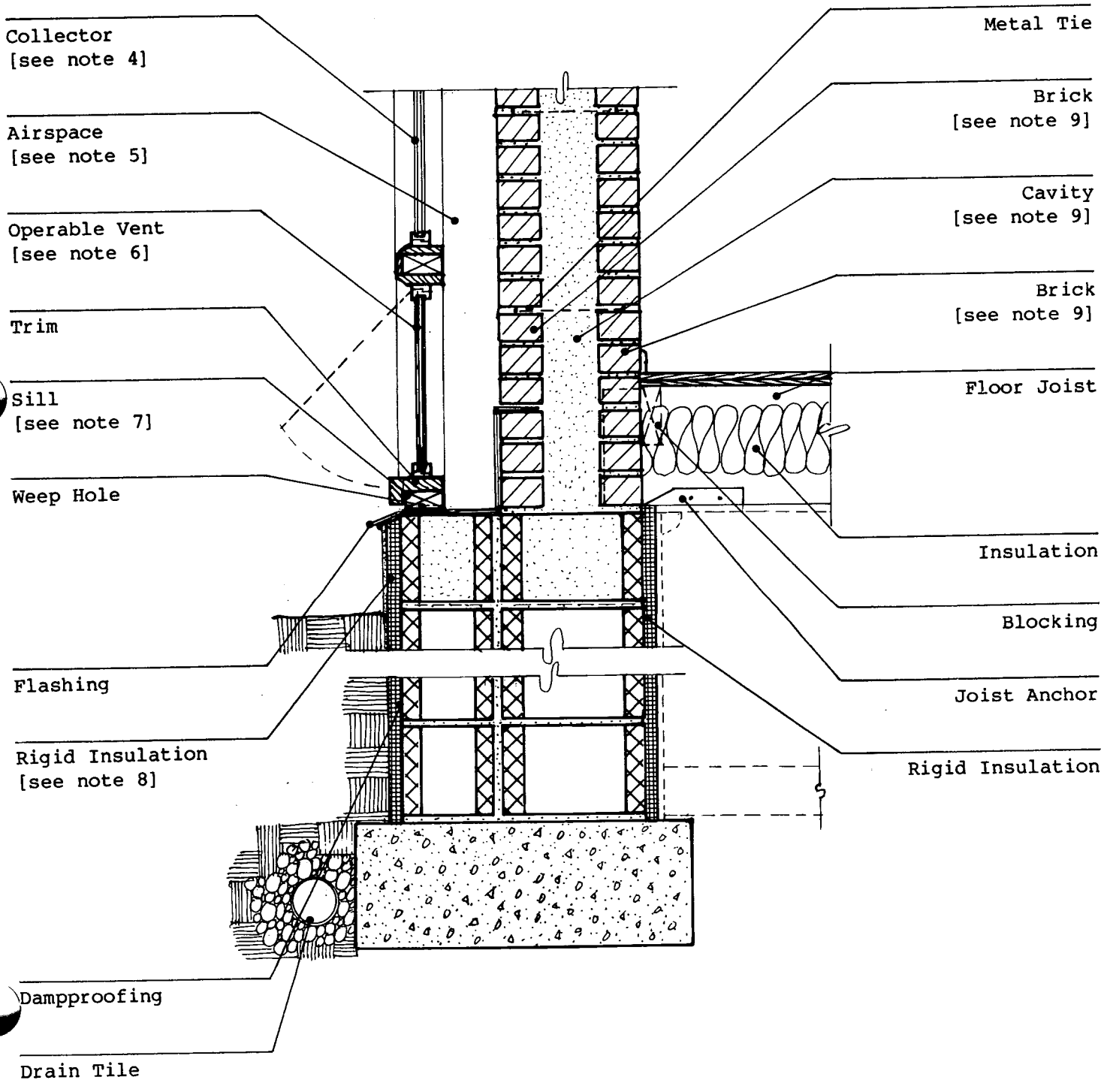
Operable Wall Vent

Thermal Storage Wall
Brick Cavity Wall
Wood First Floor

3.2322

Detail





Thermal Storage Wall
Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.

[2] Placement of reinforcing, metal ties, joist anchors, flashing and weep holes to be determined by local building codes and/or accepted practice. Floor joists must bear on solid masonry not less than 4" thick. Fire-cut joists as required.

[3] Insulation levels at floor must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

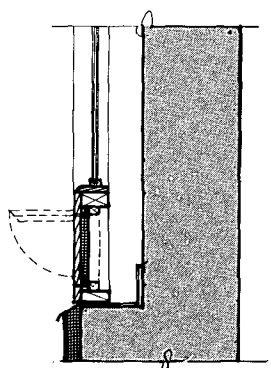
[5] Width of airspace may vary. For further information, see Key Page 3.2100.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

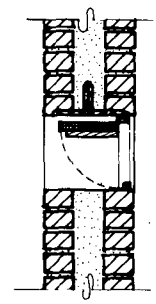
[7] Sill can be wood or masonry at builder's option. Pressure treating should be specified if lumber is used. Sill to foundation and collector frame to foundation connections must meet local building codes.

[8] It is recommended that the Thermal Storage Wall foundation be insulated on both sides to prevent heat losses to the outside and to the ground. In heated basements and heated crawl spaces insulation is not required on the inside. Insulation levels on both sides should be equal and should meet code requirements for foundation insulation. Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

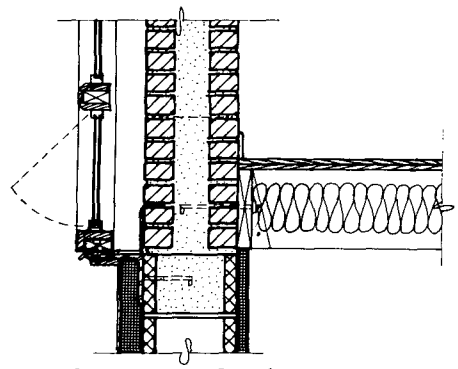
[9] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2130.



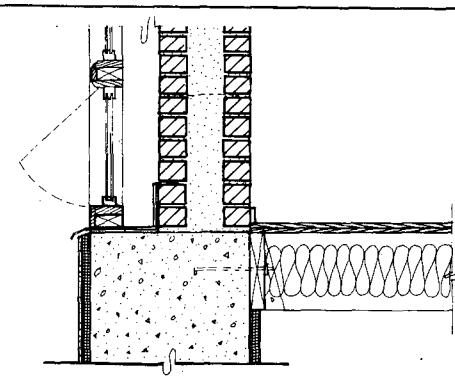
Opaque Insulated Exterior Vent



Operable Wall Vent



Steel Angle Glazing Support

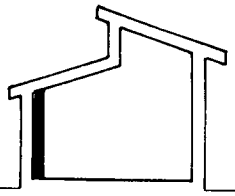


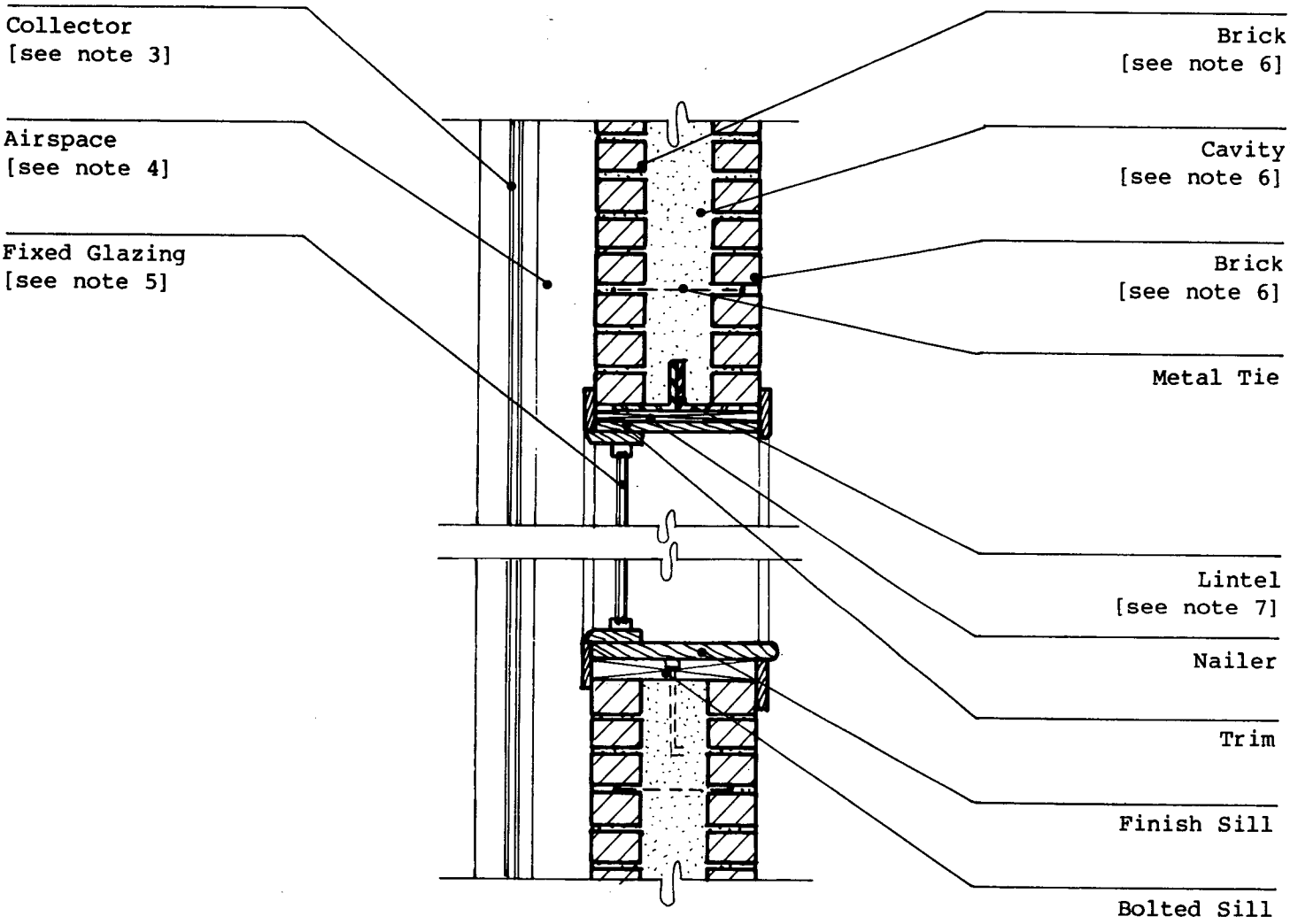
Concrete Foundation

Thermal Storage Wall
Brick Cavity Wall
Direct Gain Window

3.2324

Detail





Construction Notes

[1] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice.

[2] The storage mass should not be insulated. For further information, see Section 3.2000.

[3] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

[4] Width of airspace may vary. For further information, see Key Page 3.2100.

[5] Conventional window for light, view and/or Direct Gain may be single or double glazed. For information on Direct Gain systems see Section 3.1000.

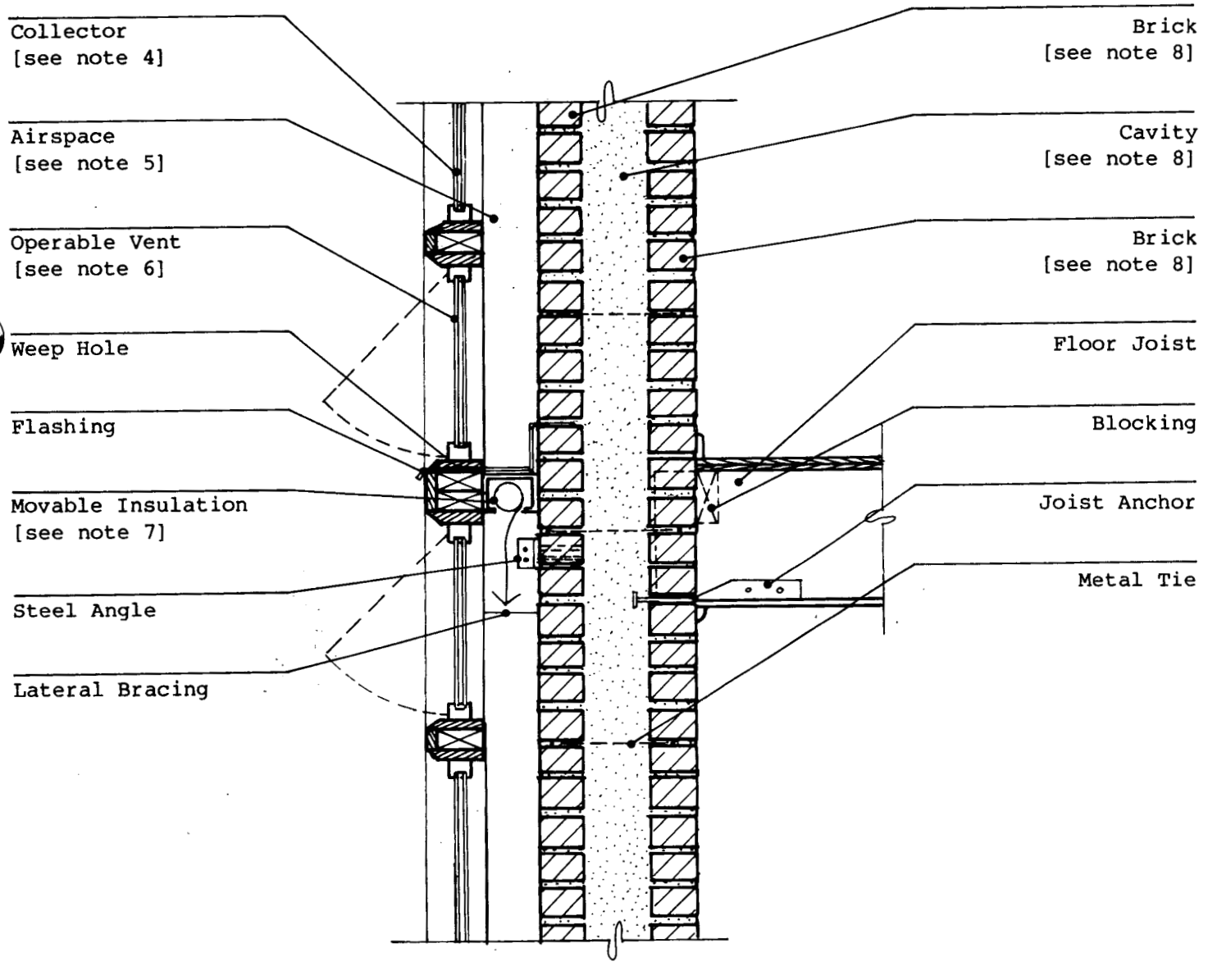
[6] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2130.

[7] Lintel fabricated from steel angles designed for loading and clear span per local building codes and/or accepted practice. Provide 6" minimum bearing at each end. Alternate reinforced brick, or other lintel may be specified at builder's option.

Thermal Storage Wall
Brick Cavity Wall
Wood Upper Floor

3.2326

Detail



Thermal Storage Wall
Construction Notes

[1] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.

[2] Placement of reinforcing, metal ties, joist anchors, flashing and weep holes to be determined by local building codes and/or accepted practice. Floor joists must bear on solid masonry not less than 4" thick. Fire-cut joists as required.

[3] The storage mass should not be insulated. For further information, see Section 3.2000.

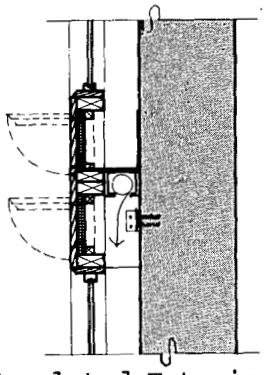
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

[5] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.

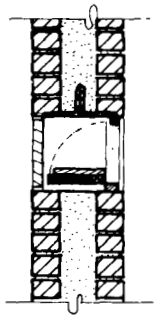
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Where airspace is not continuous, top and bottom vents should be provided for each section. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

[7] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. Where upper and lower portions of Thermal Storage Wall are separated, movable insulation must be installed in each section. For further information, see Sections 3.2000 and 4.4300.

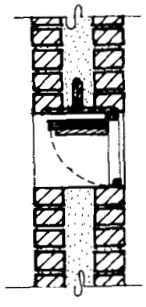
[8] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2130.



Opaque Insulated Exterior Vents



Operable Wall Vent with Backdraft Damper

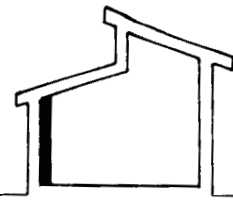


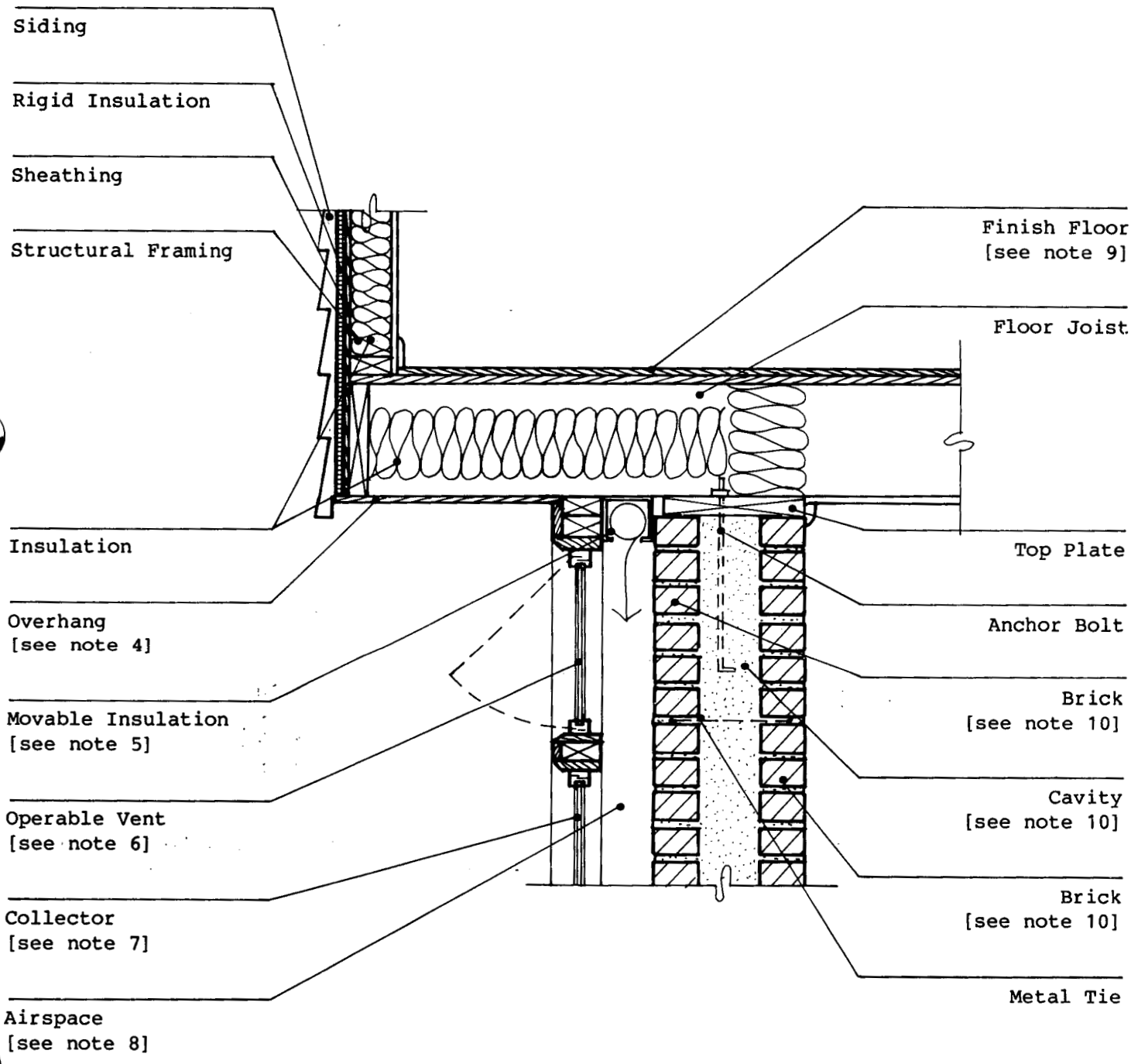
Operable Wall Vent

Thermal Storage Wall
Brick Cavity Wall
Wood Upper Floor Overhang

3.2328

Detail





Construction Notes

[1] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.

[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.

[3] Insulation levels at frame wall and floor at overhang must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.

[5] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. For further information see Sections 3.2000 and 4.4300.

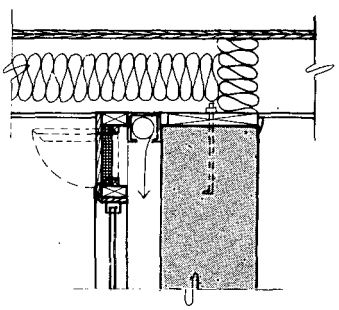
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

[7] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

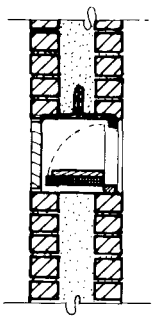
[8] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.

[9] Direct Gain system may be incorporated into upper level design. For further information, see Section 3.1000.

[10] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2130.



Opaque Insulated Exterior Vent

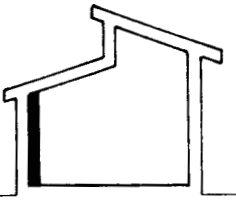


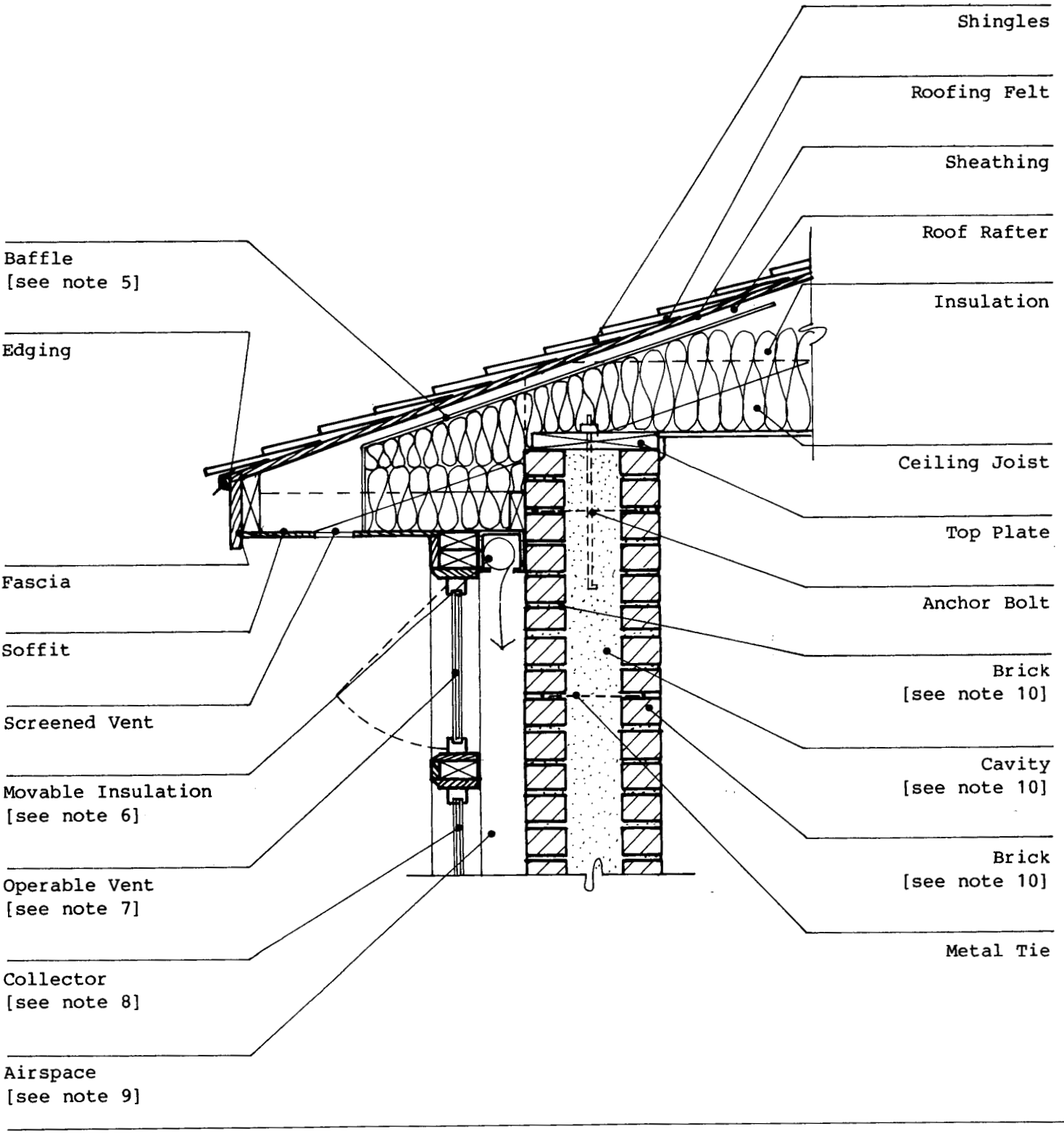
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Brick Cavity Wall
Roof

3.2330

Detail





[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections. Provide gutters and downspouts as required. Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.

[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.

[3] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.

[4] Insulation in ceiling must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[5] Provide baffles where necessary to maintain 1" minimum airspace for venting attic.

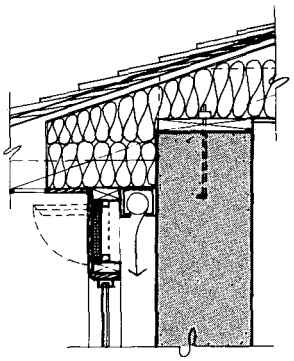
[6] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. For further information see Sections 3.2000 and 4.4300.

[7] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

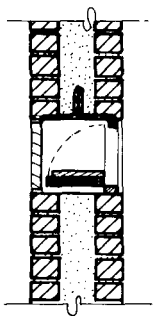
[8] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

[9] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.

[10] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2130.



Opaque Insulated Exterior Vent

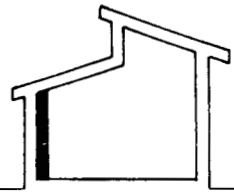


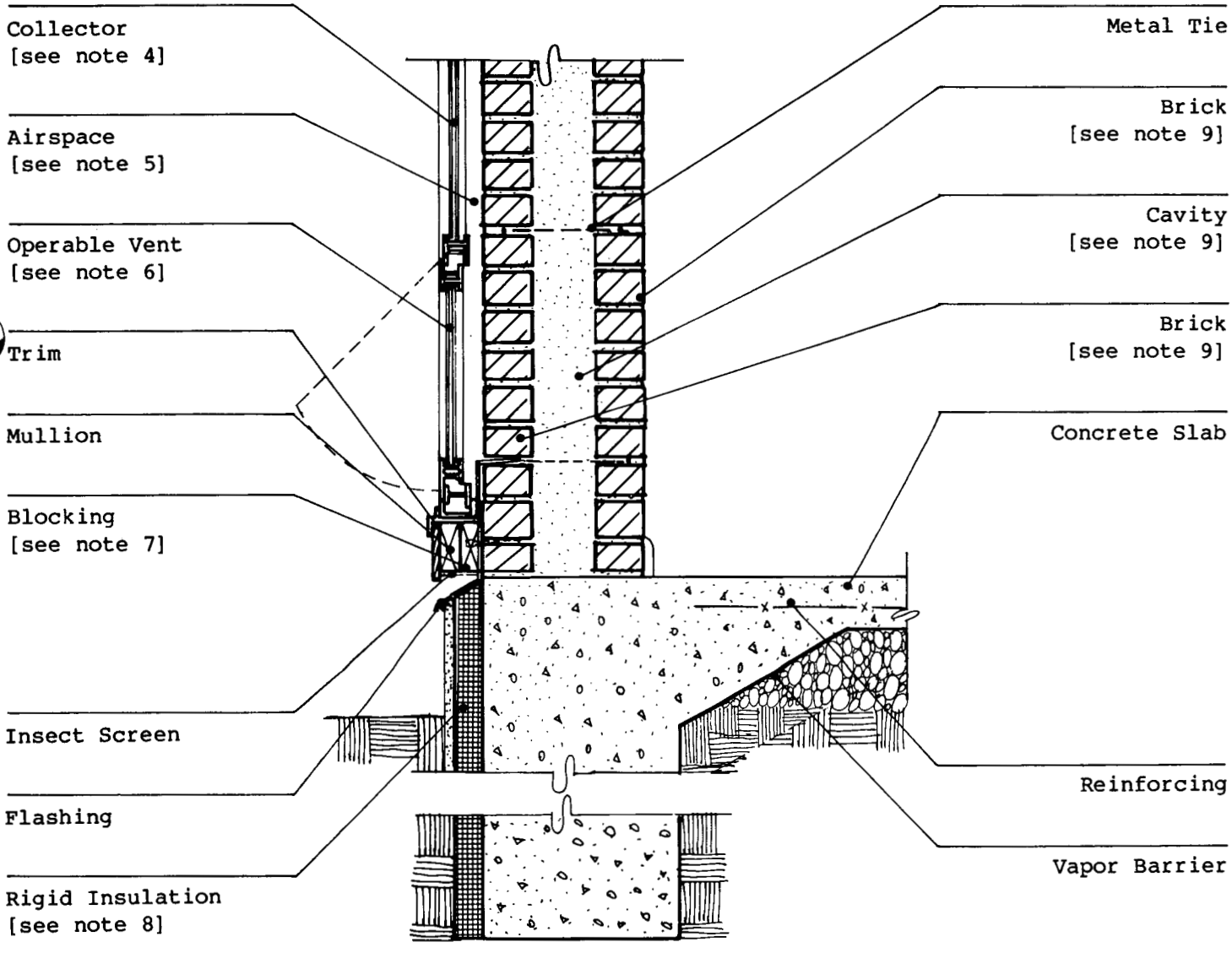
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Brick Cavity Wall
Concrete Slab-On-Grade

3.2332

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code. Where ground water problems exist, provide sufficient granular fill at haunch to prevent water penetration at slab.

[2] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code.

[3] Insulation levels at foundation/slab must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

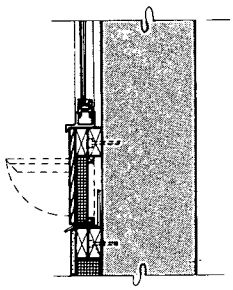
[5] Width of airspace may vary. For further information, see Key Page 3.2102.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

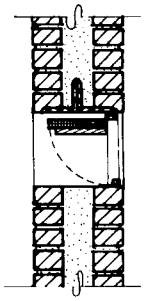
[7] Blocking can be discontinuous to provide weep holes where required. It is recommended that wood be pressure treated and insect screens (as shown) be provided at weep holes.

[8] Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

[9] Brick facing and Concrete Masonry back-up unit must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2128.



Opaque Insulated Exterior Vent

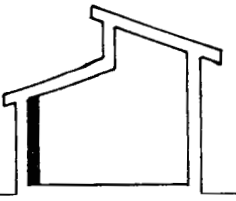


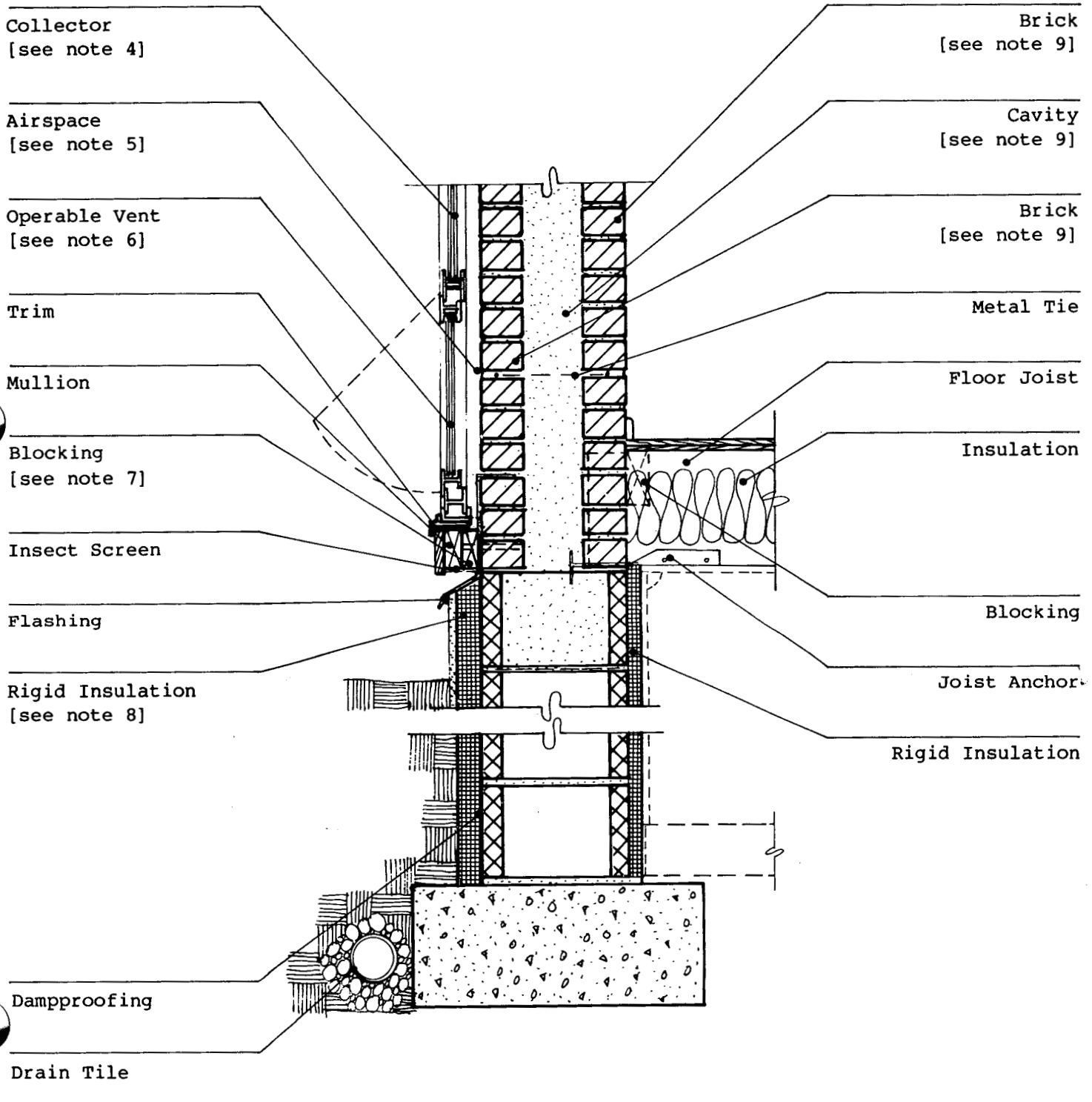
Operable Wall Vent

Thermal Storage Wall
Brick Cavity Wall
Wood First Floor

3.2334

Detail





Thermal Storage Wall
Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.

[2] Placement of reinforcing, metal ties, joist anchors, flashing and weep holes to be determined by local building codes and/or accepted practice. Floor joists must bear on solid masonry not less than 4" thick. Fire-cut joists as required.

[3] Insulation levels at floor must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

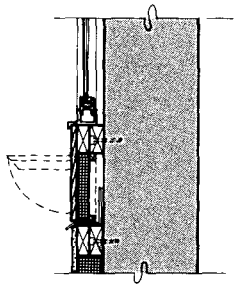
[5] Width of airspace may vary. For further information, see Key Page 3.2102.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

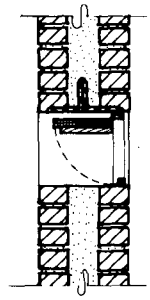
[7] Blocking can be discontinuous to provide weep holes where required. It is recommended that wood be pressure treated and insect screens (as shown) be provided at weep holes.

[8] It is recommended that the Thermal Storage Wall foundation be insulated on both sides to prevent heat losses to the outside and to the ground. In heated basements and heated crawl spaces insulation is not required on the inside. Insulation levels on both sides should be equal and should meet code requirements for foundation insulation. Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

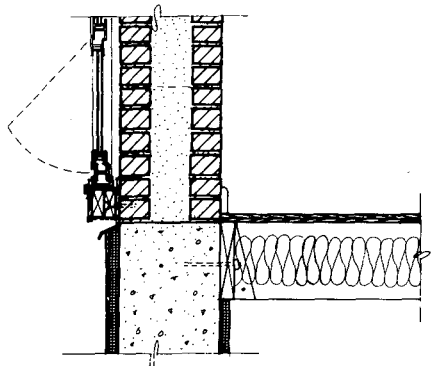
[9] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2130.



Opaque Insulated Exterior Vent



Operable Wall Vent

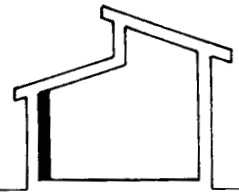


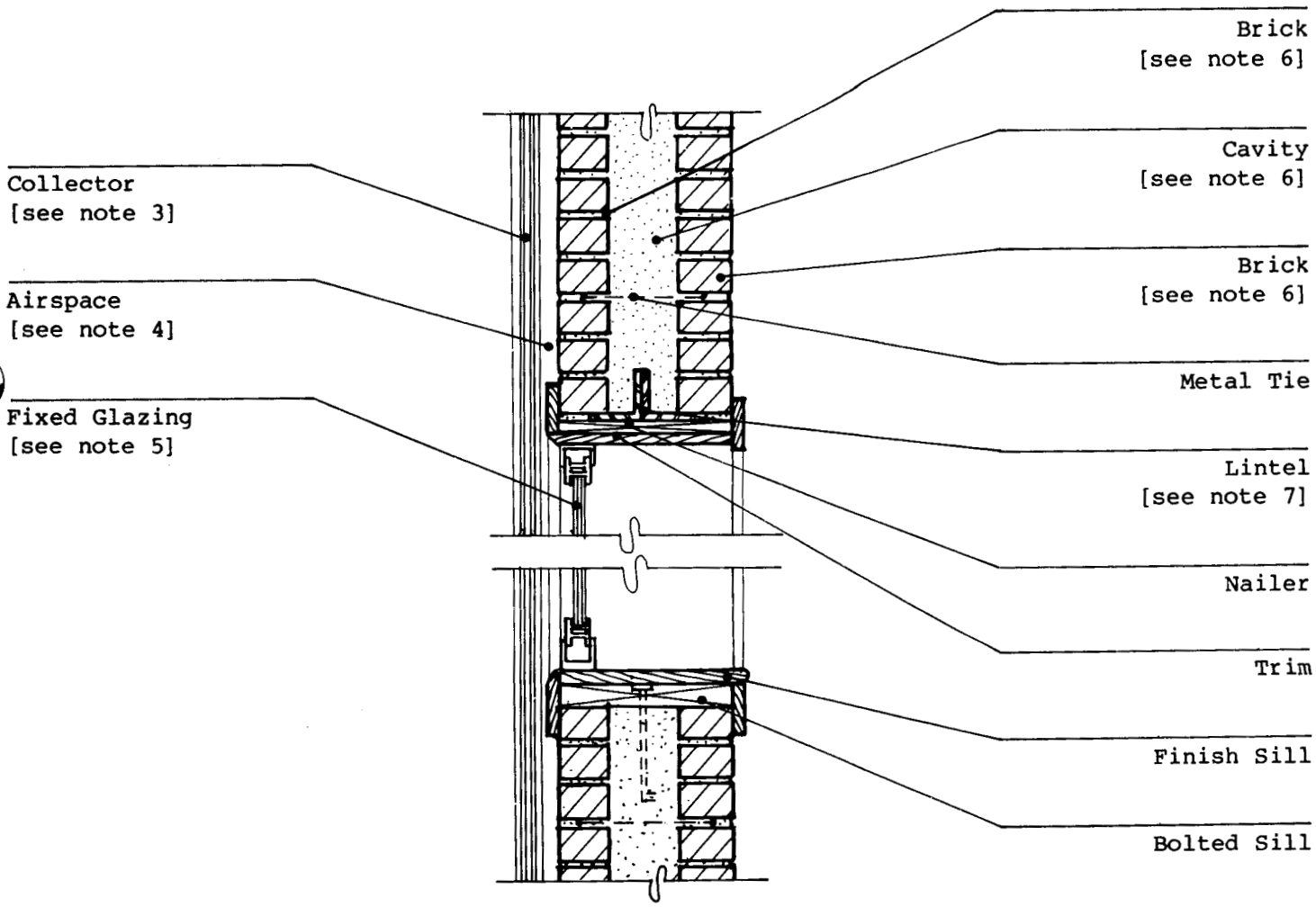
Concrete Foundation

Thermal Storage Wall
Brick Cavity Wall
Direct Gain Window

3.2336

Detail





Construction Notes

[1] Placement of reinforcing and metal ties to be determined by local building codes and/or accepted practice.

[2] The storage mass should not be insulated. For further information, see Section 3.2000.

[3] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

[4] Width of airspace may vary. For further information, see Key Page 3.2102.

[5] Conventional window for light, view and/or Direct Gain may be single or double glazed. For information on Direct Gain systems, see Section 3.1000.

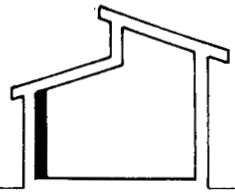
[6] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2130.

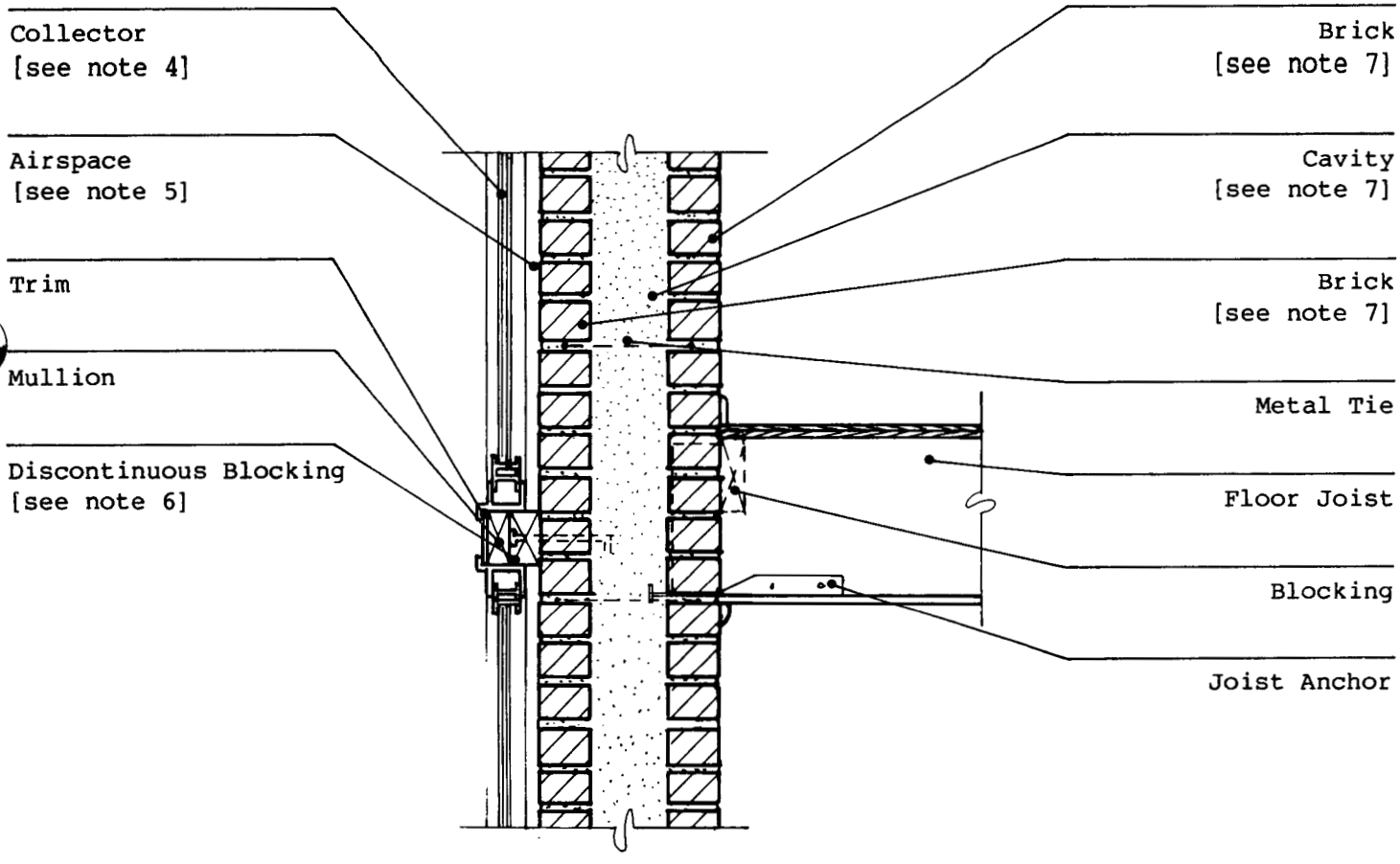
[7] Lintel fabricated from steel angles designed for loading and clear span per local building codes and/or accepted practice. Provide 6" minimum bearing at each end. Alternate reinforced brick, or other lintel may be specified at builder's option.

Thermal Storage Wall
Brick Cavity Wall
Wood Upper Floor

3.2338

Detail



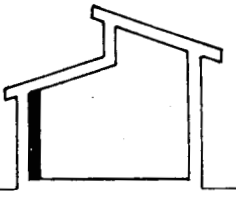


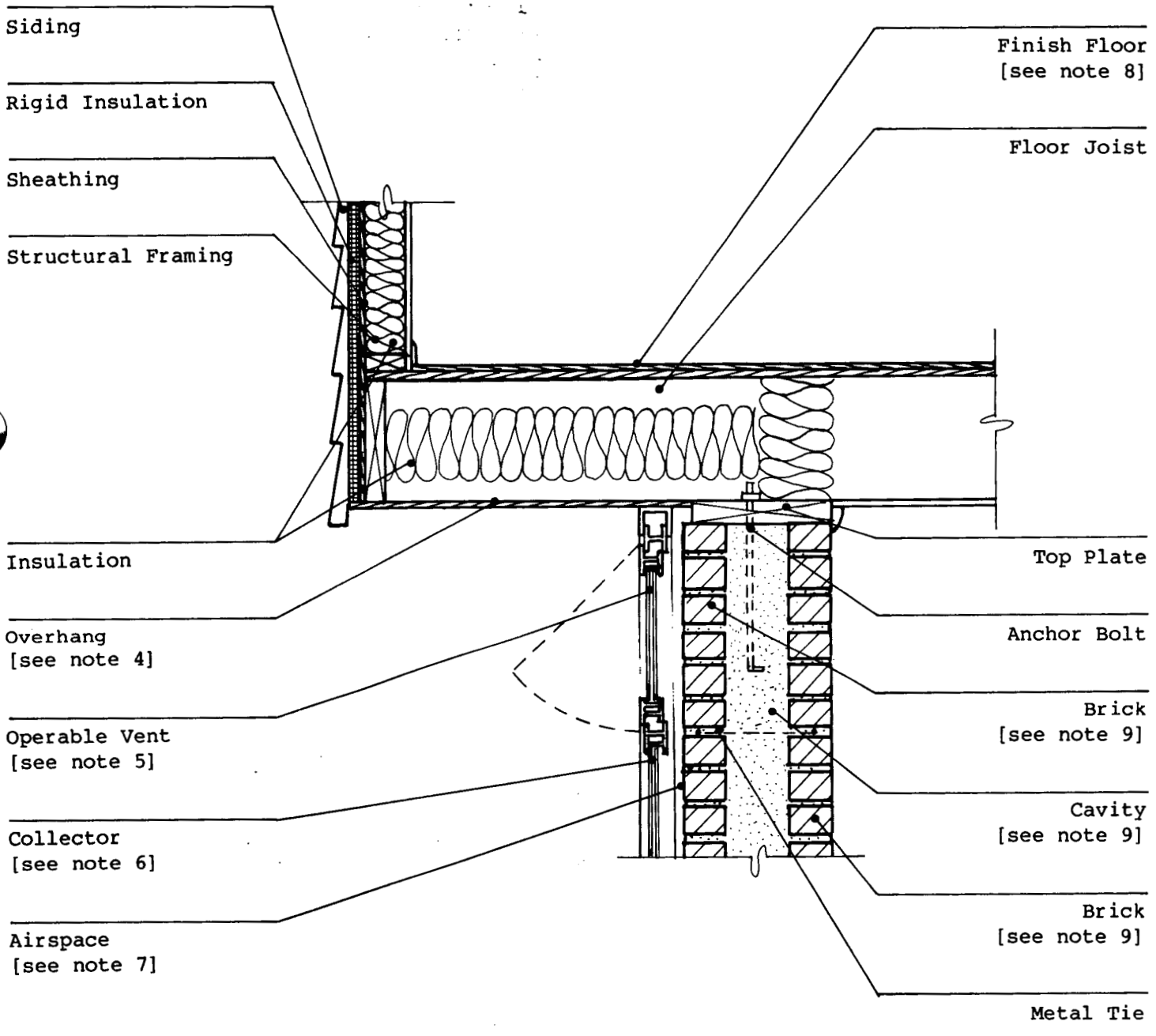
[1] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.
[2] Placement of reinforcing, metal ties and joist anchors to be determined by local building codes and/or accepted practice. Floor joists must bear on solid masonry not less than 4 inches thick. Fire-cut joists as required.
[3] The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[5] Width of airspace may vary. For further information, see Key Page 3.2102.
[6] Discontinuous blocking to allow for adequate air circulation in airspace.
[7] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2130.

Thermal Storage Wall
Brick Cavity Wall
Wood Upper Floor Overhang

3.2340

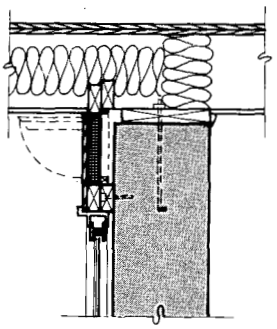
Detail



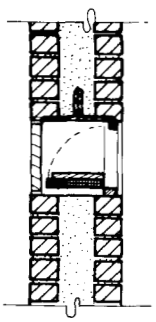


Thermal Storage Wall
Construction Notes

[1] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.
[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.
[3] Insulation levels at frame wall and floor at overhang must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.
[5] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[6] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[7] Width of airspace may vary. For further information, see Key Page 3.2102.
[8] Direct Gain system may be incorporated into upper level design. For further information, see Section 3.1000.
[9] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2130.



Opaque Insulated Exterior Vent

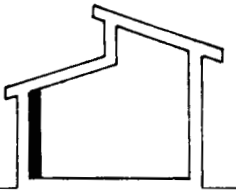


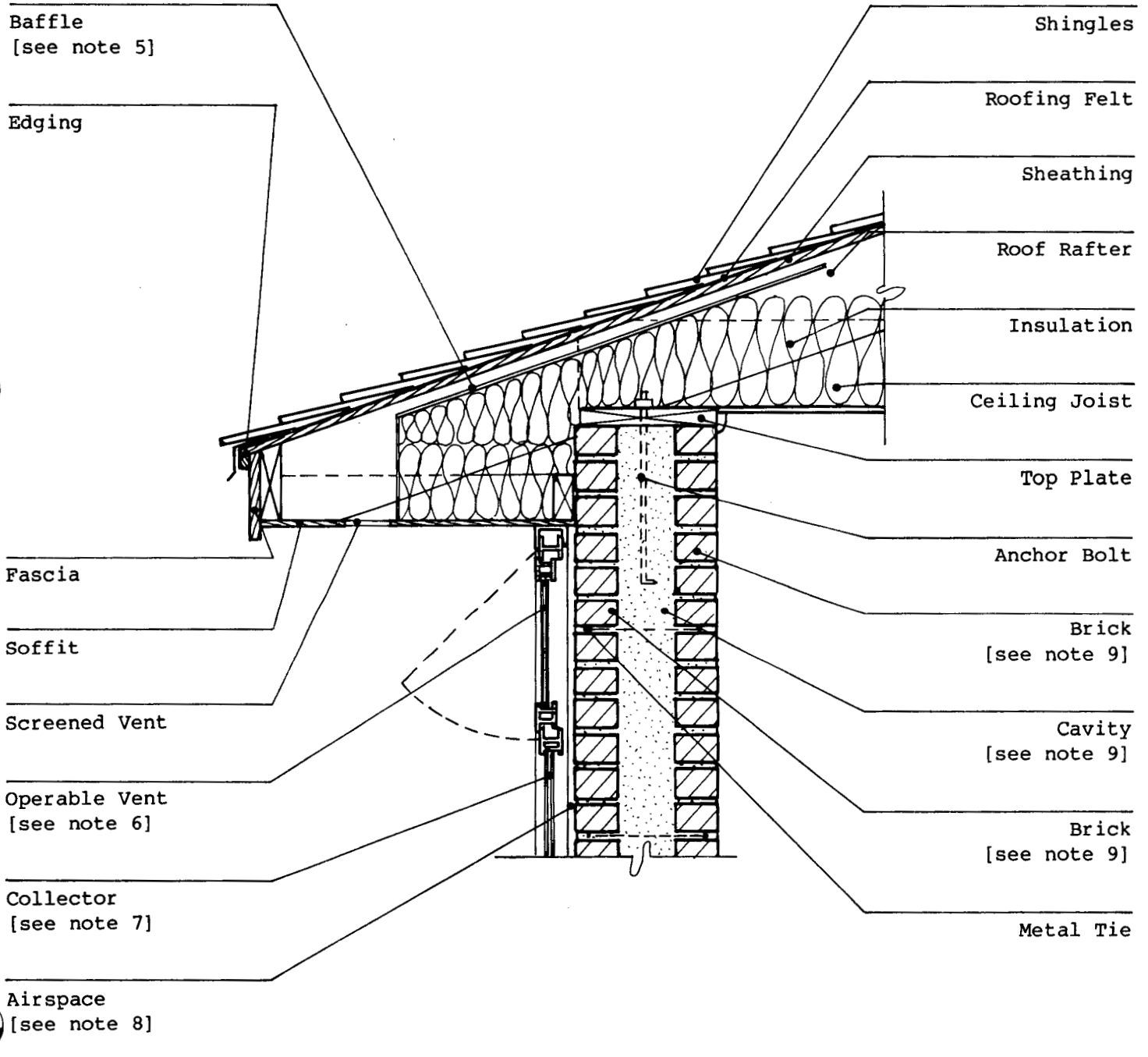
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Brick Cavity Wall
Roof

3.2342

Detail





[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections. Provide gutters and downspouts as required. Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.

[2] Placement of reinforcing, metal ties and anchor bolts to be determined by local building codes and/or accepted practice.

[3] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.

[4] Insulation in ceiling must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

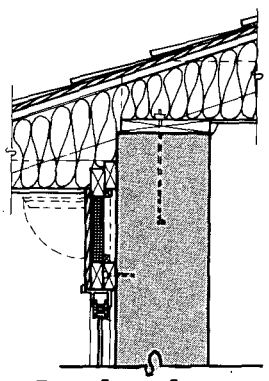
[5] Provide baffles where necessary to maintain 1" minimum airspace for venting attic.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

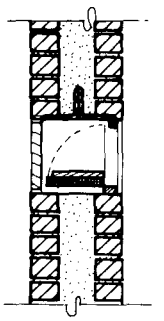
[7] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

[8] Width of airspace may vary. For further information, see Key Page 3.2102.

[9] Exterior and interior wythes of cavity wall must be solid or hollow with fully grouted cores. Cavity must be filled solid. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2130.



Opaque Insulated Exterior Vent

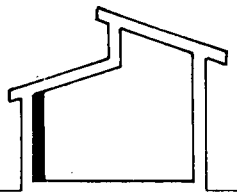


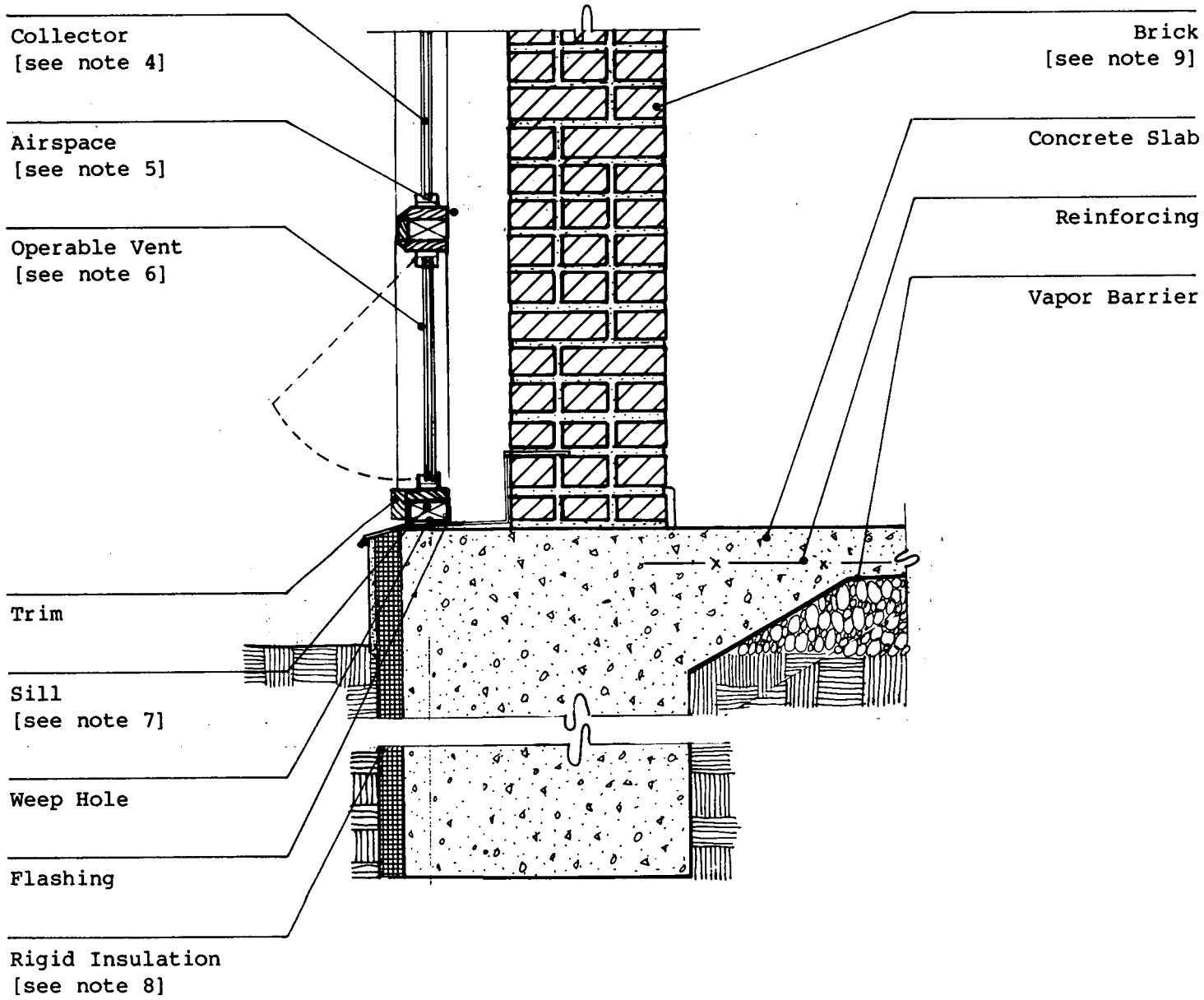
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Solid Brick Wall
Concrete Slab-On-Grade

3.2344

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code. Where ground water problems exist, provide sufficient granular fill at haunch to prevent water penetration at slab.

[2] Placement of reinforcing, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab is not recommended except where required by local conditions and/or code.

[3] Insulation levels at foundation/slab must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

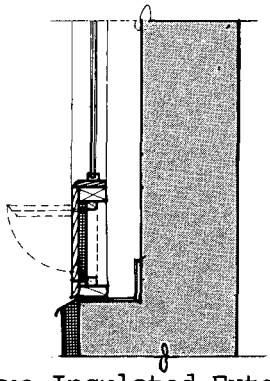
[5] Width of airspace may vary. For further information, see Key Page 3.2100.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. For more information, see Section 3.2000.

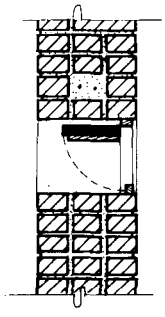
[7] Sill can be wood or masonry at builder's option. Pressure treating should be specified if lumber is used. Sill to foundation and collector frame to foundation connections must meet local building codes.

[8] Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation.

[9] Solid Brick Thermal Storage Wall. Bricks must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2132.



Opaque Insulated Exterior Vent

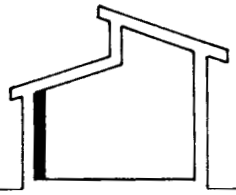


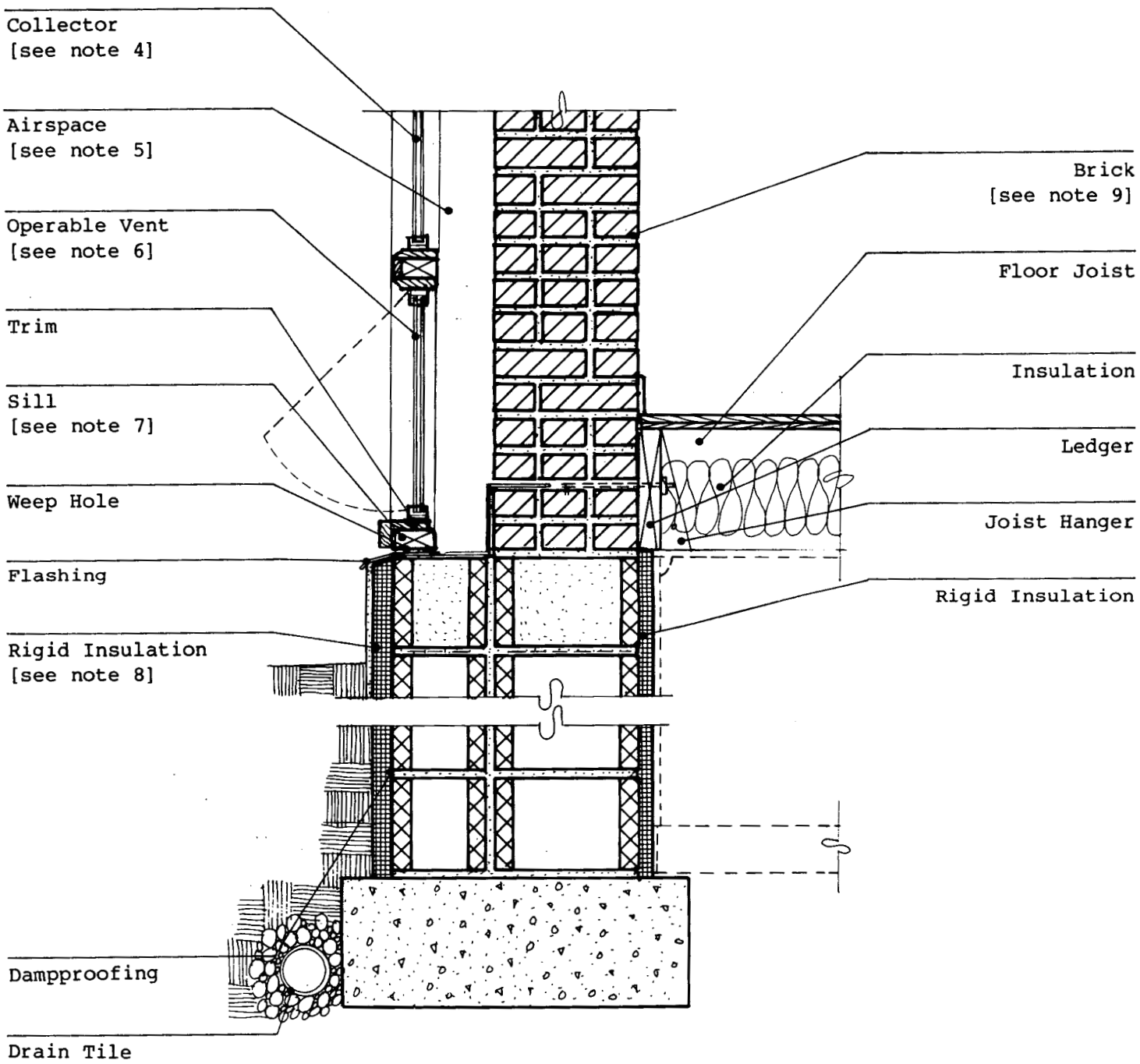
Operable Wall Vent

Thermal Storage Wall
Solid Brick Wall
Wood First Floor

3.2346

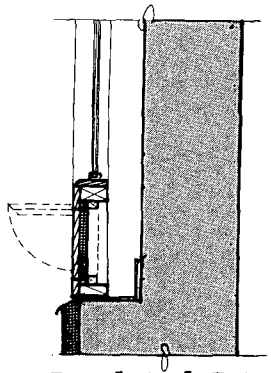
Detail



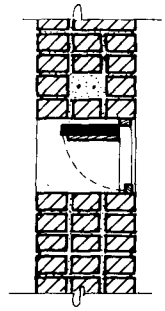


Thermal Storage Wall
Construction Notes

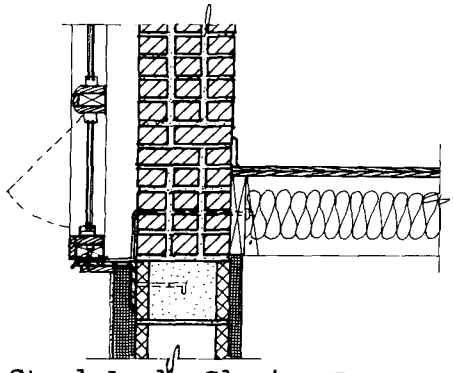
[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.
[2] Placement of reinforcing, flashing and weep holes to be determined by local building codes and/or accepted practice.
[3] Insulation levels at floor must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.
[5] Width of airspace may vary. For further information, see Key Page 3.2100.
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[7] Sill can be wood or masonry at builder's option. Pressure treating should be specified if lumber is used. Sill to foundation and collector frame to foundation connections must meet local building codes.
[8] It is recommended that the Thermal Storage Wall foundation be insulated on both sides to prevent heat losses to the outside and to the ground. In heated basements and heated crawl spaces insulation is not required on the inside. Insulation levels on both sides should be equal and should meet code requirements for foundation insulation. Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.
[9] Solid Brick Thermal Storage Wall. Bricks must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2132.



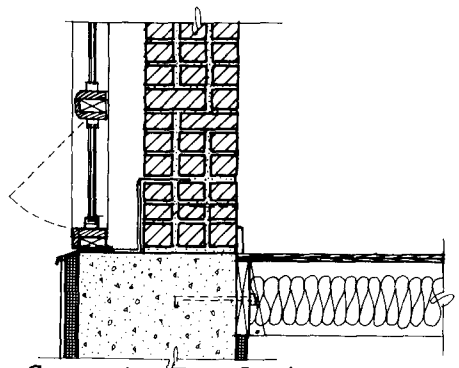
Opaque Insulated Exterior Vent



Operable Wall Vent



Steel Angle Glazing Support

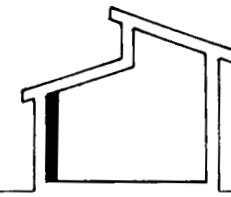


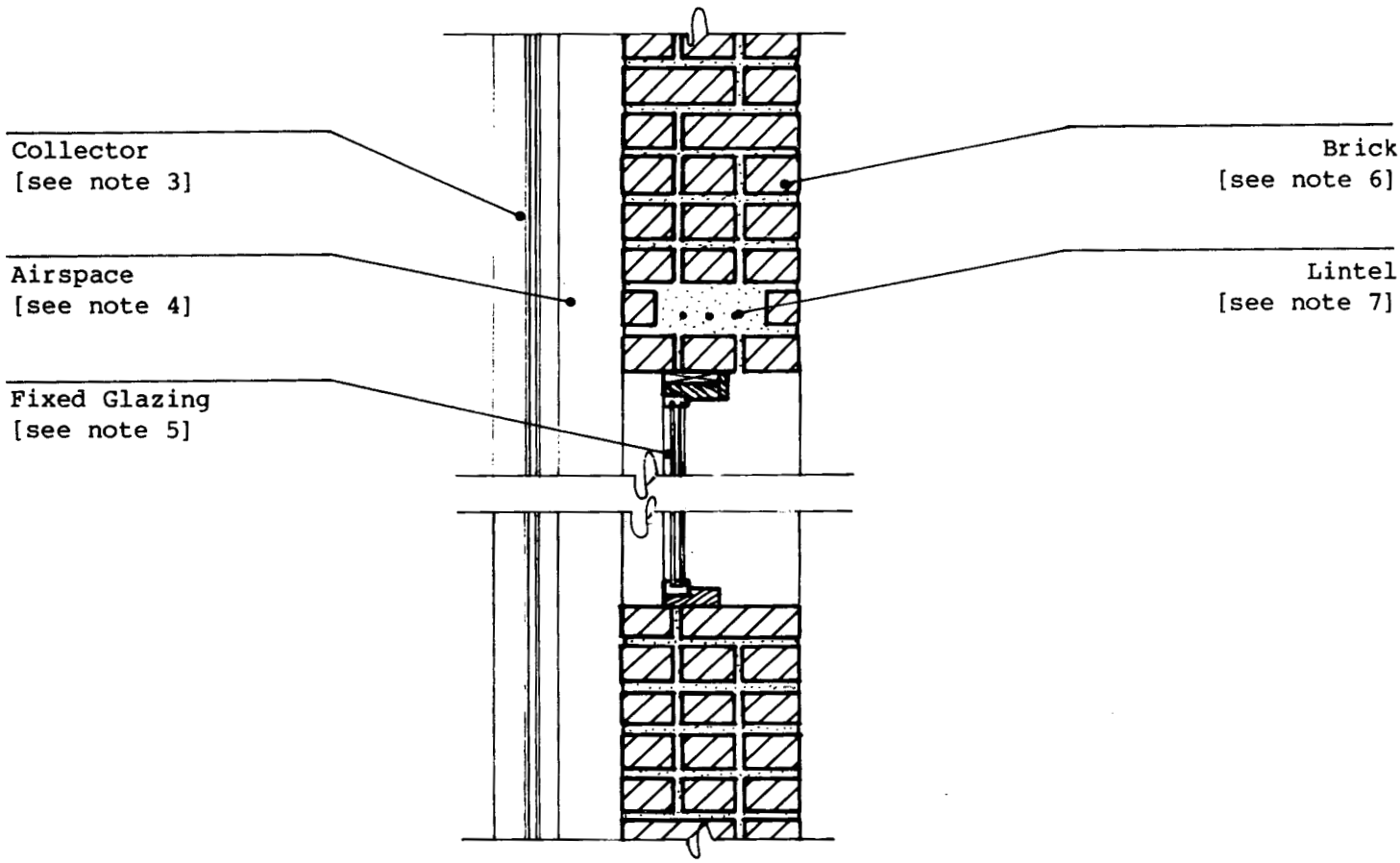
Concrete Foundation

Thermal Storage Wall
Solid Brick Wall
Direct Gain Window

3.2348

Detail





Construction Notes

[1] Placing of reinforcing to be determined by local building codes and/or accepted practice.

[2] The storage mass should not be insulated. For further information, see Section 3.2000.

[3] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

[4] Width of airspace may vary. For further information, see Key Page 3.2100.

[5] Conventional window for light, view and/or Direct Gain may be single or double glazed. For information on Direct Gain systems, see Section 3.1000.

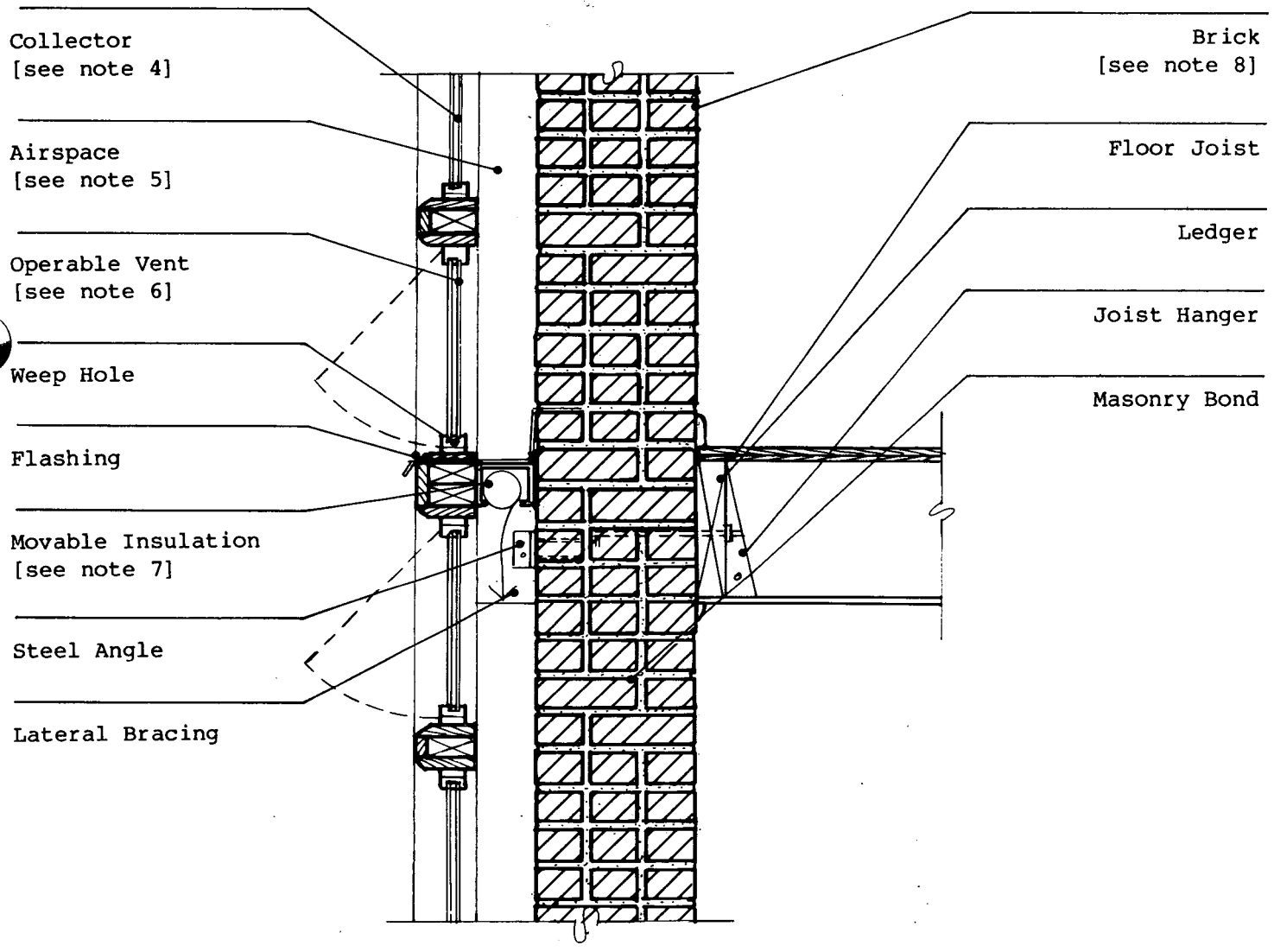
[6] Solid Brick Thermal Storage Wall. Bricks must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2132.

[7] Reinforced Brick lintel may be of standard or special units. Lintel should be designed for loading and clear span per local building codes and/or accepted practice. Alternate jack arch or steel lintel may be specified at builder's option.

Thermal Storage Wall
Solid Brick Wall
Wood Upper Floor

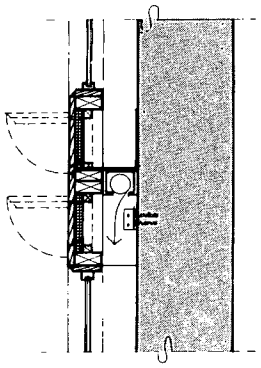
3.2350

Detail

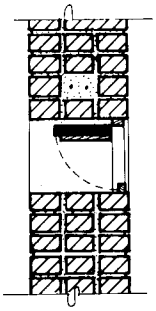


Construction Notes

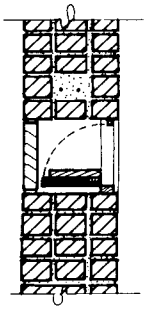
[1] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.
[2] Placement of reinforcing, flashing and weep holes to be determined by local building codes and/or accepted practice.
[3] The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.
[5] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Where airspace is not continuous, top and bottom vents should be provided for each section. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[7] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. Where upper and lower portions of Thermal Storage Wall are separated, movable insulation must be installed in each section. For further information, see Sections 3.2000 and 4.4300.
[8] Solid Brick Thermal Storage Wall. Bricks must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2132.



Opaque Insulated Exterior Vents



Operable Wall Vent

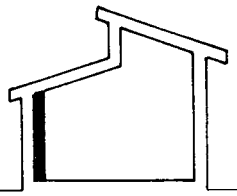


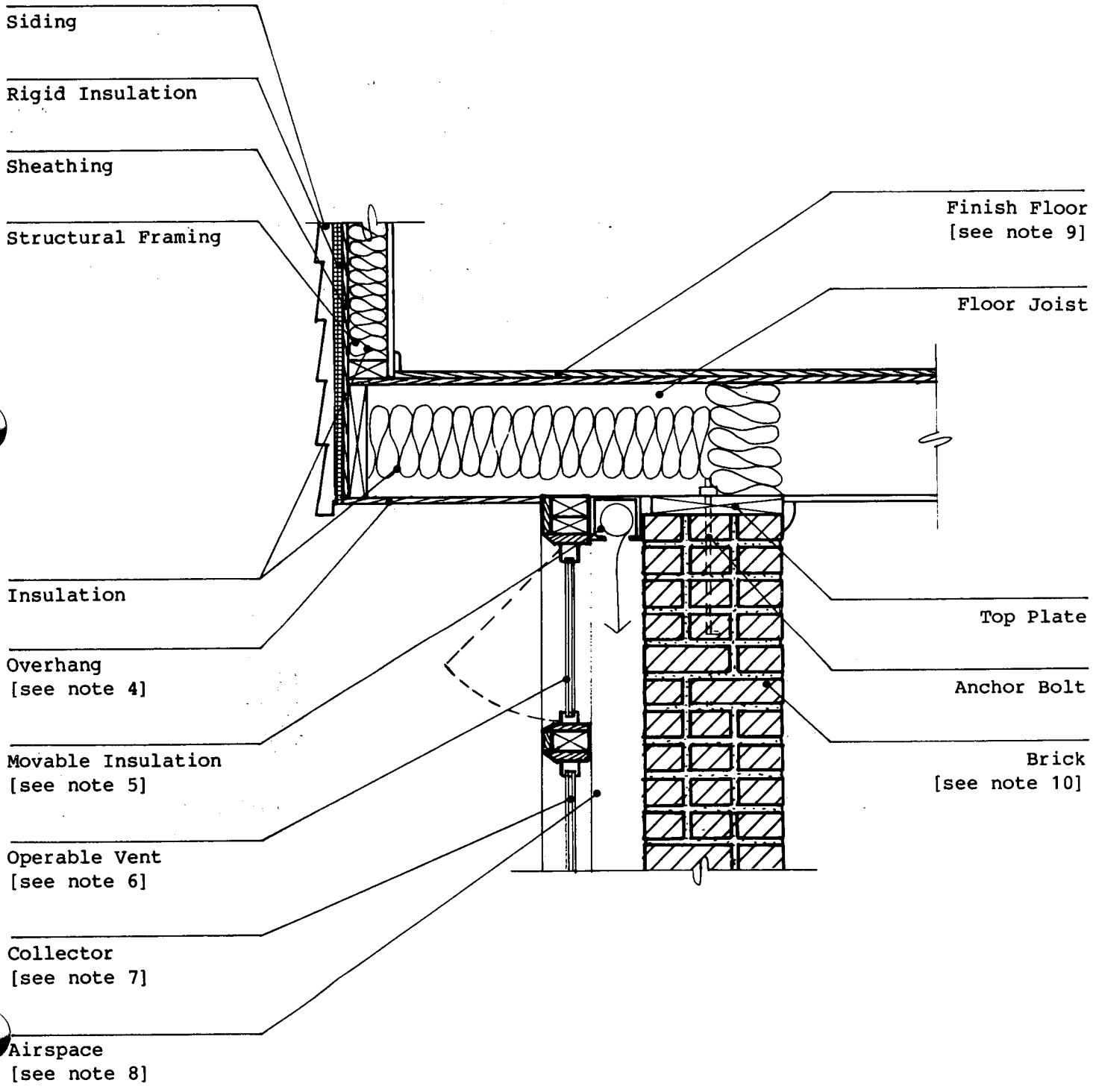
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Solid Brick Wall
Wood Upper Floor Overhang

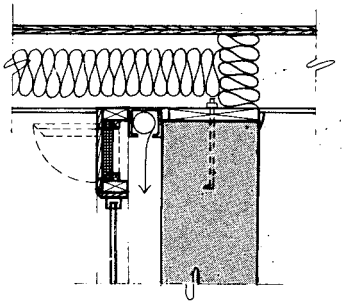
3.2352

Detail

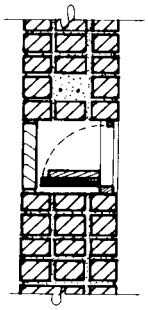




[1] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.
[2] Placement of reinforcing and anchor bolts to be determined by local building codes and/or accepted practice.
[3] Insulation levels at frame wall and floor at overhang must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.
[5] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. For further information, see Sections 3.2000 and 4.4300.
[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[7] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.
[8] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.
[9] Direct Gain system may be incorporated into upper level design. For further information, see Section 3.1000.
[10] Solid Brick Thermal Storage Wall. Bricks must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2132.



Opaque Insulated Exterior Vent

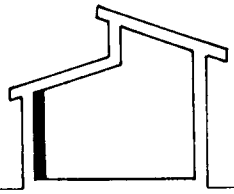


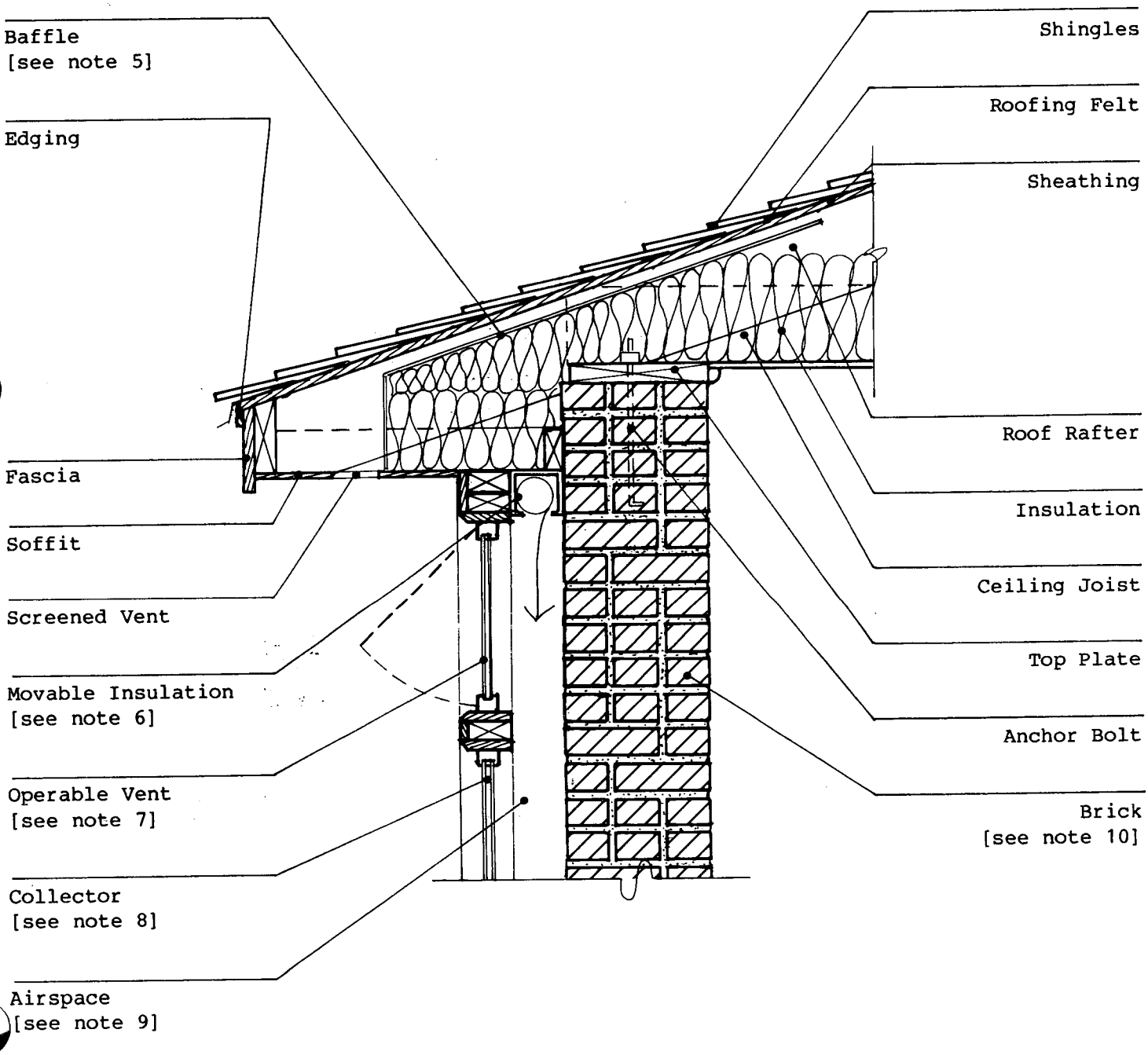
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Solid Brick Wall
Roof

3.2354

Detail





[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections. Provide gutters and downspouts as required. Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information, see Sections 3.2000 and 4.4100.

[2] Placement of reinforcing and anchor bolts to be determined by local building codes and/or accepted practice.

[3] Structural framing for Collector component to be designed per local building code restrictions and/or accepted practice.

[4] Insulation in ceiling must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[5] Provide baffles where necessary to maintain 1" minimum airspace for venting attic.

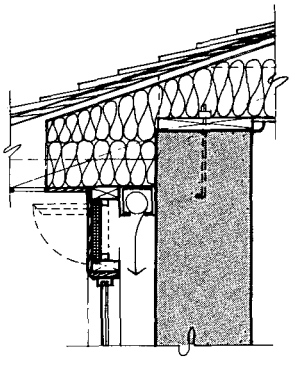
[6] Movable insulation to control nighttime and cloudy day heat loss and to prevent overheating during cooling season should be provided. Installation and operation per manufacturer's recommendation. For further information see Sections 3.2000 and 4.4300.

[7] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

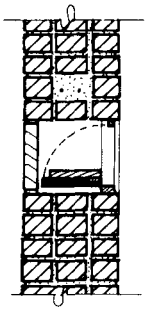
[8] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2100.

[9] Width of airspace may vary. Where movable insulation is installed, care must be taken to provide adequate space for its installation and operation. For further information, see Key Page 3.2100.

[10] Solid Brick Thermal Storage Wall. Bricks must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2132.



Opaque Insulated Exterior Vent

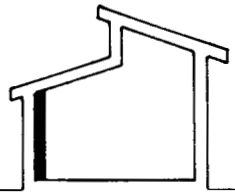


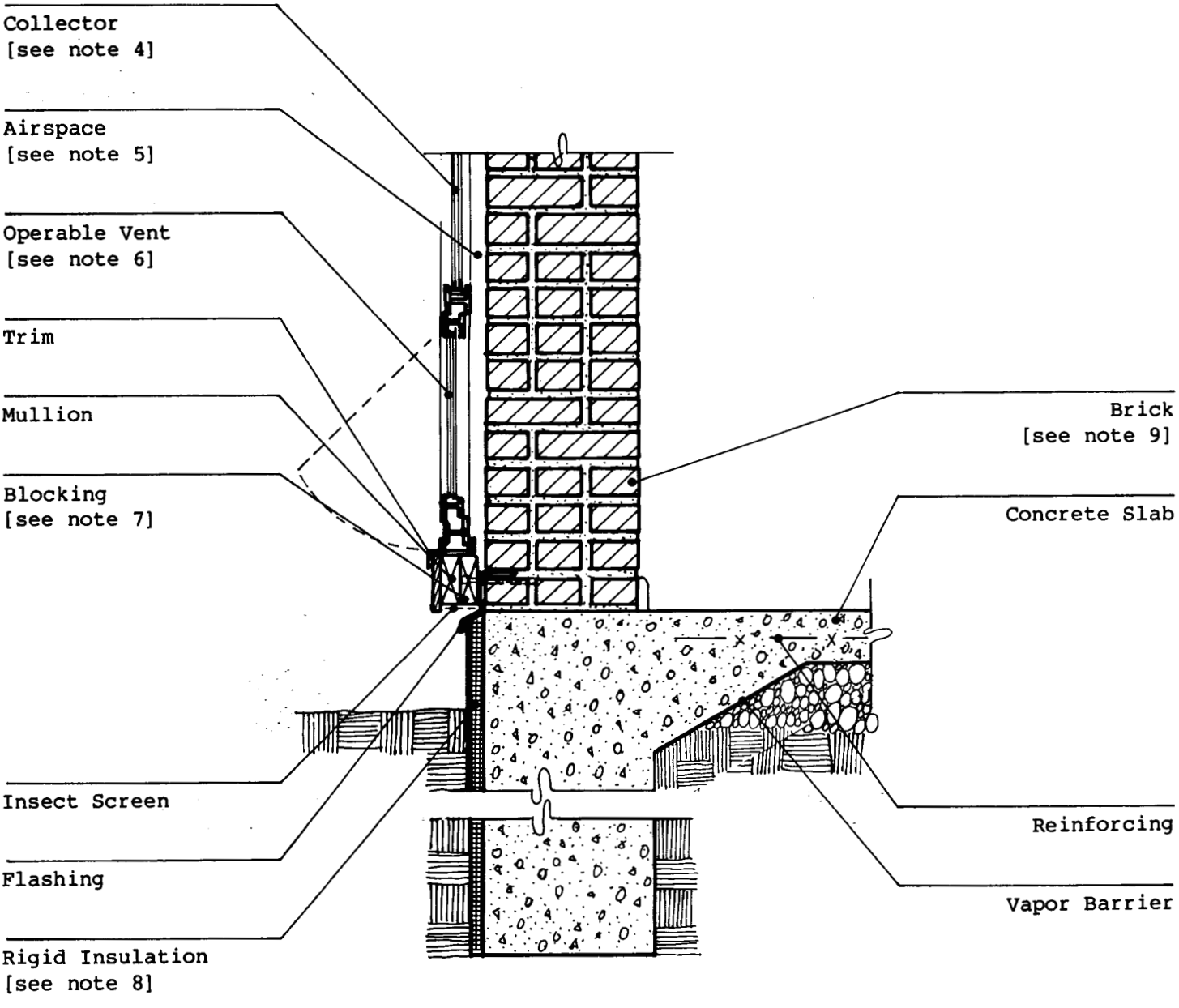
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Solid Brick Wall
Concrete Slab-On-Grade

3.2356

Detail





Thermal Storage Wall
Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code. Where ground water problems exist, provide sufficient granular fill at haunch to prevent water penetration at slab.

[2] Placement of reinforcing, flashing and weep holes to be determined by local building codes and/or accepted practice. Reinforcing in concrete slab-on-grade construction is not recommended except where required by local conditions and/or code.

[3] Insulation levels at foundation/slab must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

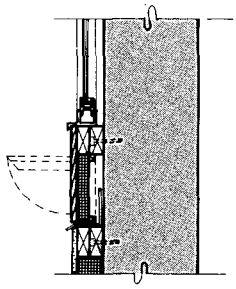
[5] Width of airspace may vary. For further information, see Key Page 3.2102.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

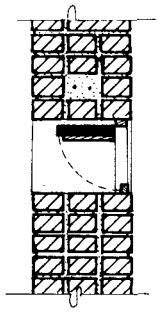
[7] Blocking can be discontinuous to provide weep holes where required. It is recommended that wood be pressure treated and insect screens (as shown) be provided at weep holes.

[8] Insulation levels should meet code requirements for foundation insulation. Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

9] Solid Brick Thermal Storage Wall. Bricks must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2132.



Opaque Insulated Exterior Vent

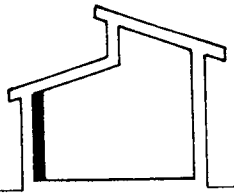


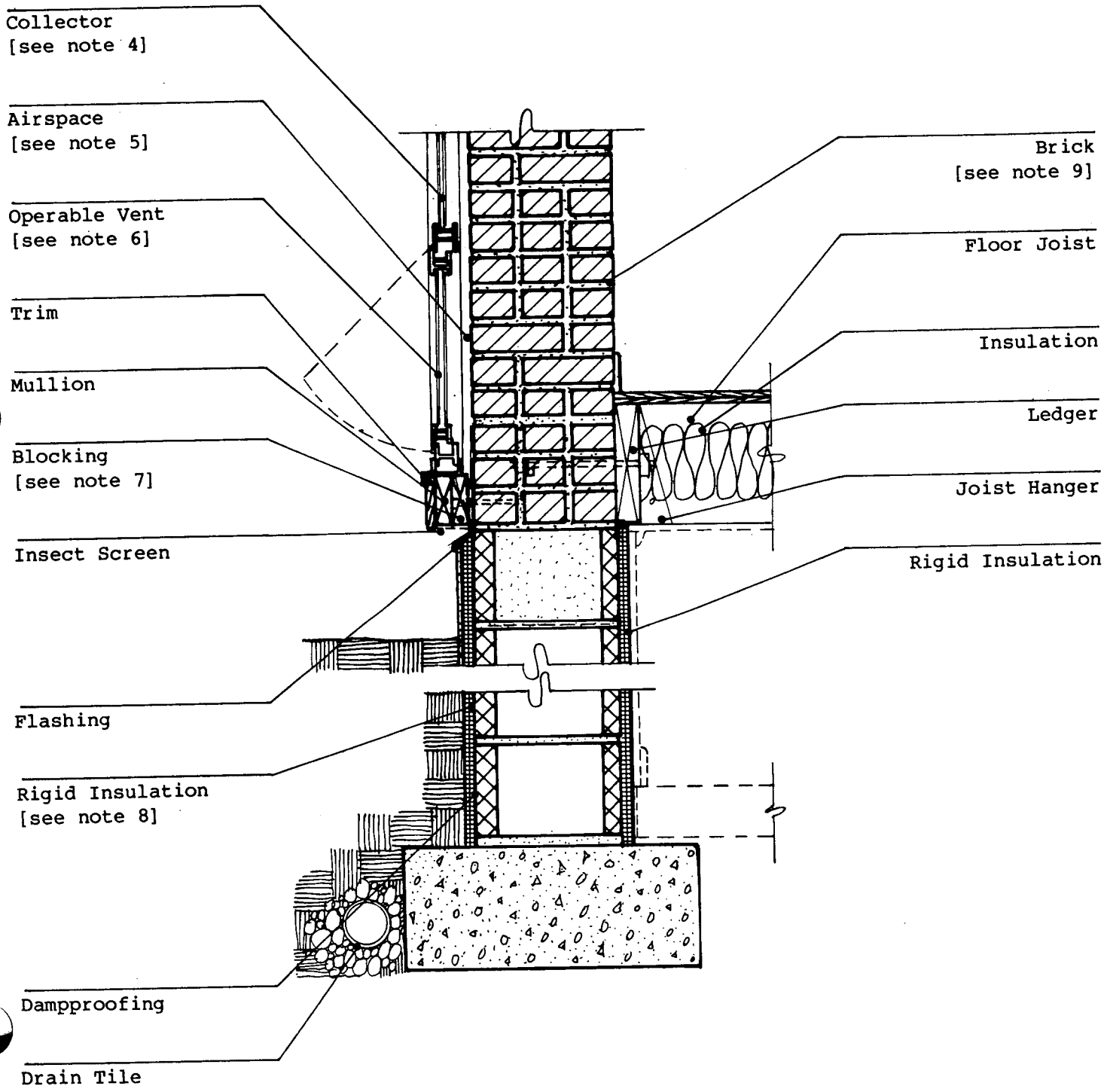
Operable Wall Vent

Thermal Storage Wall
Solid Brick Wall
Wood First Floor

3.2358

Detail





Thermal Storage Wall
Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.

[2] Placement of reinforcing, flashing and weep holes to be determined by local building codes and/or accepted practice.

[3] Insulation levels at floor must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

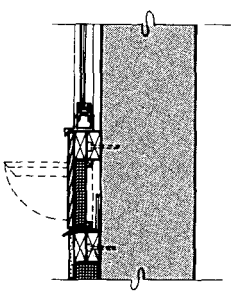
[5] Width of airspace may vary. For further information, see Key Page 3.2102.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

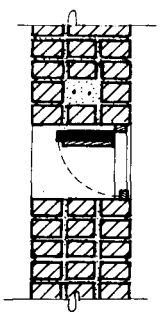
[7] Blocking can be discontinuous to provide weep holes where required. It is recommended that wood be pressure treated and insect screens (as shown) be provided at weep holes.

[8] It is recommended that the Thermal Storage Wall foundation be insulated on both sides to prevent heat losses to the outside and to the ground. In heated basements and heated crawl spaces insulation is not required on the inside. Insulation levels on both sides should be equal and should meet code requirements for foundation insulation. Insulation must be protected where exposed outside above grade. Cement plaster over wire lath or other methods may be employed. Where dampproofing is used allow for complete curing before applying insulation. Consult insulation manufacturer for recommended installation methods.

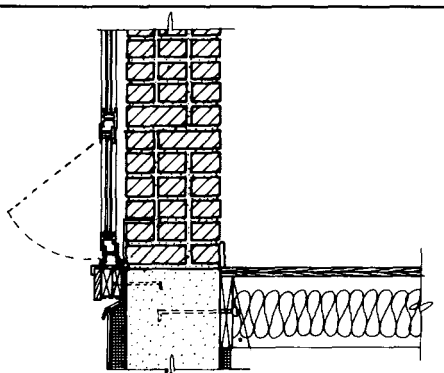
[9] Solid Brick Thermal Storage Wall. Bricks must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2132.



Opaque Insulated Exterior Vent



Operable Wall Vent

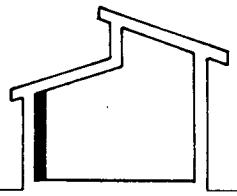


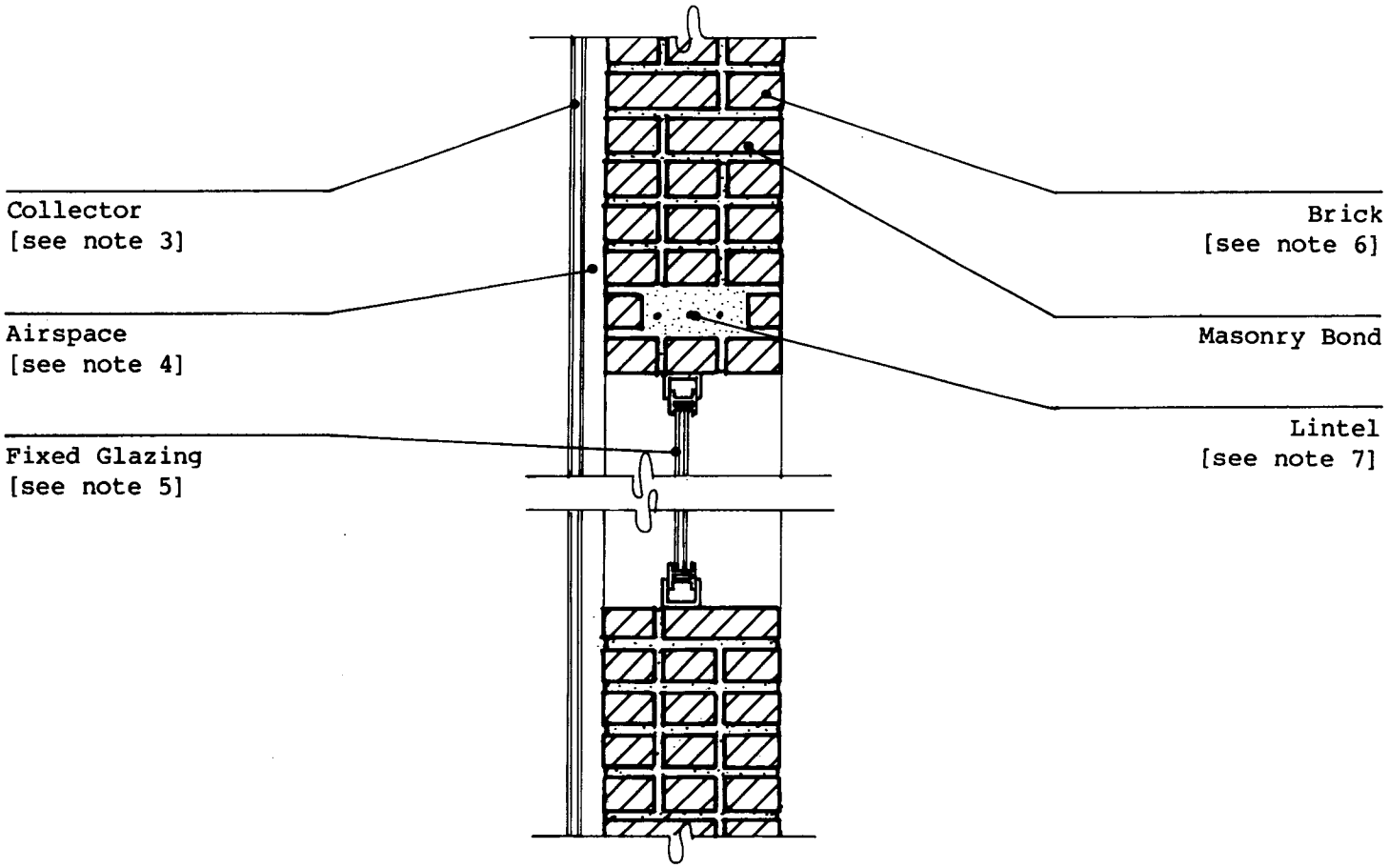
Concrete Basement Wall

Thermal Storage Wall
Solid Brick Wall
Direct Gain Window

3.2360

Detail





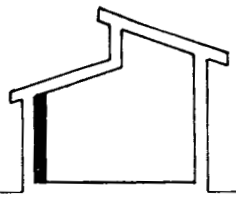
Thermal Storage Wall
Construction Notes

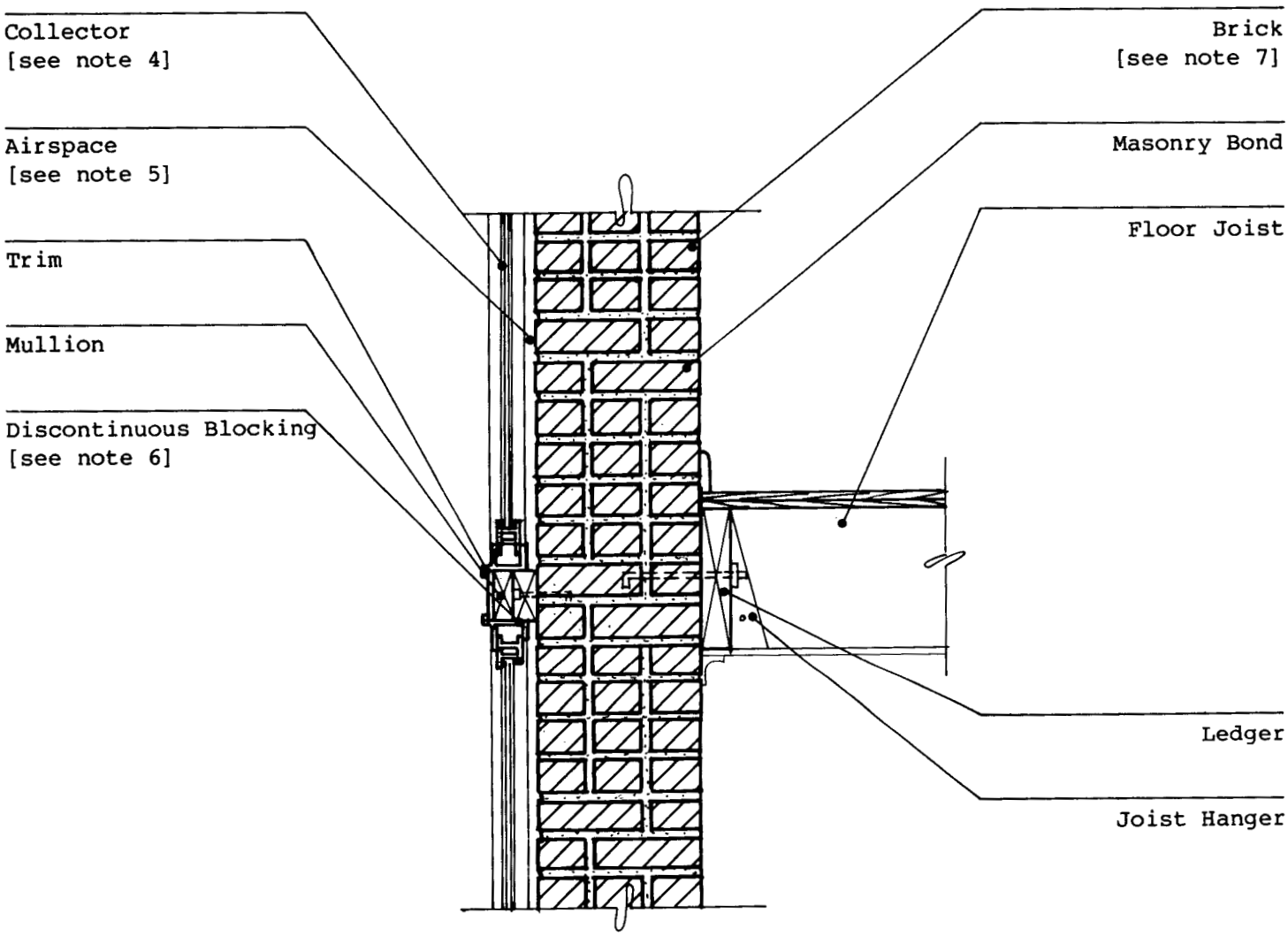
[1] Placing of reinforcing to be determined by local building codes and/or accepted practice.
[2] The storage mass should not be insulated. For further information, see Section 3.2000.
[3] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[4] Width of airspace may vary. For further information, see Key Page 3.2102.
[5] Conventional window for light, view and/or Direct Gain may be single or double glazed. For information on Direct Gain systems, see Section 3.1000.
[6] Solid Brick Thermal Storage Wall. Bricks must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2132.
[7] Reinforced Brick lintel may be of standard or special units. Lintel should be designed for loading and clear span per local building codes and/or accepted practice. Alternate jack arch or steel lintel may be specified at builder's option.

Thermal Storage Wall
Solid Brick Wall
Wood Upper Floor

3.2362

Detail



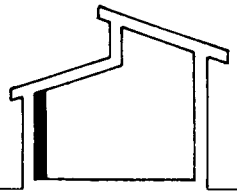


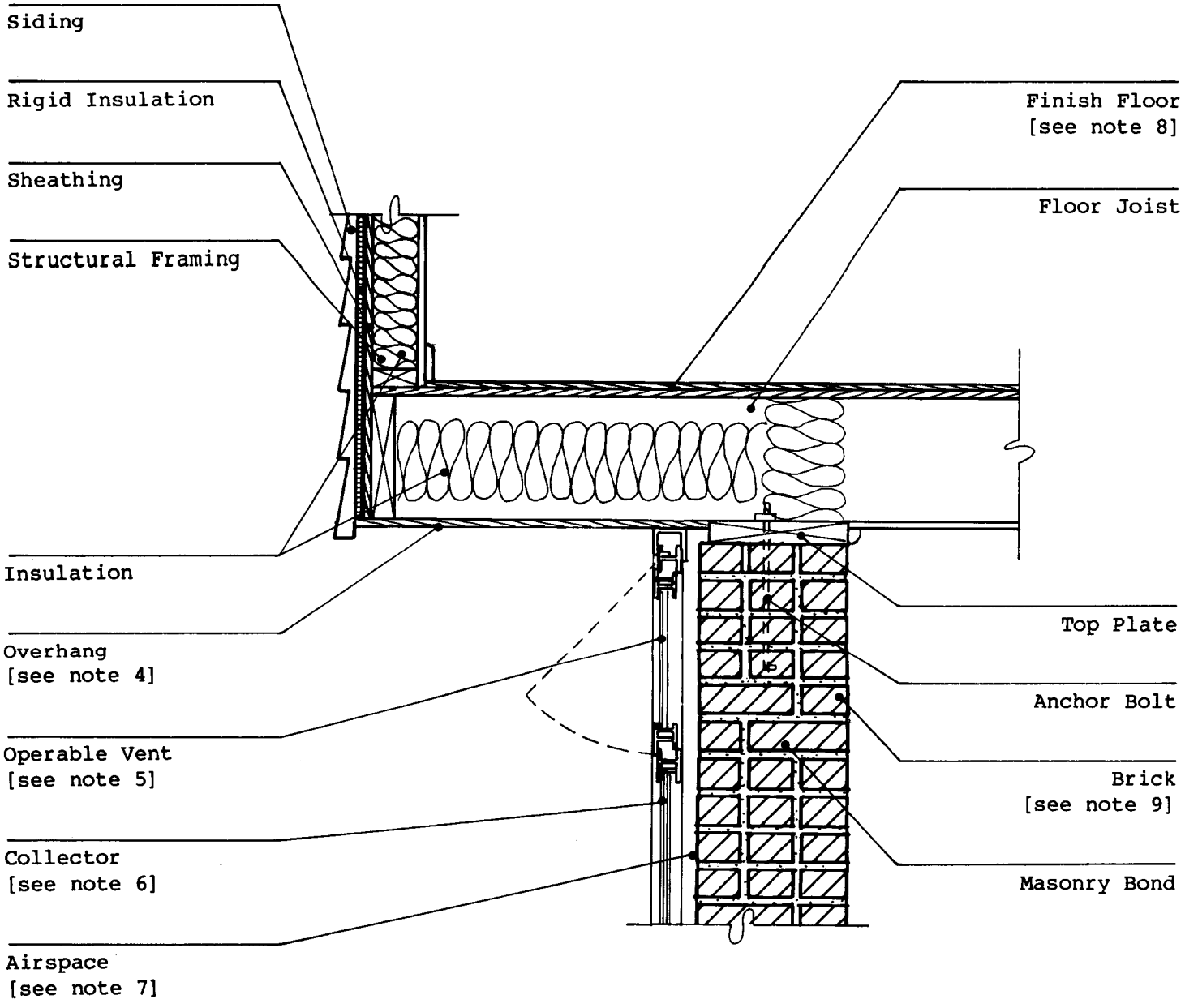
[1] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.
[2] Placing of reinforcing to be determined by local building codes and/or accepted practice.
[3] The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[5] Width of airspace may vary. For further information, see Key Page 3.2102.
[6] Discontinuous blocking to allow for adequate air circulation in airspace.
[7] Solid Brick Thermal Storage Wall. Bricks must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2132.

Thermal Storage Wall
Solid Brick Wall
Wood Upper Floor Overhang

3.2364

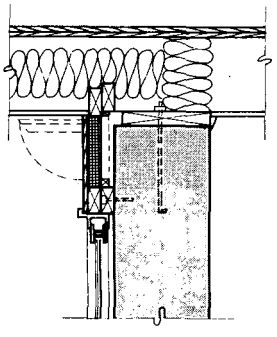
Detail



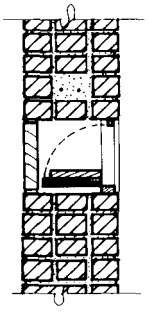


Construction Notes

[1] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.
[2] Placement of reinforcing and anchor bolts to be determined by local building codes and/or accepted practice.
[3] Insulation levels at frame wall and floor at overhang must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.
[4] Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.2000 and 4.4100.
[5] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.
[6] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.
[7] Width of airspace may vary. For further information, see Key Page 3.2102.
[8] Direct Gain system may be incorporated into upper level design. For further information, see Section 3.1000.
[9] Solid Brick Thermal Storage Wall. Bricks must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2132.



Opaque Insulated Exterior Vent

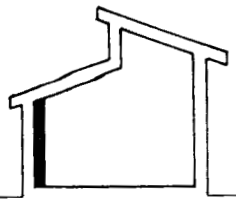


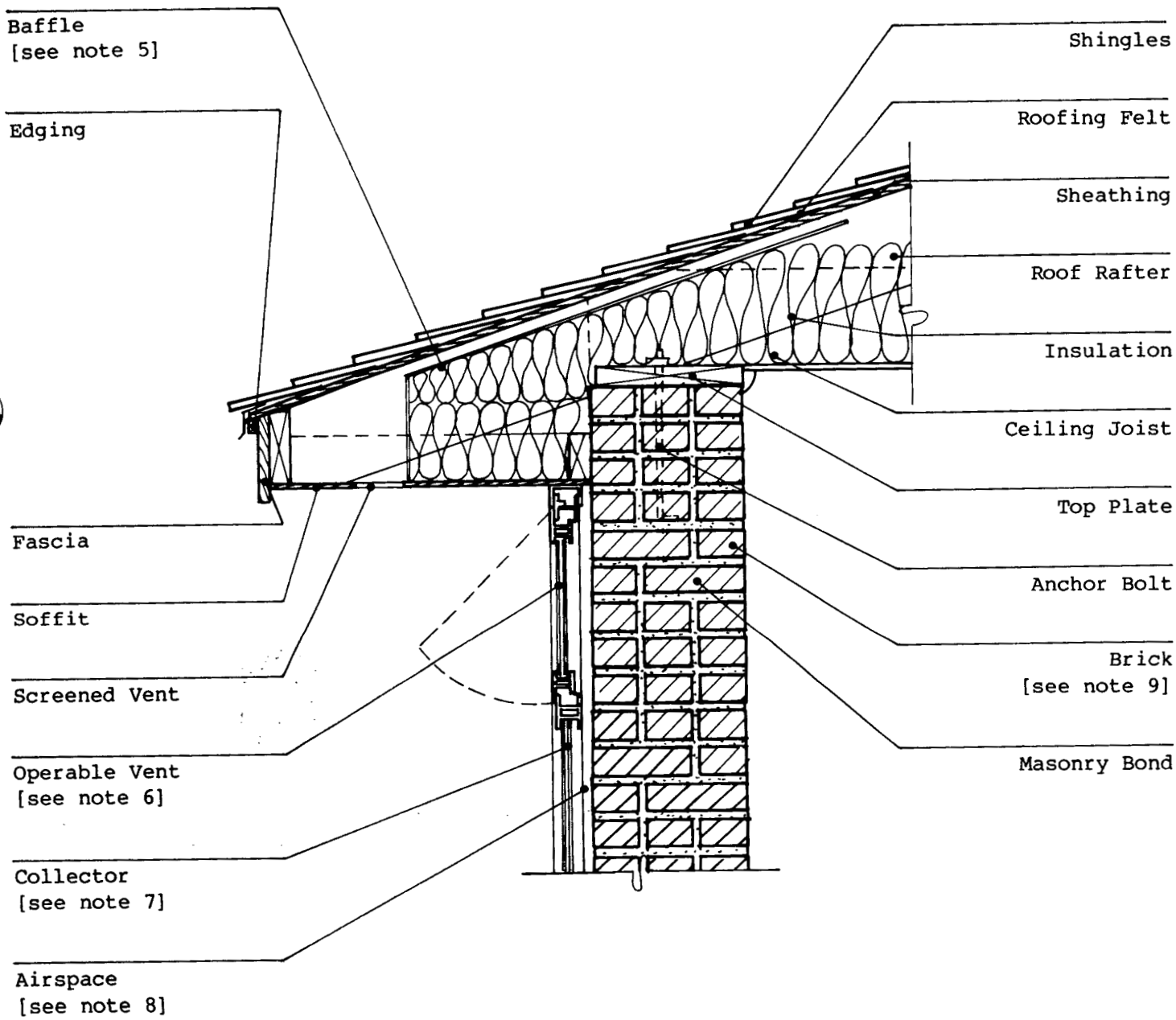
Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
Solid Brick Wall
Roof

3.2366

Detail





[1] Other roof configurations may be used at builder's option. Consult local building codes for restrictions and special requirements concerning roof connections. Provide gutters and downspouts as required. Overhang at Collector should be sized to optimize solar gains during heating season and prevent overheating during cooling season. For further information see Sections 3.1000 and 4.4100.

[2] Placement of reinforcing and anchor bolts to be determined by local building codes and/or accepted practice.

[3] Structural connections at Collector component to be designed to meet local building codes and/or accepted practice.

[4] Insulation in ceiling must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated. For further information, see Section 3.2000.

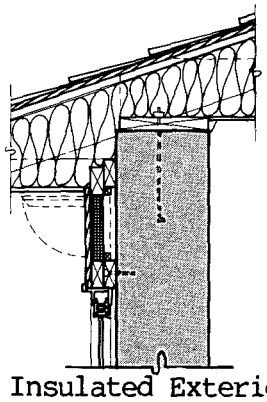
[5] Provide baffles where necessary to maintain 1" minimum airspace for venting attic.

[6] Portions of the Collector should be operable to allow venting of the Thermal Storage Wall airspace during periods of excessive heat gain. Awning-type or other operable windows may be specified. See also hinged alternate below. For more information, see Section 3.2000.

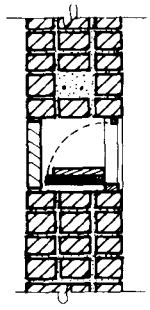
[7] Double glazing is recommended. Collector components should be operable or removable for periodic maintenance and cleaning. For information on material variations and thermal performance characteristics, see Key Page 3.2102.

[8] Width of airspace may vary. For further information, see Key Page 3.2102.

[9] Solid Brick Thermal Storage Wall. Bricks must be solid or hollow with fully grouted cores. For information on finishes, material variations and thermal performance characteristics, see Key Page 3.2132.



Opaque Insulated Exterior Vent

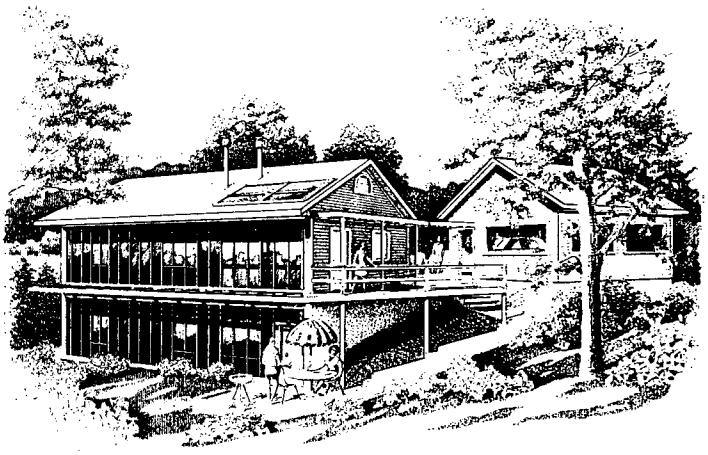


Operable Wall Vent with Backdraft Damper

Thermal Storage Wall
TVA Solar House 2

3.2900

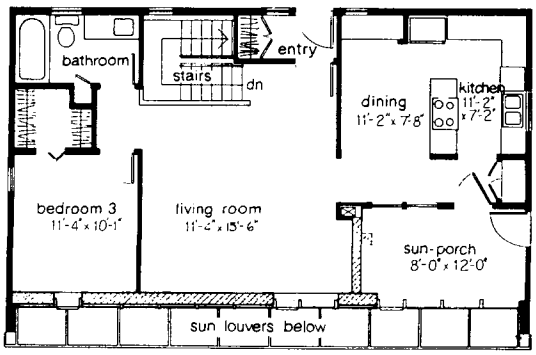
Case Study



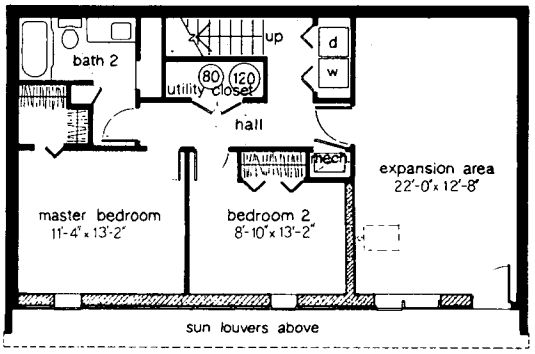
Solar House 2 is a 2-level plan with 1,000 square feet on each level.

Site restraints require that this house be built on a south facing slope with main entry on the north. The driveway approach is also from the north. Optional carport and deck can be located on the east side of the house.

Passive systems for heating include a two-story Thermal Storage Wall, Direct Gain, and an upper level Sunspace. Passive cooling is provided through adequate cross ventilation and shading.



upper level



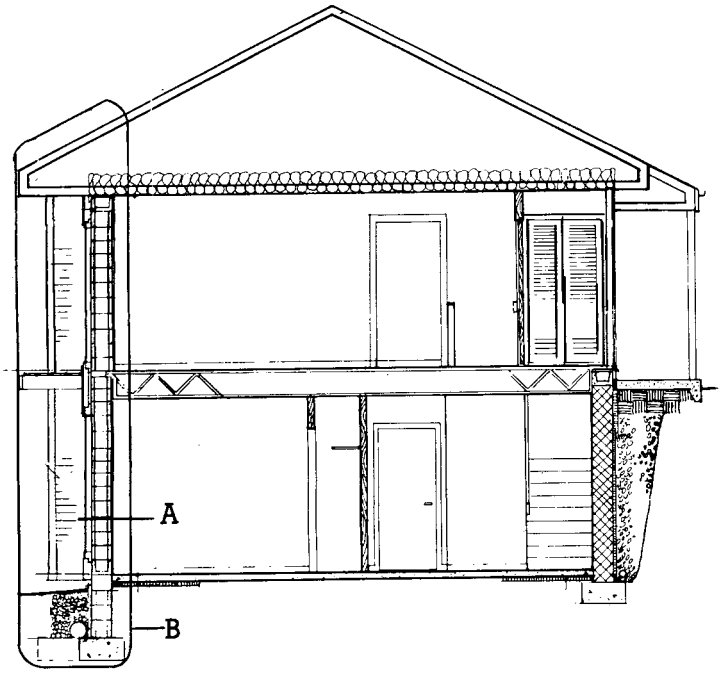
lower level

north

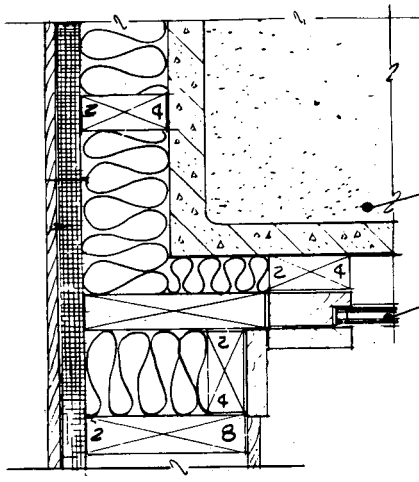
Sponsor

Solar Applications Branch
Architectural Design Branch
Tennessee Valley Authority
Knoxville, Tennessee

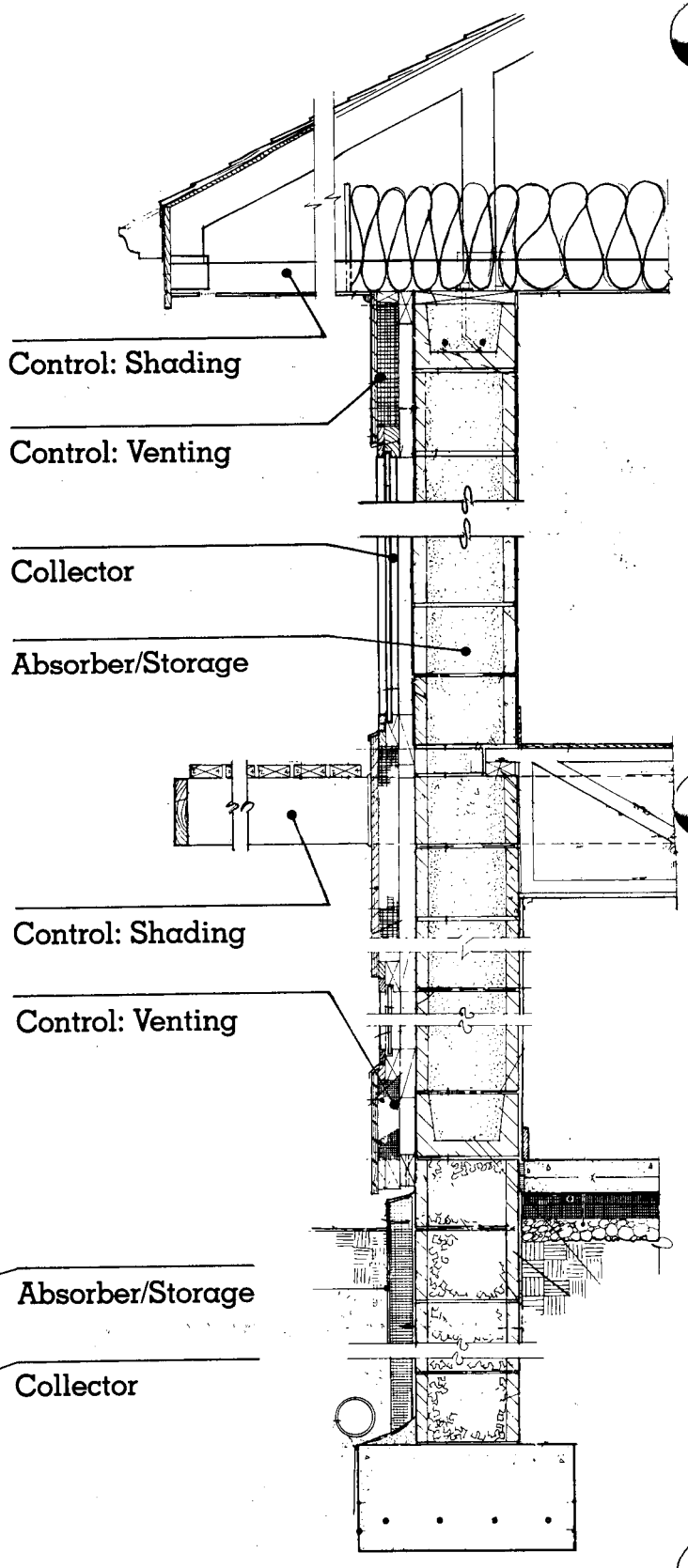
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Building Section



A Corner Detail: Plan



B Thermal Storage Wall Detail: Section

Thermal Storage Wall
SSEC Louisville House

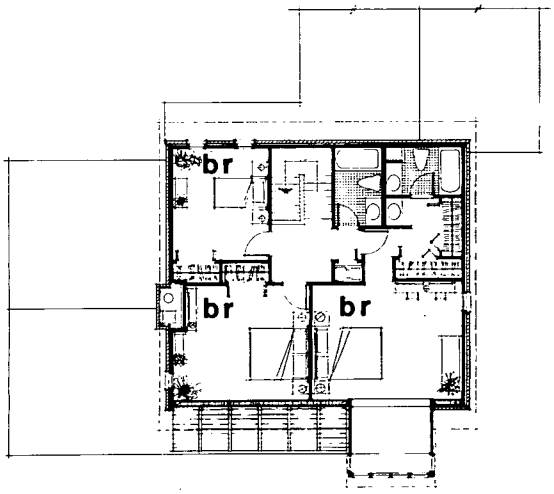
3.2902

Case Study

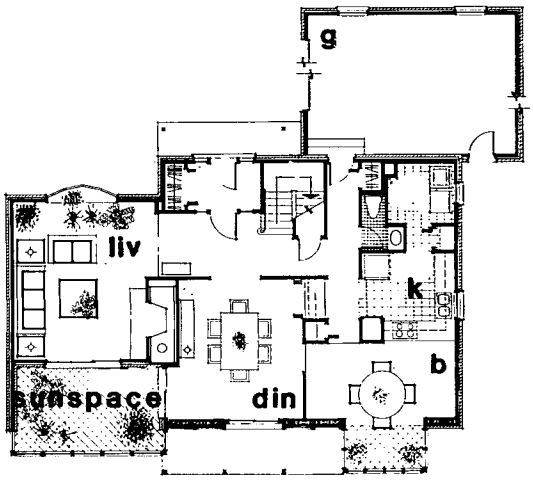


This 2,300 square foot house located in Louisville, Kentucky, receives a major portion of its heating needs from the sun. Passive solar features combined with energy conservation techniques such as high insulation levels, tight construction for infiltration control, and double glazed windows, produce an anticipated energy use reduction of 60% as compared to a typical new house.

The passive systems employed are a two-story Thermal Storage Wall, a double height Attached Sunspace adjacent to the breakfast/family room, and a single height Attached Sunspace adjacent to the living room. The home is bright, comfortable and fits well with the prevailing style of suburban Louisville homes.



Upper Floor



north

Lower Floor

Builder

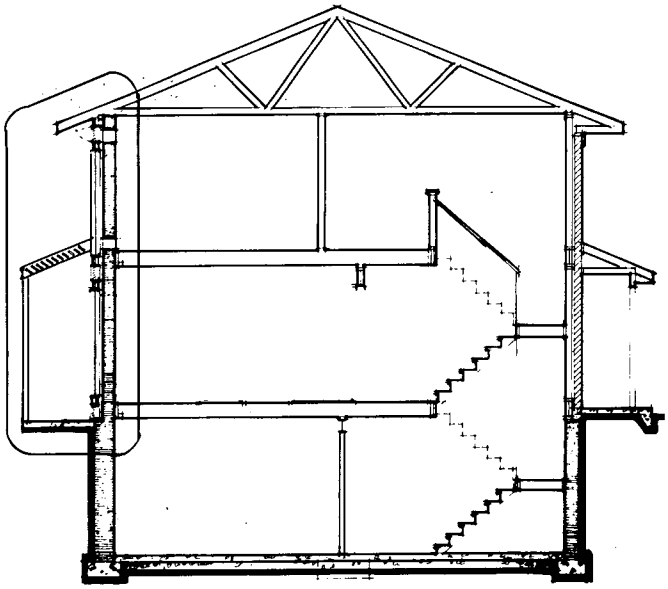
Omikron Construction Company
Jim Scaggs
Louisville, Kentucky

Designer

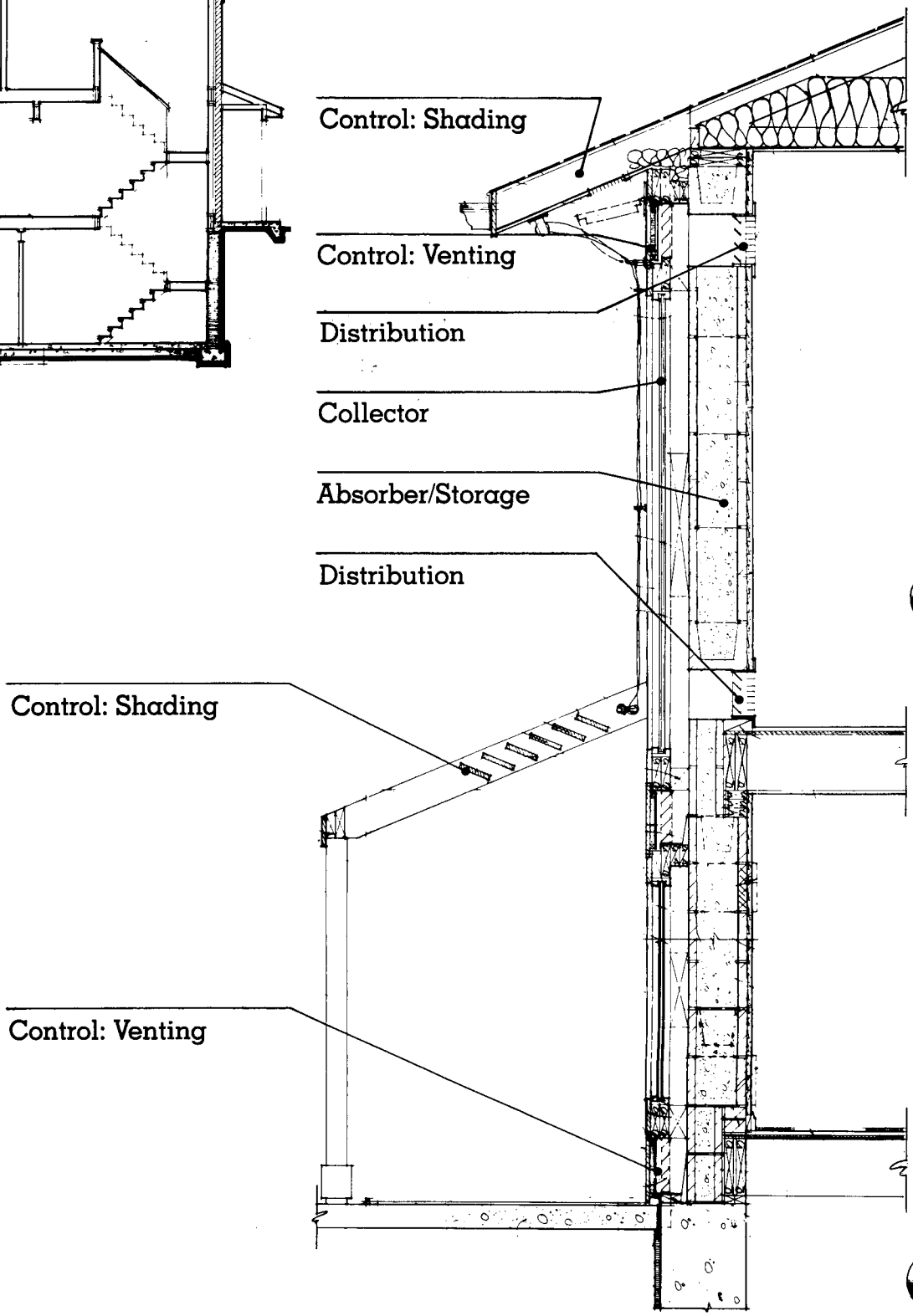
Chrisman, Miller Wallace, Inc.
Lexington, Kentucky

Sponsor

Southern Solar Energy Center
Atlanta, Georgia



Building Section

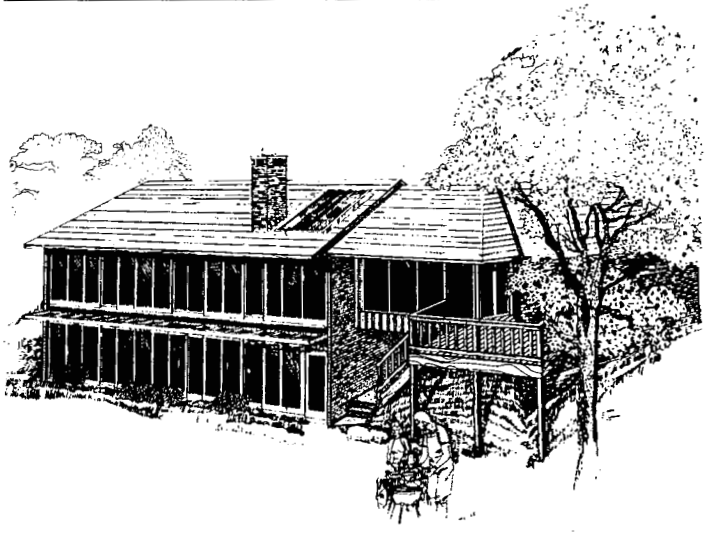


Thermal Storage Wall Detail: Section

Thermal Storage Wall
General Shale House

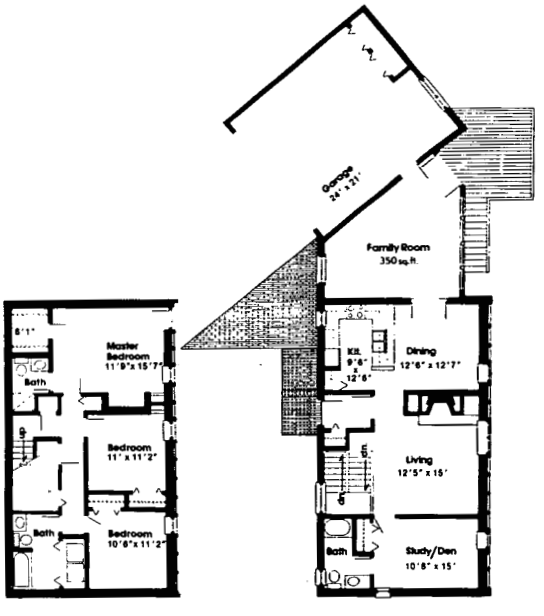
3.2904

Case Study



This is a two-story 2,350 square foot house. Direct Gain, Thermal Storage Wall, and Attached Sunspace systems are designed to provide up to 70% of the heating requirements for the home. Roof eaves and a sunscreen are designed to shield the wall from the summer sun.

Energy conservation features include an air-lock entry vestibule and a super-insulated building envelope.



Upper Floor Plan

Lower Floor Plan

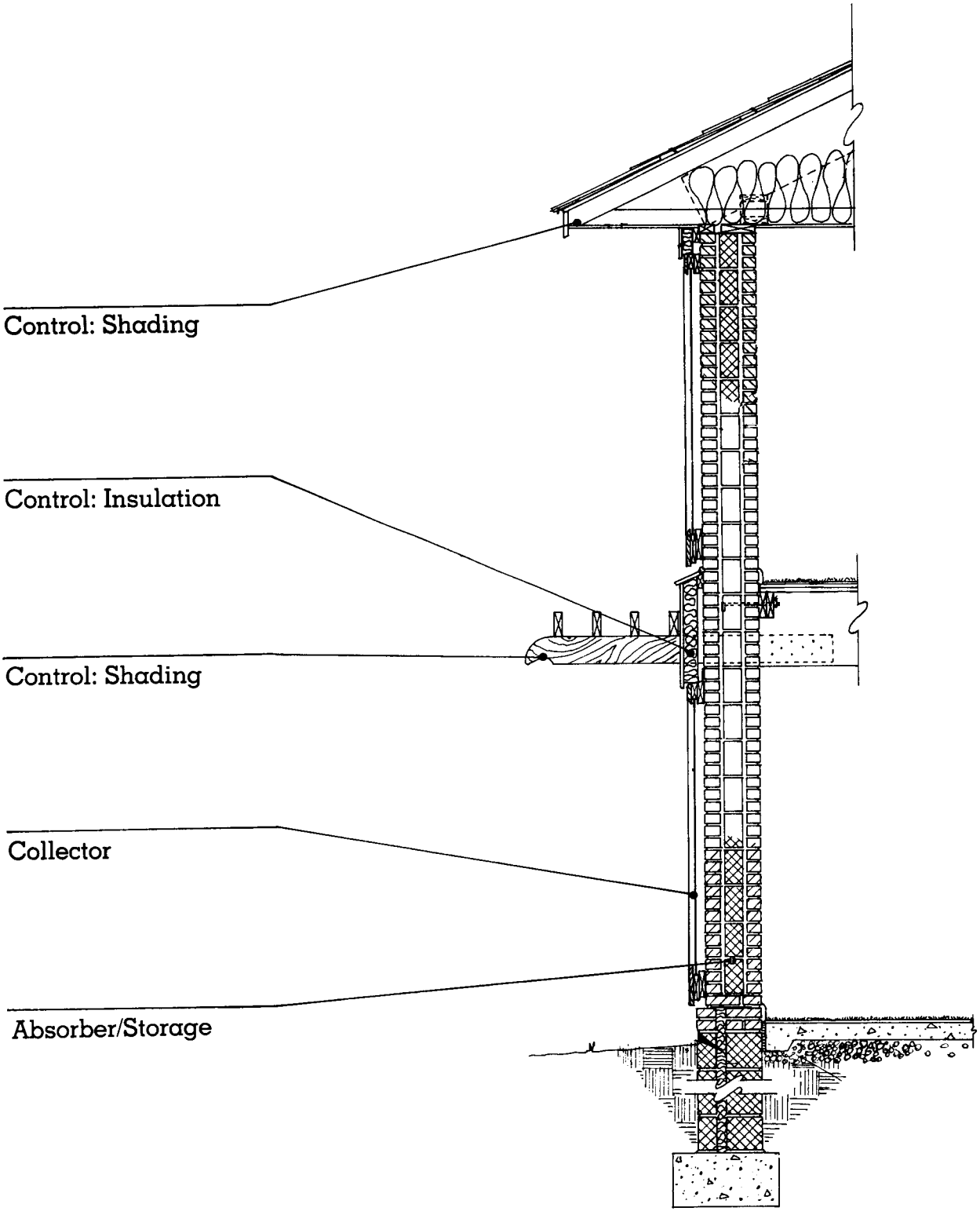
north

Builder/Designer

Barth and Ramsbottom, Inc.
Architects and Contractors
Knoxville, Tennessee

Sponsor

General Shale Products, Inc.
Johnson City, Tennessee

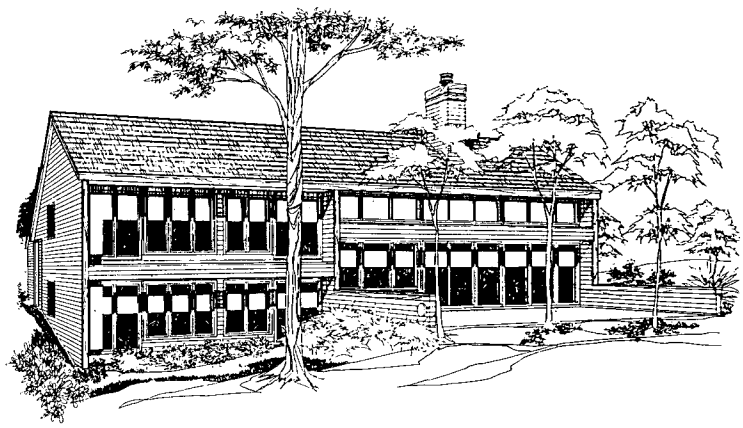


Thermal Storage Wall Detail: Section

Thermal Storage Wall
PCA Split-Level Solar House

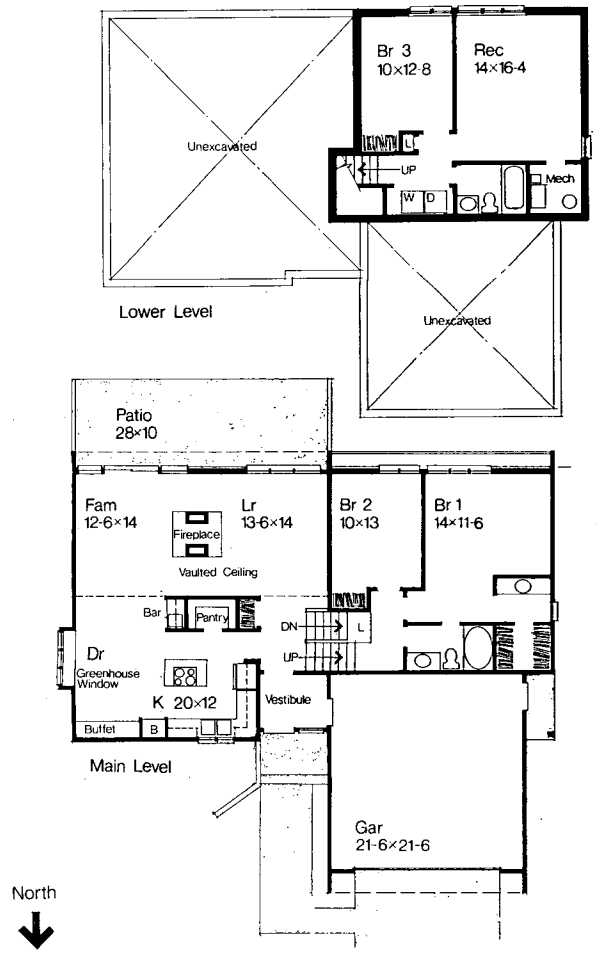
3.2906

Case Study



Thermal Storage Wall and Direct Gain systems together provide passive solar heating for this 2,100 square foot split-level home. The open plan of the main living area aids in the natural circulation of solar heated air as well as providing a generous kitchen/dining/family living center.

Energy conserving features, such as earth berming on the north and east, have been provided. Sunscreens, incorporated into the exterior design on the south to control excessive heat gain during the cooling season, are important features used in conjunction with the two-story Thermal Storage Wall.

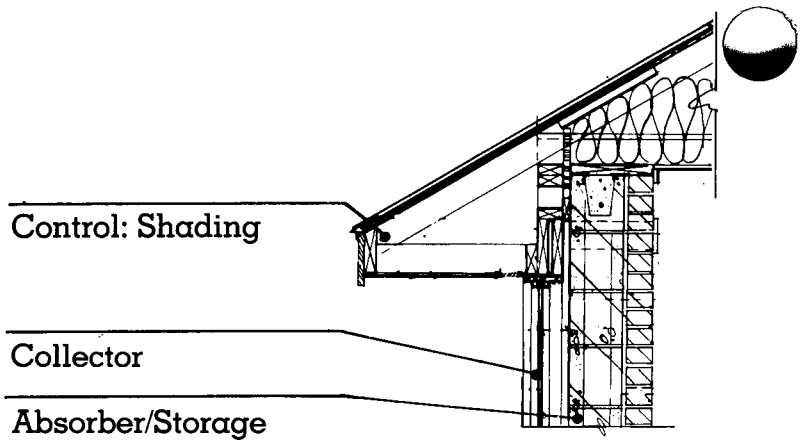


Designer

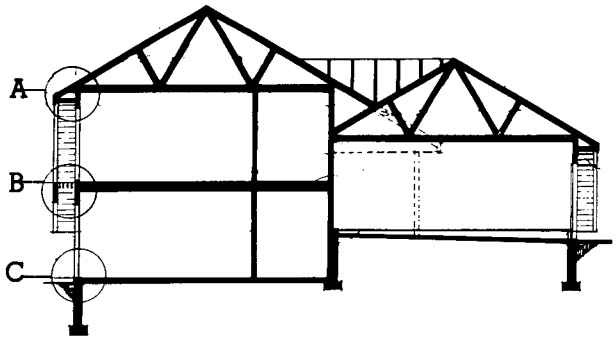
John D. Bloodgood Architects, P.C.
Des Moines, Iowa

Sponsor

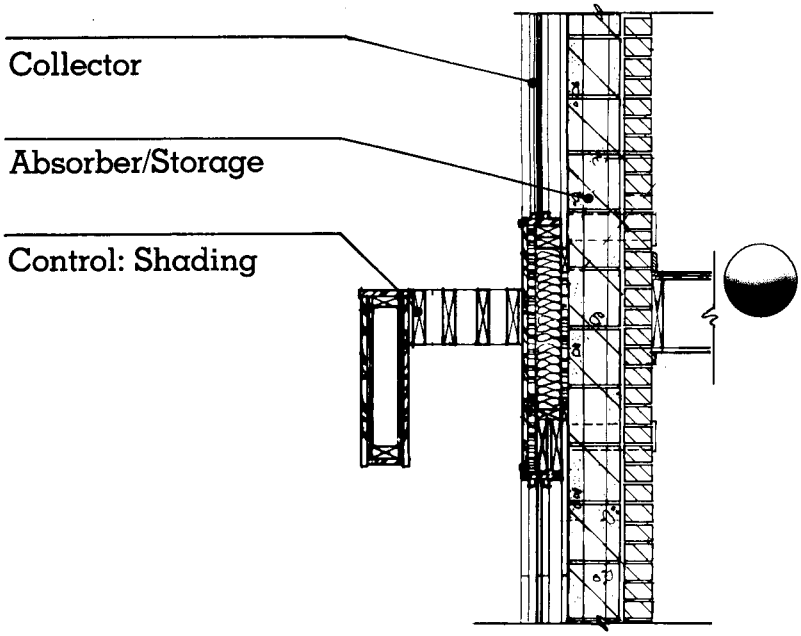
Portland Cement Association
Skokie, Illinois



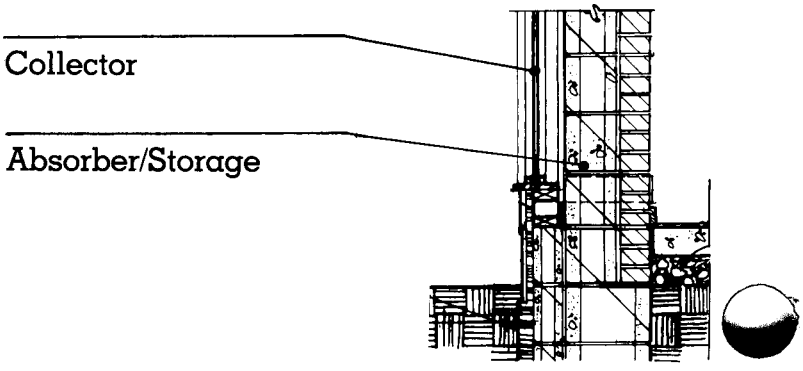
A Thermal Storage Wall: Roof Detail



Building Section



B Thermal Storage Wall: Upper Floor Detail



C Thermal Storage Wall: Foundation Detail

Thermal Storage Wall
TVA Solar House 9

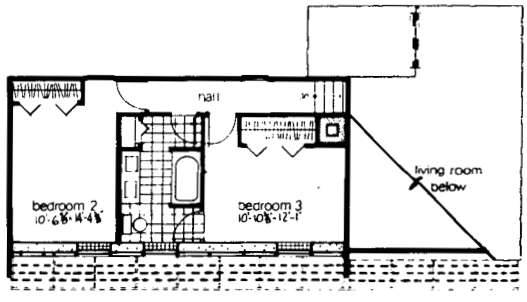
3.2908

Case Study

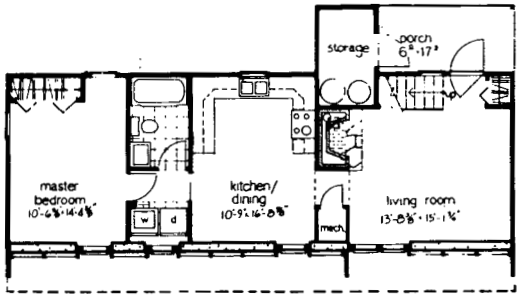


A two-story Thermal Storage Wall provides passive solar heating for this 1,200 square foot traditional house. Operable windows placed in the Thermal Storage Wall provide natural light and ventilation. Overhangs and wing walls provide shading for the Thermal Storage Wall, reducing heat gain during cooling season.

This house is suitable for flat or slightly sloping sites.



upper level 549 sf



lower level 822 sf
+ 549 sf upper level
1,371 sf gross house

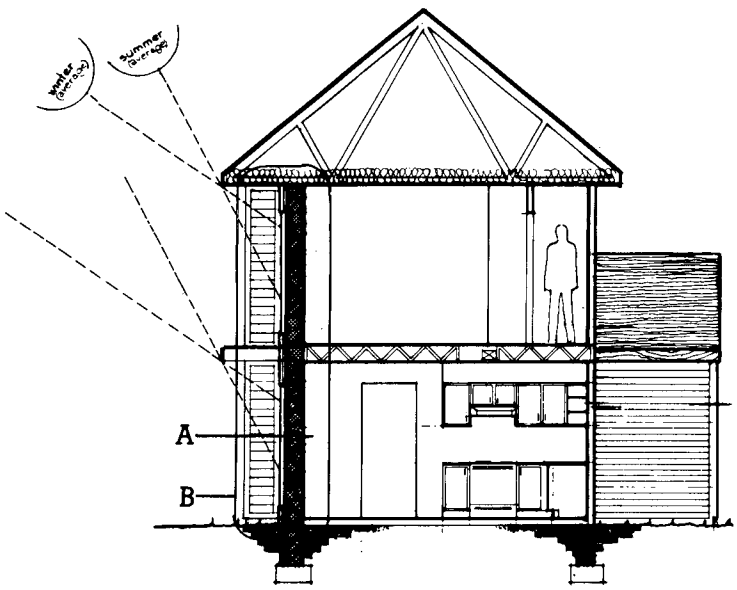
91 sf pc

north

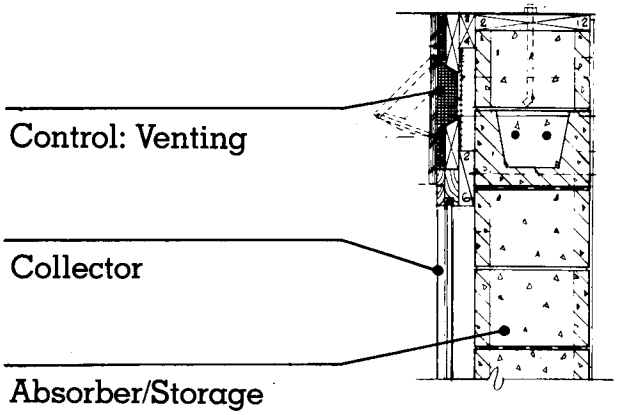
Sponsor

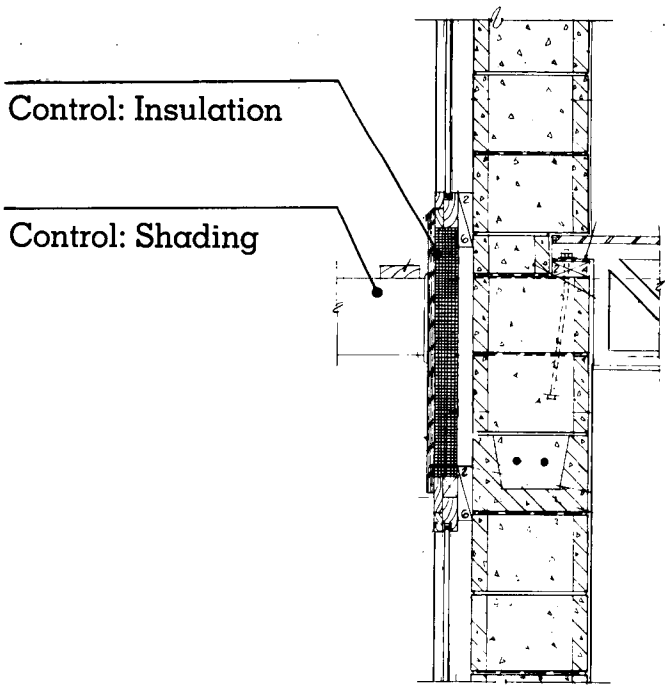
Solar Applications Branch
Architectural Design Branch
Tennessee Valley Authority
Knoxville, Tennessee

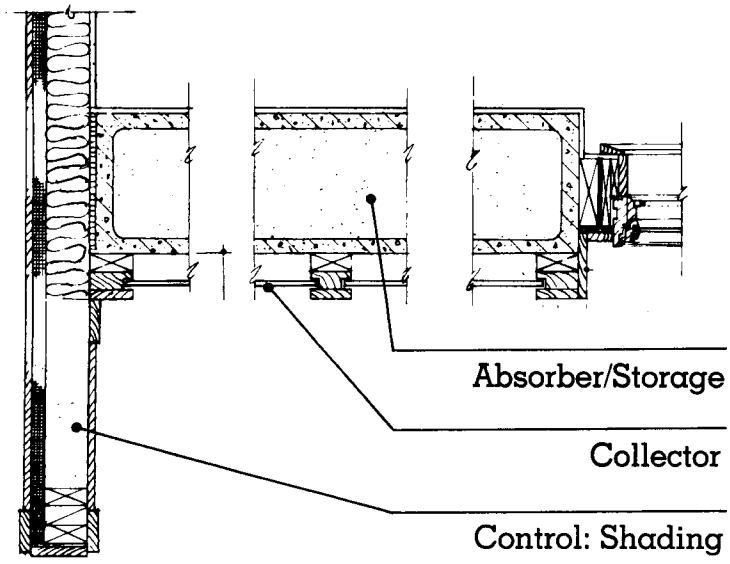
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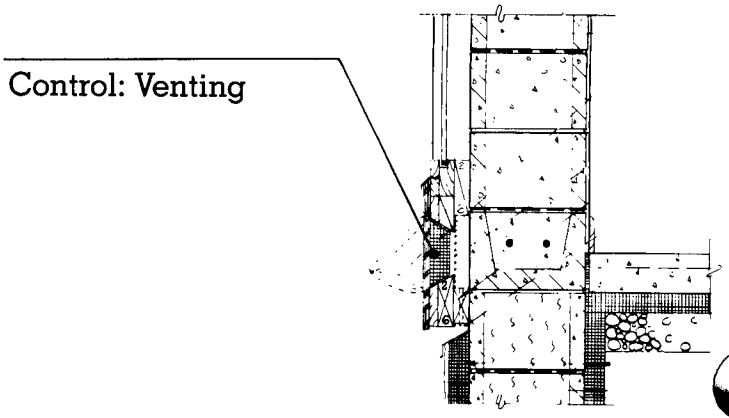


Building Section









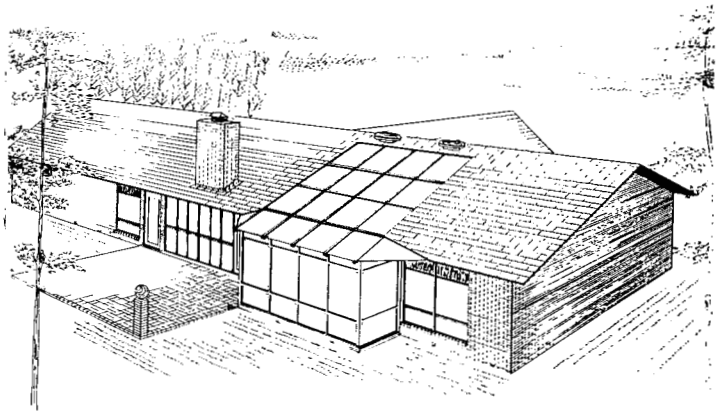
A Corner Detail: Plan

B Thermal Storage Wall Detail: Section

Thermal Storage Wall
Pine Hall House

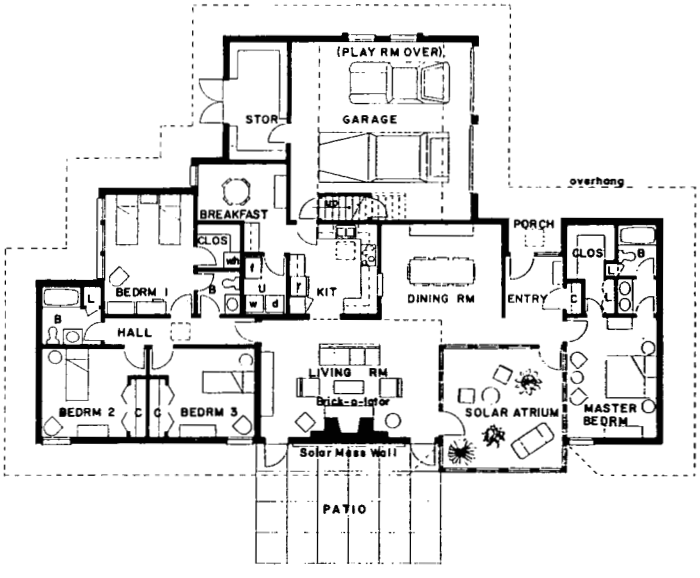
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Case Study



This 2,000 square foot house uses brick floors and walls as storage media for the Direct Gain and Attached Sunspace systems. A Thermal Storage Wall system is also incorporated into the design. The result of the combined systems is an anticipated 50% reduction in heating and cooling costs. A heat pump supplies back-up heating.

Summer cooling is augmented by an exhaust fan located in the Sunspace which pulls cool night air through the house.



Main Floor Plan

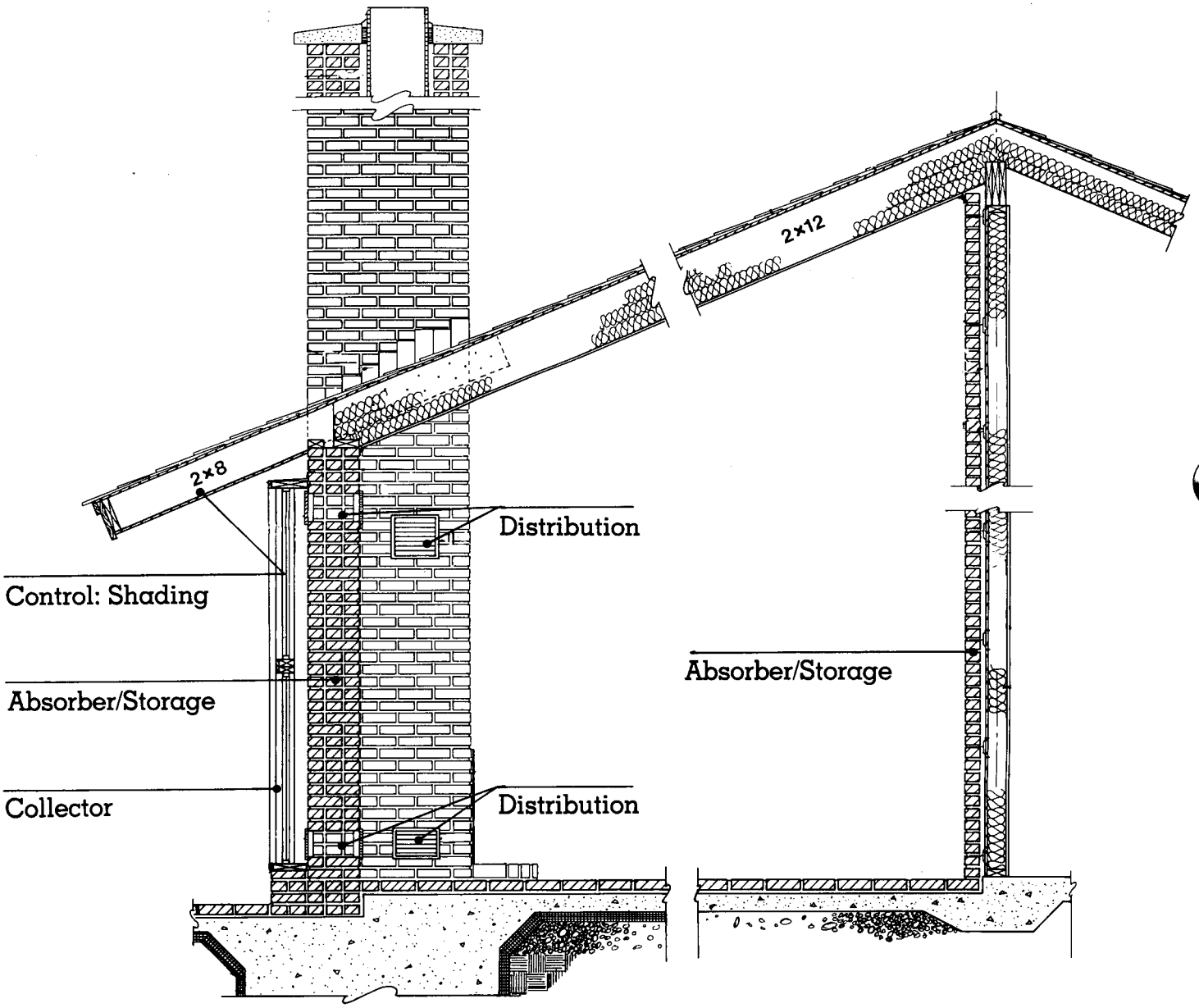
Builder

E. Jack Reich and Sons
Winston-Salem, North Carolina

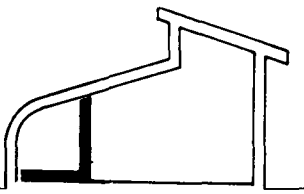
Sponsor

Pine Hall Brick and Pipe Co.
Winston-Salem, North Carolina

S



Building Section



Design Overview

Attached Sunspaces are designed to be used primarily for heating and are effective in areas with moderate to severe winter climates. As the name implies they are spaces designed for passive solar gain that are "attached" to the south side of a building. Such spaces often serve as working greenhouses. In these cases they are referred to as "attached greenhouses" or "solar greenhouses," to distinguish them from the standard, "non-solar" varieties which are generally not as well constructed and detailed (see Figure 3.32).

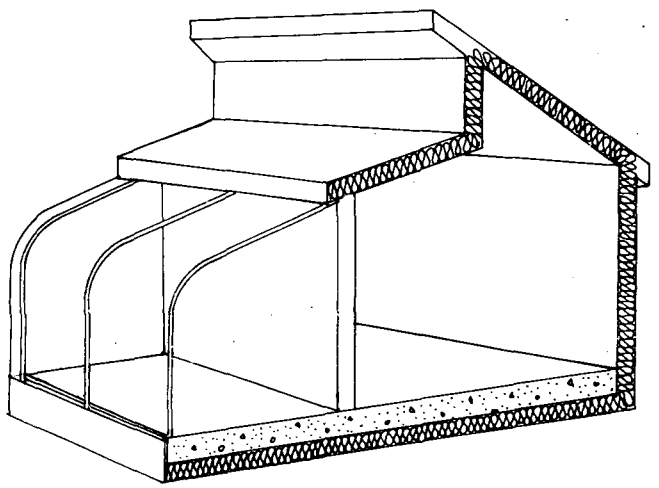


Figure 3.32

A Sunspace can project from the house or the house can be designed to "wrap around" the Sunspace and partially enclose it. The latter configuration has the advantages of: (1) reducing heat losses from both the Sunspace and the house; (2) transferring heat easily to a greater area of the surrounding house; and, (3) allowing for the inclusion of a larger amount of thermal storage material than is possible in a projecting Sunspace. Whether they project from the house or are enclosed by it, Attached Sunspaces can have two basic floor configurations. In the first and most common, the Sunspace floor is level with, or only slightly below or above, that of the living area. In the second, the so-called "pit" Sunspace, the floor level is located below the frost line and thus significantly below the floor of the adjacent living spaces. The "pit" variety has the advantage of increased headroom and of reduced floor and perimeter heat losses due to the relatively constant temperatures of the surrounding earth. A "pit" Sunspace can actually gain heat from the ground in winter if, as is often the case, the temperature in the Sunspace is allowed to drop below the surrounding subsurface ground temperature. In these instances the Sunspace floor slab need not be insulated (see Figure 3.33).

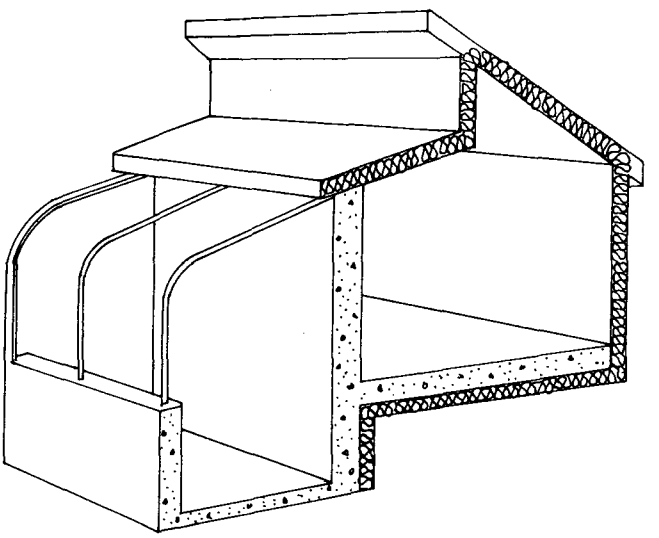


Figure 3.33

The solar energy collected and absorbed

by an Attached Sunspace is used to heat both the Sunspace itself and the adjacent living areas. The ways in which this energy is stored and distributed form the basis for distinguishing five separate Attached Sunspace "subsystems" which differ significantly from each other in terms of operation and construction: Open Wall, Direct Gain, Air Exchange, Thermal Storage Wall, and Remote Storage. Where appropriate in this Section, each of these subsystems is treated separately, with the Key Pages organized to reflect this "subsystem," rather than "component" orientation (i.e., each subsystem has its own Key Page and Index to Details).

There are two basic modes of operation for any Attached Sunspace subsystem. In the first, the Sunspace serves as an extension of the living area. It is not thermally isolated from the living space and its temperature is not allowed to fluctuate outside the comfort range. In most cases, this type of Sunspace will require some form of auxiliary energy system to maintain comfortable temperatures (see Figure 3.34).

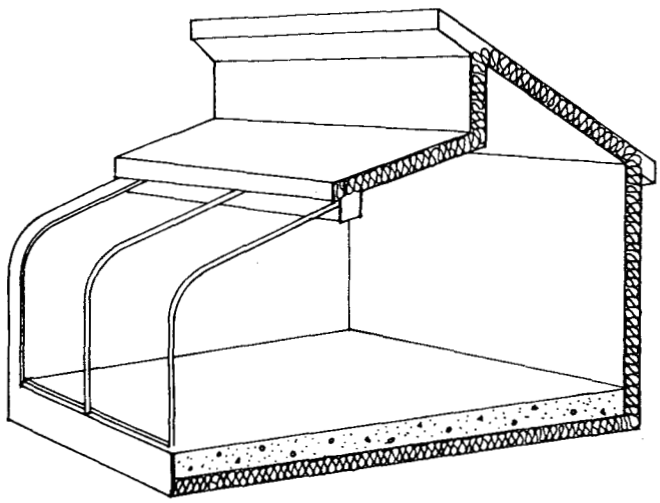


Figure 3.34

In the second mode, the Sunspace is a separate, distinct area which is thermally isolated from the living space. It is not a direct extension of the living space and its temperature can be allowed to fluctuate outside the comfort range. In this case, an auxiliary energy system is not required (see Figure 3.35).

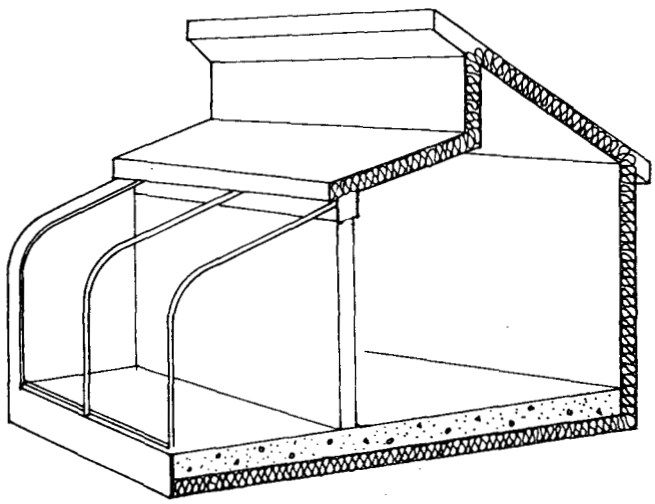


Figure 3.35

Each of the five subsystems, in its pure form, operates in one or the other of these two modes. It should be noted, however, that very often one or more systems are combined to function together. In such "hybrid" configurations, the actual mode of operation will depend on the particular subsystems involved and the way in which the space is intended to be used. This will, in turn, determine the amount and location of insulation (fixed and/or movable) employed and whether or not an auxiliary energy system is necessary.

Seasonal Operation (Heating)

During the heating season, sunlight enters an Attached Sunspace through the south facing collector (an expanse of glass or plastic), is absorbed by elements within the Sunspace, and is converted to heat. This basic process is the same for all the Attached Sunspace subsystems. It is only in the next stages of operation (storage, distribution, and control of this heat) that these subsystems differ significantly from each other. The following descriptions summarize the

operating characteristics for each of the subsystems during the heating season.

Open Wall Subsystem - In this subsystem the Sunspace opens directly to the living spaces and is basically an extension of these areas. Because of this openness there is a direct and unimpeded transfer of warm air between the two spaces. While the sun is shining, heat is generated in the Sunspace and the resulting warm air moves freely to the adjacent living spaces. Some of this heat is also stored in storage components (e.g., a masonry paver floor) located in the Sunspace and/or living spaces (see Figure 3.36).

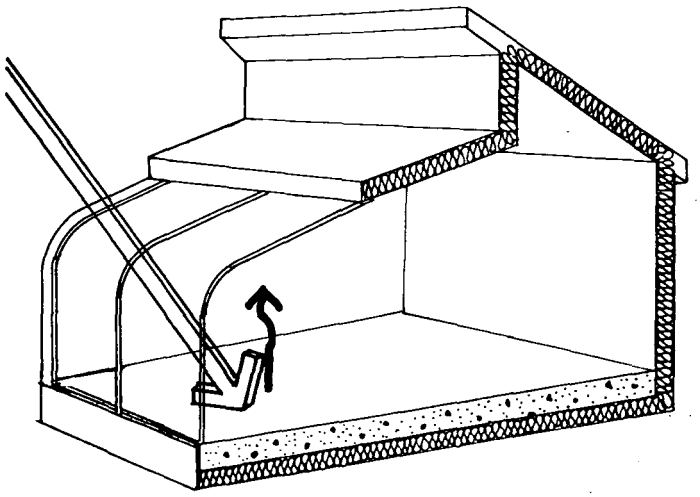


Figure 3.36

It is important to note that this subsystem, unlike the other four which follow, is essentially an extension of the living area and its temperature must be maintained at the same level as the other living spaces. The provision of storage material in the Open Wall Sunspace will help dampen temperature fluctuations, but the Sunspace in this subsystem will still need to be heated at night and during prolonged periods of cloudy weather. At these times, the direction of heat transfer is reversed and the Sunspace will receive heat from the adjacent living area as well as from the storage components located in the Sunspace itself (see Figure 3.37).

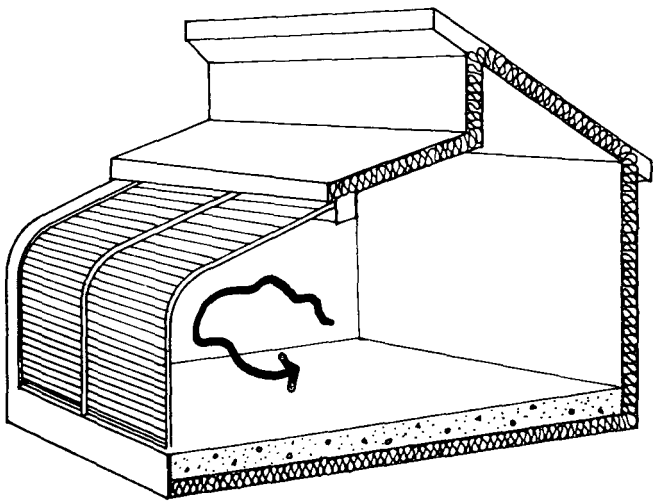


Figure 3.37

In order to avoid excessive loss of this heat, the Sunspace collector should be provided with some form of movable insulation which can be used during these periods. The Sunspace floor will also need to be insulated to the same level as the standard living space floor (see "Control" section below).

Direct Gain Subsystem - Although this subsystem is similar to the Open Wall System in construction, it is generally operated as an isolated space and is not provided with backup heating from the auxiliary energy system. The open connection between the Sunspace and the living areas is replaced by a glazed, shared wall. Because of the thermal separation which this wall provides, temperatures in the Sunspace can be allowed to fluctuate without seriously affecting the amount of heat lost from the living space. However, it may still be advisable to double glaze the shared wall in severe climates.

The use of movable insulation located at the shared wall glazing will further reduce heat losses from the living areas. This may not be cost effective, however, because the Sunspace, if properly designed, will act as a buffer between the

outside air and the living areas reducing the rate of heat loss. As a result, movable insulation will not reduce heat loss as much in this situation as it would if the living spaces were exposed directly to the outside.

Heat generated in the Sunspace can be used both to warm the Sunspace itself and to supply heat to the adjacent living areas. When providing heat only for itself, the Sunspace is acting simply as a climatic buffer for the adjacent living spaces. Some Direct Gain radiation does reach the living spaces through the glazed shared wall. However, if the glazed shared wall can be opened (e.g., patio doors), the Sunspace can provide heated air, in addition to solar radiation, to the living spaces when it is required (see Figure 3.38).

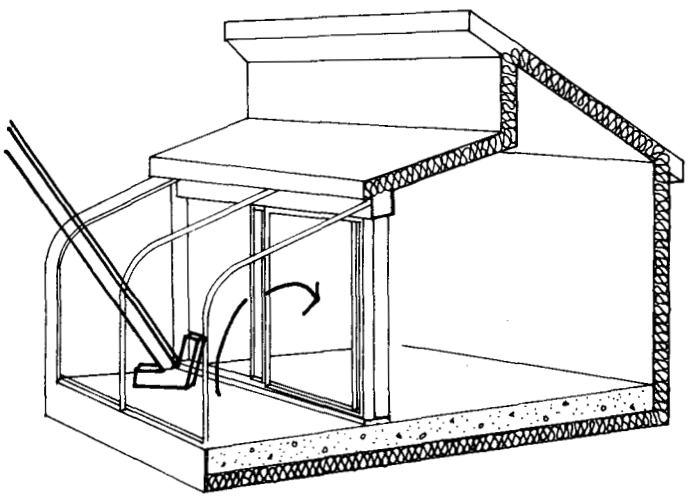


Figure 3.38

When this heat is no longer desired or when the Sunspace is no longer receiving solar radiation the homeowner can simply close the glazed wall (see Figure 3.39).

Air Exchange System - In this subsystem, the living area and the Sunspace are separated by an opaque frame wall containing operable vents. These vents allow for the transfer of heated air from the Sunspace directly to the living areas during periods of heat gain. The vents,

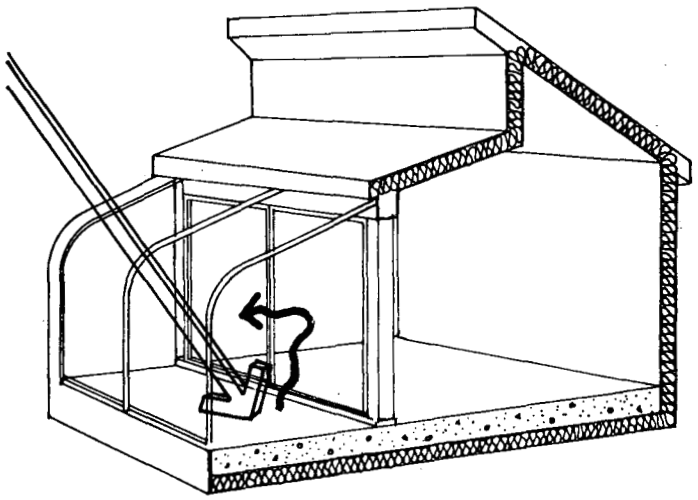


Figure 3.39

which are either manually or automatically operated, can be closed off when heat is no longer wanted or during periods of heat loss (see Figure 3.40).

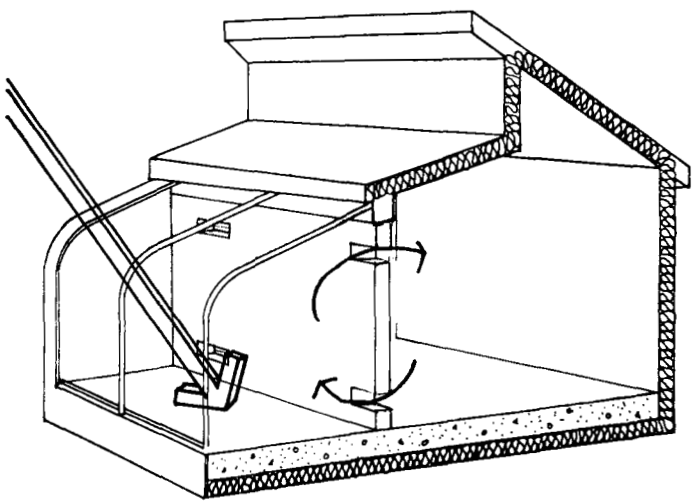


Figure 3.40

Closing the vents effectively turns the Sunspace into a buffer zone, reducing the overall heat loss from the living spaces (see Figure 3.41). Because the temperature difference is reduced, it may not be necessary to insulate this opaque shared wall. One advantage such insula-

tion might have, however, is to reduce heat gain through the wall during the cooling season, especially if the wall receives direct solar radiation during this period.

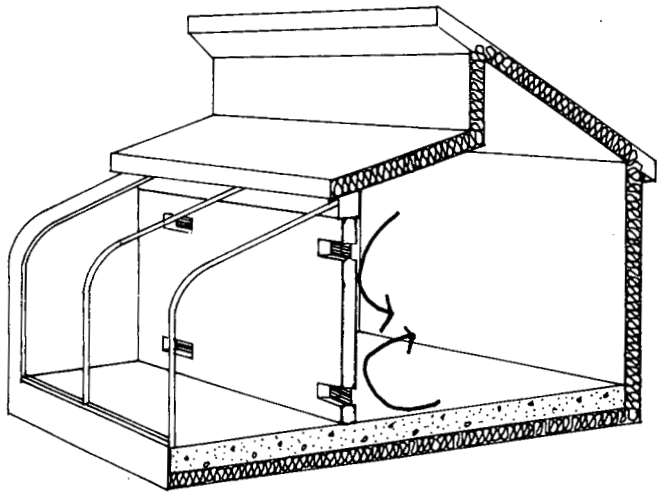


Figure 3.41

Thermal Storage Wall Subsystem - In this subsystem the shared wall between the living areas and the Sunspace is a mass wall and functions much like a standard Thermal Storage Wall. In fact, it may be easiest to visualize this subsystem as simply a Thermal Storage Wall with an enlarged airspace between the collector and storage components.

The wall absorbs incoming solar radiation and stores it. The resulting heat then slowly migrates through the wall to the adjacent living area. The wall reradiates the heat it has stored to both the living space and also back into the Sunspace itself. In doing so it not only heats the living area but also helps to maintain a relatively constant temperature in the Sunspace (see Figure 3.42).

Because this Sunspace temperature is higher than the surrounding outside air, the Sunspace acts as a thermal "buffer zone," reducing the amount of heat lost from the living space at night and during prolonged overcast periods. Movable insulation placed at the collector will

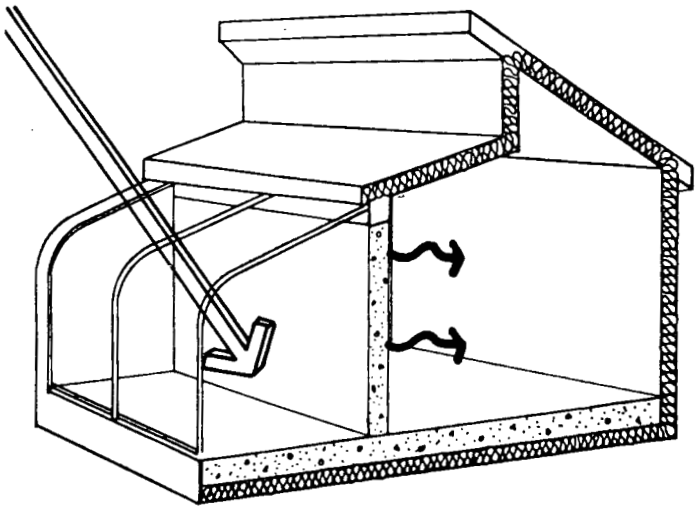


Figure 3.42

significantly improve the overall efficiency of the system. By reducing the amount of stored heat which escapes, this insulation will maintain higher temperatures in the Sunspace during the heating season. Due to these higher temperatures the shared mass wall will have less of a tendency to transfer its heat into the Sunspace and will thus provide a greater portion of its heat to the adjacent living areas (see Figure 3.43).

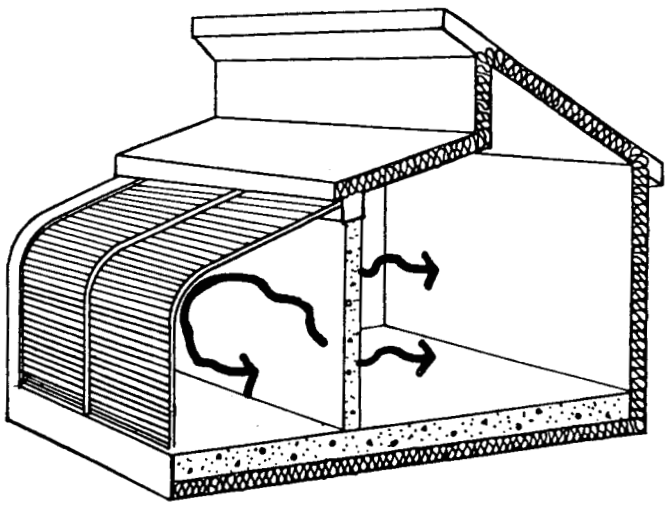


Figure 3.43

Such insulation should be located at the collector, but placement on the outside face of the shared storage wall is also possible.

It should be noted that the storage wall can also function as a vented Thermal Storage Wall. In this instance, the Sunspace is actually a "hybrid" combination of the Thermal Storage Wall and the Air Exchange Subsystems (see Figure 3.44).

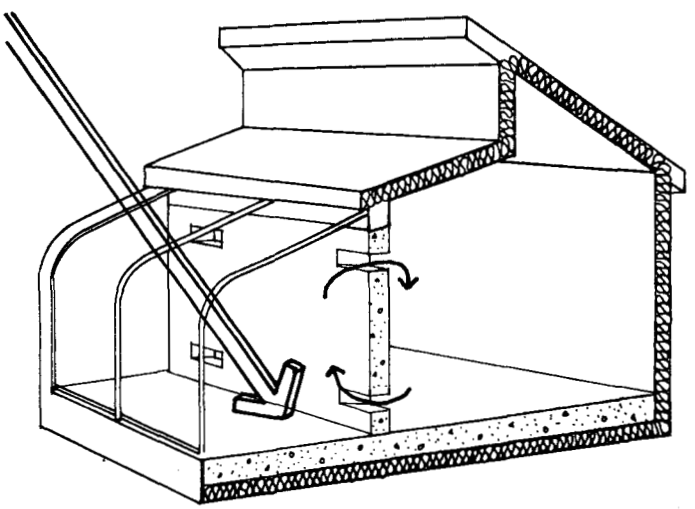


Figure 3.44

Remote Storage Subsystem - In the Remote Storage Subsystem the common wall between the living spaces and the Sunspace is opaque but is not vented, or constructed of mass materials. Its primary purpose is to thermally separate the Sunspace from the living spaces. Heat which is generated in the Sunspace is removed (usually by some form of fan system) for storage in some "remote" location away from the Sunspace and the living areas (see Figure 3.45).

The "remote storage" usually takes the form of a rock or gravel bed located under the uninsulated floor slab of the living space. Heat from the hot air blown through this gravel is stored in the rocks and then radiated up through the slab into the room to be heated. The temperature of this air is usually low

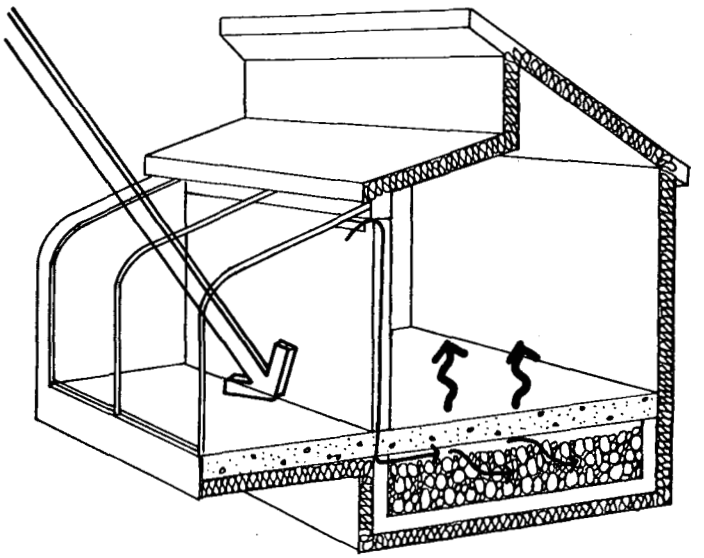


Figure 3.45

(90°F or less) and the resulting radiant heat reaching the living space will not cause the room to overheat. It might seem logical to develop a system in which the rocks are used to heat air which is in turn distributed to the rest of the home through ducts. This is not efficient, however, due to the relatively low delivery temperatures of the heat available from the storage bed (65-75°F).

Seasonal Operation (Cooling)

During the cooling season the Sunspace can easily overheat, adding to the cooling load on the auxiliary system. Therefore, the collector in any of the five subsystems should be well shaded to prevent unwanted heat gain. Deciduous trees and other types of vegetation can be used, as can building elements such as overhangs, louvers, and shades. If movable insulation has already been provided, it can serve a dual purpose and also act as a shading device.

The Sunspace should also be properly vented. If possible, low vents, to admit cool air, should be located in the shade on the windward side of the Sunspace and high vents, to exhaust hot air, on the leeward side. These vents can either be

operable glazing elements or they can form part of the opaque frame. Gable vents on the east and west endwalls are also possible. In order to reduce infiltration losses at the edges of these vents, it is preferable to have a few large vents serve the space rather than a series of smaller ones with a larger aggregate edge area (see Figure 3.46).

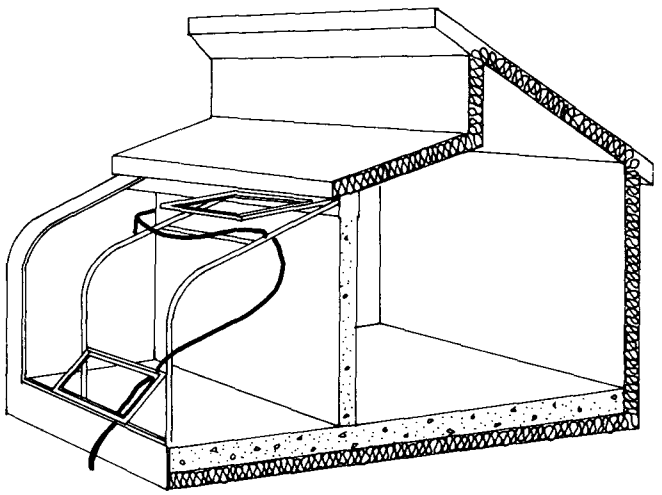


Figure 3.46

If properly managed, the storage mass within the Sunspace can also help cool it. Placing vents so as to allow cool night air to pass over the storage mass will cause it to become cooler. If properly shaded from the sun, this cooler mass will absorb heat generated in the Sunspace during the day, effectively cooling it and, depending on the subsystem involved, the adjacent living areas as well. The mass will then dissipate this collected heat to the night air, completing the diurnal cycle. Openings placed between the Sunspace and the adjacent living spaces will enhance the cooling effect of the mass by inducing cooled air to circulate through the rest of the home (see Figure 3.47).

It must be reiterated that the majority of Sunspace configurations built consist of "hybrid" combinations of the subsystems described above. It is not uncommon for a Thermal Storage Wall to include operable vents to allow for direct transfer of heated air, nor for the opaque shared wall in a Remote Storage Subsystem to include windows which allow for some Direct Gain heating in the living areas. As noted above, the thermal performance of such hybrids is, in general, very difficult to quantify. It should be assumed, however, that combining subsystems will not result in significant decreases in overall thermal performance if the general rules of thumb for Attached Sunspaces are followed.

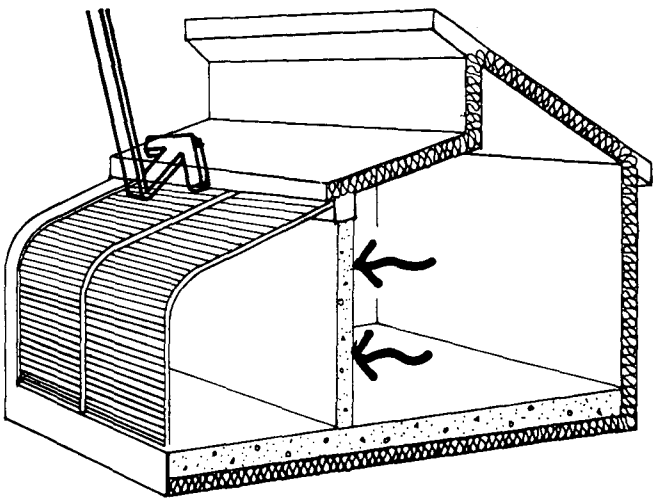


Figure 3.47

Advantages

- The Sunspace can be used for growing plants and/or food.
- The Sunspace acts as a buffer zone to reduce heat loss from the adjacent living spaces.
- The Sunspace can serve more than one function, including being an extension of the living space.
- The Sunspace can become an aesthetic asset to a house.

Disadvantages

- The thermal performance can vary significantly from one design to another and predicting performance accurately is difficult.
- Costs can be kept low by using less expensive materials, but these tend to degrade fairly quickly and the installation as a whole will be less durable. Quality construction, on the other hand, can be expensive.
- If used as a working greenhouse certain characteristics such as excess humidity, odors, control of insects, provision for running water, and drainage, must be accomodated in the design.

Collector

As in all passive solar applications, the purpose of the Attached Sunspace collector is to admit and trap solar energy. Although often perceived as a net energy loser, the large expanse of south facing glazing in a well designed Sunspace collector actually gains much more heat than it loses. The collector component functions in the same way in each of the Attached Sunspace subsystems, and the design and materials information presented below applies to all five subsystems.

There is a wide variety of possible collector configurations. A large number of Sunspaces are site-fabricated to meet specific and often idiosyncratic design specifications and the collectors for the majority of these site-built installations are framed in wood. Prefabricated, off-the-shelf collector units are usually framed in metal. Both systems have advantages and disadvantages.

The prefabricated systems are generally simple to erect, relatively impermeable to the effects of weather, and require little maintenance. They can be expensive and their dimensional modularity may inhibit design and system sizing flexibility. They may also be difficult to insulate in precisely the manner necessary to ensure maximum thermal performance. The metal frame collector system should be equipped with thermal breaks in the frame.

Site-built systems can be adapted to any particular design situation and can be insulated and shaded to meet specific conditions. Unless carefully detailed, however, such systems are notorious for failing to maintain a tight seal against the weather. Special attention must be paid to caulking and sealing the glazing material and periodic inspections should be made to ensure that the seals are still holding (see Section 4.1300 for a discussion of sealants). Rough-sawn or green wood should be avoided in such applications in favor of kiln-dried lumber. Wood should also be treated to resist moisture. Copper naphthenate should be used in greenhouse applications rather than creosote or pentachlorophenol which give off fumes that are potentially harmful to vegetation. Regardless of the material, the collector frame should be painted a light color in order to reflect more light into the Sunspace.

At present, the most common Sunspace collector material is glass and it is recommended that double glazing be used in applications where glass alone, not in combination with any other collector material, is used. For many prefabricated greenhouse manufacturers, double glazing is currently standard. In site-built applications the simplest and most common glazing type is patio door replacement glass which can be easily obtained double glazed.

Materials other than glass are, however, gaining in popularity. These include various forms of fiberglass, acrylics, polycarbonates, and certain glazing films such as polyethylene. Each of these has its own advantages and disadvantages which are discussed in detail in Section 4.1100. Each can also be used in combination with any of the other materials to maximize the best qualities of each. For example, the roof of the Sunspace might be constructed of corrugated

fiberglass because of its ease of handling during construction, while the vertical portion might be standard double glass to provide a view to the outside. Combinations and variations such as this should be considered for each individual application. The advantages of using a light-diffusing collector material to promote a balanced distribution of incoming solar energy should also be considered if storage mass is evenly distributed throughout the Sunspace.

In general, collector material on the east and west walls is thermally inefficient, losing more heat than it gains. It is recommended that such walls be opaque and well insulated where possible or, that the house itself "wrap around" the Sunspace on the east and west.

Rules of Thumb

- o Orientation:
  Extend the sunspace along the south wall of the building for the most efficient performance. Orientation can be up to 20° east or west of true south without significant loss in performance. East is generally preferred to allow morning sun to "wake up" the Sunspace.

- o Sloped Glazing:
  The angle of tilt for any sloped surface of the Sunspace collector should be between 45° and 60°. The tilt should be slightly flatter (nearer 45°) in overcast or foggy areas, and slightly steeper (nearer 60°) in mostly clear and sunny areas.

- o End Walls:
  East and west walls of Sunspace should be opaque and well-insulated. "Wrapping" the main building around the Sunspace is a good approach.

- o Sizing:
  Table 3.3 can be used to determine the collector size.

  For example, for Madison, Wisconsin, at 43°NL with an average January temperature of 21.8°F (data available from local and/or national weather bureau), select the closest "Average Winter Outdoor Temperature" (20°F). Reading across the table it is recommended that 0.9 to 1.5 square feet of glazing be used per square foot of floor area. Because Madison is at a relatively high latitude, the upper end of this range should be employed and a figure of 1.3 will be adequate. Thus to heat a living space of 200 square feet, 260 square feet of south facing glazing will be required.

Storage

The five Attached Sunspace subsystems embody unique approaches to the problem of thermal storage and each is treated separately below.

Open Wall Subsystem - In this subsystem solar radiation is absorbed by and stored in the Sunspace floor and, where applicable, the opaque endwalls, if they are made of suitable materials (see Figure 3.48).

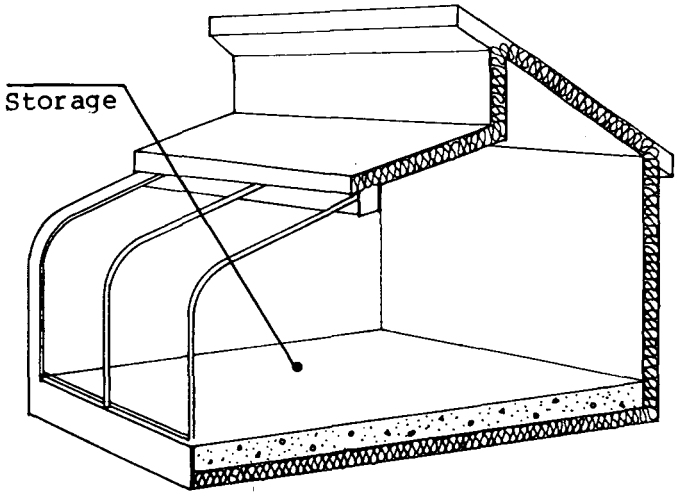


Figure 3.48

Storage elements can also be provided in the living areas and will prove very

Table 3.3

Average Winter Outdoor Temperature (Clear Day)*	Square Feet of Sunspace Glazing Needed for Each One Square Foot of Floor Area**
COLD CLIMATES	
20°F	0.90 - 1.50
25°F	0.78 - 1.30
30°F	0.65 - 1.17
TEMPERATE CLIMATES	
35°F	0.53 - 0.90
40°F	0.42 - 0.69
45°F	0.33 - 0.53

* Temperatures listed are for December and January, usually the coldest months.

** Within each range choose a ratio according to your latitude. For southern latitudes (i.e., 35°NL) use the lower glazing to floor area ratios; for northern latitudes (i.e., 48°NL), use the higher ratios. For a poorly insulated sunspace or building, always use slightly more glazing.

effective if sunlight can penetrate deeply enough into the living spaces to strike them directly. The majority of the heat reaching the living areas, however, will be in the form of warm air generated in the Sunspace during the day.

The storage components in the Sunspace and the adjacent living spaces can be made from any of a variety of high thermal storage capacity materials and should be as dark a color as possible to increase absorption of solar radiation (see Section 4.2000).

Direct Gain Subsystem - In this subsystem the storage components are the same as in the Open Wall Subsystem and function in a similar manner (see Figure 3.49).

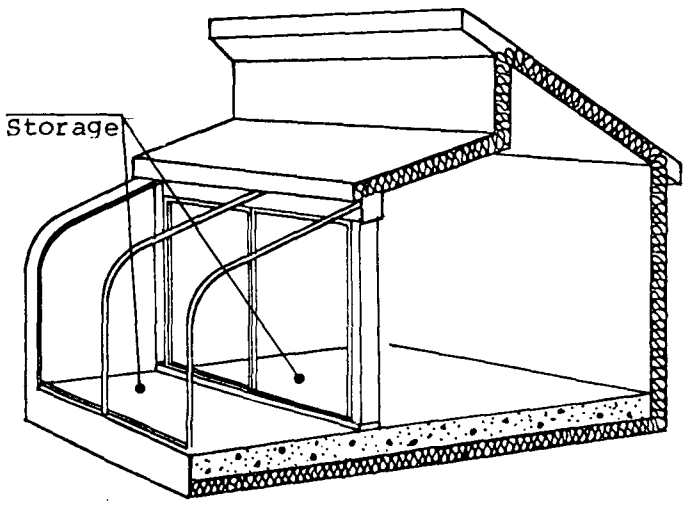


Figure 3.49

The chief difference is that the living area storage components, while still receiving direct solar radiation through the glazed shared wall, do not normally receive convected warm air from the Sunspace. The heat collected and stored in the Sunspace is only available to the living areas when the shared wall glazing is opened. At other times, when the glazing is closed, this heat is used to maintain warm temperatures in the otherwise unheated Sunspace. In this mode of operation the Sunspace serves as a buffer zone, reducing heat losses from the adjacent living areas, thereby reducing overall fuel consumption.

In this subsystem, as in the Open Wall Subsystem, the storage elements can be of the same materials and construction as those found in a Direct Gain system (see Section 3.1000).

Air Exchange Subsystem - In this subsystem the living areas are separated from the Sunspace by an opaque shared wall and receive no direct solar radiation. Vents in this wall allow warm air generated in the Sunspace to be convected into the living areas (see Figure 3.50).

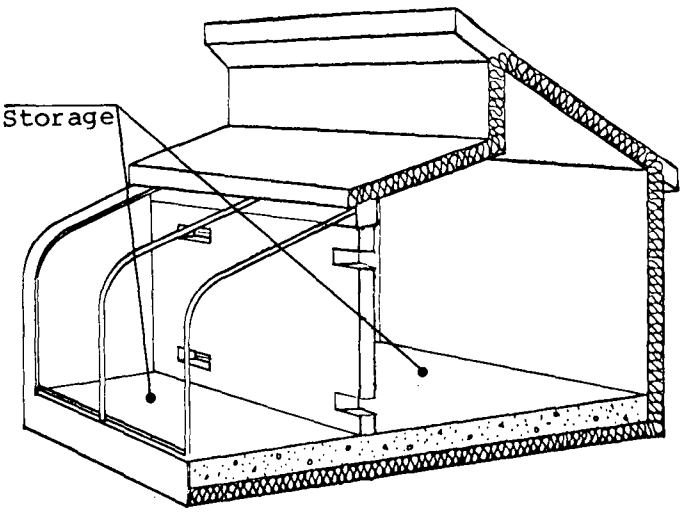


Figure 3.50

As in the other subsystems, storage mass located in the Sunspace will absorb and store heat. When heat is required in the living spaces, the wall vents are opened and warm air is allowed to flow from the Sunspace into the living areas. When the vents are closed, the stored heat is used to heat the Sunspace itself, helping it to act as a thermal buffer reducing heat losses from the adjacent living areas. Once again, the materials and construction techniques used in Direct Gain applications are appropriate for the Air Exchange Sunspace storage components (see Section 3.1000).

Thermal Storage Wall Subsystem - This subsystem acts very much like a Thermal Storage Wall with a much larger airspace between the storage wall and the collector. The mass wall separating the living areas from the Sunspace is used to absorb and store solar radiation which is in turn used to heat both the living areas and the Sunspace itself. The wall can be built of any of the Thermal Storage Wall materials covered in Section 3.2000 and will be constructed in much the same fashion (see Figure 3.51).

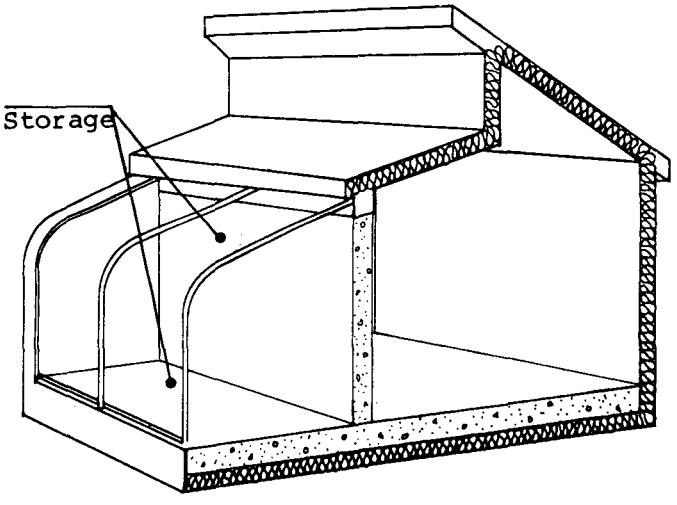


Figure 3.51

Whatever material is chosen, the Sunspace side of the wall should be painted a dark color to increase absorption of incoming solar energy (see Appendix A for the absorptivities of various materials and colors). The interior surface can be painted or left unfinished. Finishes other than paint, however, will decrease the efficiency of the wall by restricting its ability to reradiate heat. Plaster and wallpaper will have only a minor effect in this regard. Gypsum board can also be acceptable if it is attached directly to the wall (not on furring strips) and if care is taken during installation to apply a very thick coat of construction adhesive in order to increase the thermal connection between the wall and the gypsum board. Finishes which are attached to the wall with furring strips will create an insulating airspace, significantly reducing the performance of the system.

The heat radiating from the storage wall back into the Sunspace, along with heat stored in elements within the Sunspace itself, will help maintain higher than ambient temperatures in this space. As in the other subsystems, these higher temperatures will help reduce heat losses from the adjacent living spaces. As in the other subsystems, the materials and construction techniques used for Direct Gain storage components will be appropriate in the Thermal Storage Wall subsystem (see Section 3.1000).

Remote Storage System - In this subsystem, the storage is typically a "rock bed," literally a bed of rocks usually located under the floor of the major living spaces. Heat is delivered to this bed in the form of heated air from the Sunspace (see Figure 3.52).

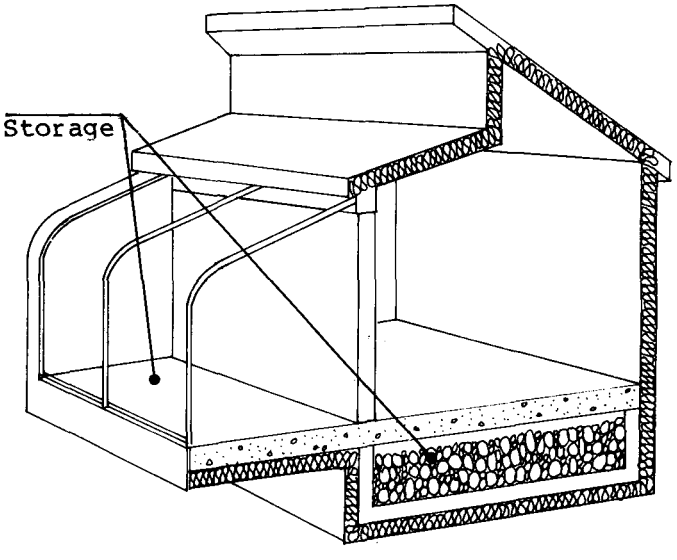


Figure 3.52

Because the temperature of this delivered heat is relatively low (90°F), it is not efficient to first store this heat in the rock bed and then circulate air from the warm bed to the living spaces. The large duct sizes and fans necessary at these low temperatures will not be cost effective. Allowing the delivered hot air to

convect up directly through openings in a frame floor can work, but it is generally better to simply allow the heat from the bed to radiate through the floor of the home. For this reason, the bed should lie under as large a portion of the living space floor as possible, and the floor should be made of a masonry material.

The masonry floor can be constructed on top of a wood floor over a crawl space, in which case the rocks should come up right under the wood subfloor, or it can simply be a slab laid directly on top of the bed.

In any rock storage system care should be taken to ensure that the heated Sunspace air is distributed evenly throughout the rock bed.

Rules of Thumb

Floors (All Subsystems)

- Thickness:
  Standard slab thicknesses are usually appropriate. Consult Rules of Thumb in the Direct Gain section.

Walls (Thermal Storage Wall Subsystem)

- Thickness:
  The recommended Attached Sunspace storage wall thickness: 8" - 18".

Rock Bed (Remote Storage Subsystem)

- Area:
  1. In cold climates the bed area should be 75-100% of the floor area of the living space to be heated.
  2. In moderate climates the bed area should be 50-75% of the floor area of the living space to be heated.

- Volume of Rock Bed:
  1. 3/4 - 1 1/2 cubic feet of fist-sized (2"-3" diameter) rocks* per square foot of Sunspace glazing (severe climates).
  2. 1 1/2 - 3 cubic feet of fist-sized (2"-3" diameter) rocks* per square foot of Sunspace glazing (moderate climates).

  * The smaller rock or gravel sizes can be more efficient due to the greater amount of surface area available for heat transfer. General rule: bed depth in the direction of air flow = 20 x diameter of rocks.

Vents (Air Exchange Subsystem)

- Size:
  Interior vents should be a minimum of 3% of the area of the shared wall between the Sunspace and the adjacent living spaces. To achieve a more balanced air flow upper vents should not be located directly over lower vents, but should be moved to one side if possible. Backdraft dampers or operable louvers should be provided for upper vents to prevent reverse thermocirculation.

Control

Shading

In each of the Attached Sunspace subsystems it is recommended that some method for shading the collector be provided to help avoid unwanted summer heat gain. Most of the devices used in Direct Gain are applicable for at least the vertical or near vertical wall section of the collector, including: vegetation (trees), trellises, vertical and/or horizontal louvers and attached awnings.

The glazed portion of the collector roof, however, represents a slightly different shading condition. The most efficient way to shade this area is to use operable wood, aluminum or plastic roller shades attached directly to the collector, preferably on the outside. Prefabricated collectors are often equipped with these shades integrated into the framing system. In site-built installations provision should be made for the inclusion of such elements as part of the site-built frame.

Introduction

Wherever possible, it is recommended that the roof portion of the collector be opaque at its connection to the home. This opaque roof will serve as an overhang for shading the Sunspace. In working greenhouse applications care should be taken to balance the amount of shading with the daylight requirements of the plants (see Figure 3.53).

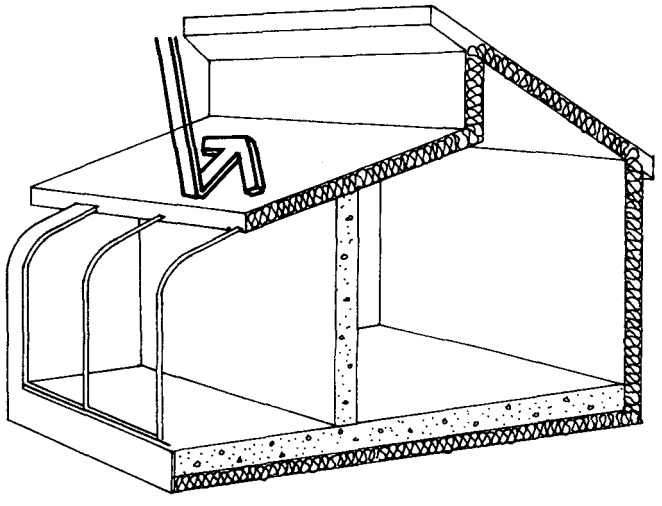


Figure 3.53

Reflecting

Reflecting panels can be used in any of the Attached Sunspace subsystems to enhance the amount of solar energy reaching the collector. They should be located so as to reflect sunlight onto the mass within the space without directing excessive radiation directly onto the plants.

Insulating (Fixed Exterior Insulation)

In general all exposed opaque surfaces in the Sunspace, including roof and endwalls, should be well insulated to reduce heat flow to the exterior. Standard insulating techniques are appropriate except in the case where a particular construction is intended to function as a storage component. For example, if an endwall in the Sunspace is to function as a Direct Gain storage component, the construction procedures and insulation techniques should follow the discussions and details in Section 3.1000.

Foundation insulation will, of course, reduce heat losses. These reductions can be increased if the floor slab is also insulated at its perimeter. However, such perimeter insulation may or may not be advisable, depending upon the particular mode in which the Sunspace is operated.

If the Sunspace is thermally isolated from the living area and its temperatures are allowed to fluctuate freely, perimeter insulation will not be necessary if foundation insulation is already provided. If the Sunspace is not thermally isolated from the living space and/or if an auxiliary energy system is used to maintain temperatures in the Sunspace within the comfort range, some insulation under the slab should be provided in addition to foundation insulation. Perimeter insulation is adequate, but insulating under the entire slab may be more effective. In general, the floor in such Sunspaces should be insulated to the same extent as a Direct Gain floor would be in the same location (see Storage Rules of Thumb, Section 3.1000).

In general, it is not necessary to provide fixed insulation for the shared wall between the Sunspace and the adjacent living spaces in any of the five subsystems. In the Open Wall and Direct Gain Subsystems such considerations do not apply. In the Air Exchange and Remote Storage Subsystems, the shared wall need not be insulated because movable insulation is already provided at the collector. In the Thermal Storage Wall Subsystem insulating the shared storage wall will effectively nullify any passive benefits which the wall might provide.

Insulating (Movable Insulation)

The provision of movable insulation at

Introduction

the Sunspace collector is recommended for all five subsystems. Such insulation will reduce heat losses during prolonged overcast periods and at night, as well as prevent unwanted heat gain during the cooling season. This will generally result in significant increases in the thermal performance of all of the subsystems. In fact, in more severe climates, certain Attached Sunspace configurations may be net energy losers if such insulation is not provided.

Most movable insulation for Attached Sunspace collectors will not be available off-the-shelf, but will need to be adapted from existing types commonly used in Direct Gain or Thermal Storage Wall applications. The most appropriate shades will be rigid panels (exterior or interior) or some form of insulating shade (either attached to the glazing frame or suspended from wires within the Sunspace).

These insulating materials may be bulky and difficult to store, if not designed into the collector framing system. Manual operation of movable insulation is often very simple but requires an active commitment on the part of the homeowners. It is therefore recommended that automatic systems, either switch or thermostatically controlled, be considered.

No matter what system is used, care must taken to ensure a tight fit between insulation and the collector to avoid infiltration losses. Local codes should also be consulted to assess the eligibility of certain materials for use in exposed situations. For example, some insulating materials such as polystyrene and urethane may be considered health or fire hazards.

Rules of Thumb

Shading

- Overhangs:
  The projection of the overhang that will be adequate (provide 100% shading at noon on June 21) at particular latitudes can be quickly calculated by using the following formula:

$$\text{Projection} = \frac{\text{window opening (height)}}{\text{F (see table below)}}$$

North Latitude	F Factor*
28°	5.6-11.1
32°	4.0- 6.3
36°	3.0- 4.5
40°	2.5- 3.4
44°	2.0- 2.7
48°	1.7- 2.2
52°	1.5- 1.8
56°	1.3- 1.5

* Select a factor according to the latitude. The higher values will provide 100% shading at noon on June 21, the lower values until August 1.

A slightly longer overhang may be desirable at latitudes where this formula does not provide enough shade during the latter part of the cooling season (see Figure 3.15).

For example, for Madison, Wisconsin, at 43°NL, select an F factor between 2.0 and 2.7 (values for 44°NL). Assuming shade is desired until August 1, choose the lower value of 2.0. If the collector height (h) is 8 feet, the projection (1) of the overhang placed at the top of the collector will be: $\frac{8}{2.0} = 4$ feet.

Reflecting

- Sizing:
  The reflector should be the same length as the collector area served and roughly twice as wide as the collector area is high.

- Slope:
  A downward slope (away from collector) of roughly 5° is recommended.

Insulating

- Fixed Insulation:
  Fixed exterior insulation R-values should meet or exceed the levels that would be maintained by the same element in a non-solar building, which should in turn meet or exceed local building code requirements.

- Movable Insulation:
  Movable insulation should have an R-value between R-4 and R-9, subject to cost-benefit considerations.

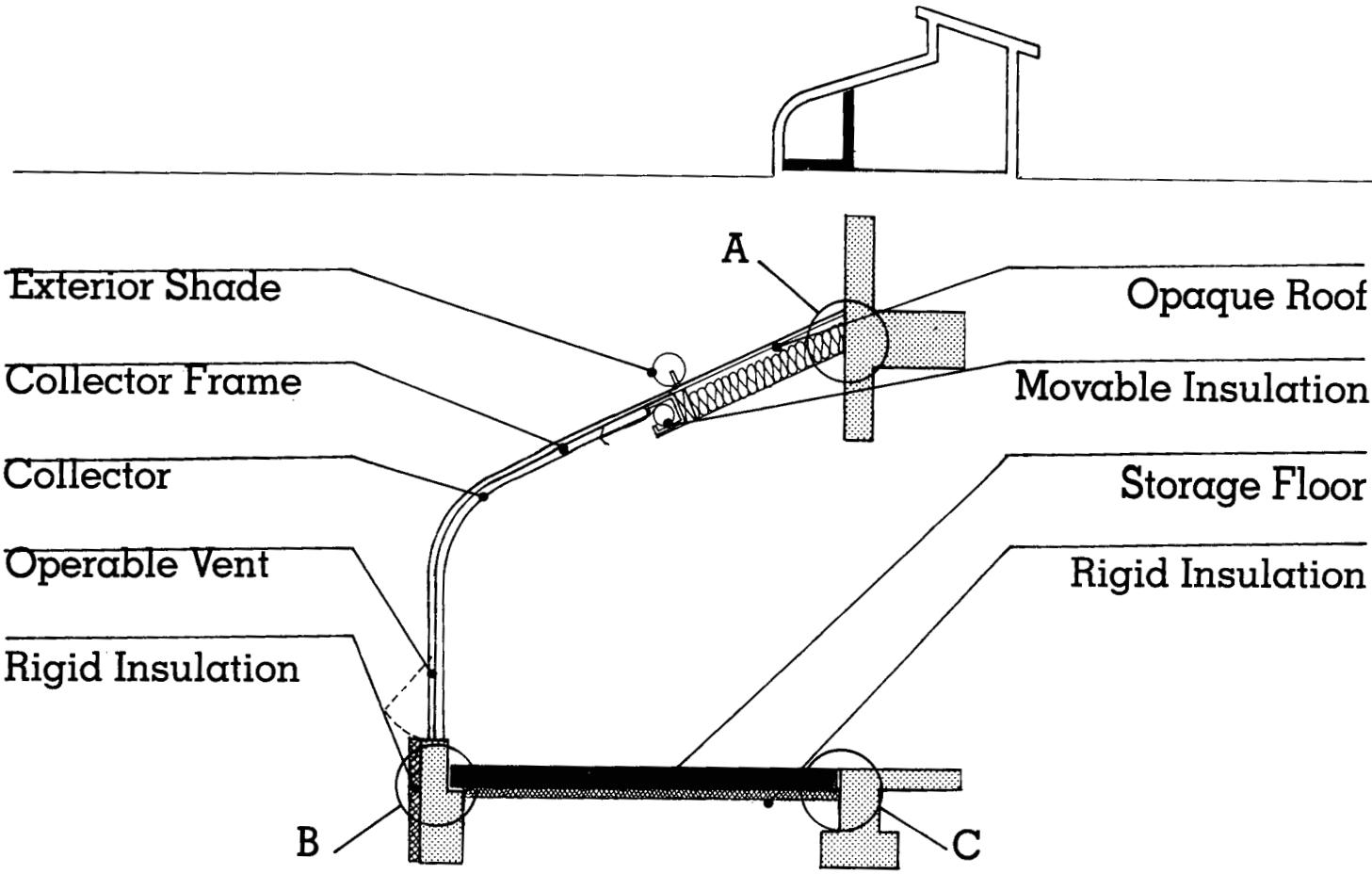
- Seal:
  All insulation should provide a tight seal to avoid heat loss at its edges.

Vents (Exterior)

- Area:
  The exterior vent area should be 1/6 of the area of the wall covered by the Sunspace. The top vents should be 1/3 larger than bottom vents. The vertical distance between vents should be as great as possible.

Attached Sunspace
Open Wall Subsystem

3.3100
Key



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Attached Sunspace
Construction Notes

GENERAL CONSTRUCTION

o This Key Page diagram and its construction notes represent a particular mode of operation for an Attached Sunspace. The reader is advised to review Section 3.3000 before selecting and constructing this particular Sunspace system.

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

EXTERIOR SHADES

o Exterior movable shades will reduce solar heat gain during the cooling season. Such shades are typically aluminum, wood, or fabric such as canvas. For further information see Section 4.4100.

COLLECTOR FRAME

o The collector frame can be site-built or prefabricated.

o Site-built systems are generally framed in wood, which should be treated to resist the effects of moisture. Special attention should be paid in these systems to properly sealing and caulking the glazing material.

o Prefabricated systems (e.g. standard greenhouses) are generally framed in metal. The frame specified in any such system should be equipped with thermal breaks. For further information see Sections 3.3000 and 4.1200.

COLLECTOR

o Double glazing is generally recommended to ensure optimum thermal performance. A 1/2" airspace between the glazing layers is recommended where feasible.

o The glazing material can be glass or plastic. For specific material information see Section 4.1100.

OPERABLE VENT

o It is recommended that the Sunspace be vented to the outside during the cooling season. Intake vents should be as low in the Sunspace wall as possible, while exhaust vents should be high, either near the ridge or high in the gable ends. For further information see Section 3.3000.

RIGID INSULATION

o The use of rigid insulation is recommended to reduce perimeter heat losses.

OPAQUE ROOF

o It is recommended that a portion of the Sunspace roof be opaque where it connects to the main house. This opaque section will serve to shade the Sunspace during the cooling season. It can be specified as part of a prefabricated system or it can be site-built. For further information on calculating the length of the opaque roof overhang see Section 3.3000.

o The opaque roof section should be insulated to a level which meets or exceeds local building/energy code requirements for roofs.

MOVABLE INSULATION

o Movable insulation to reduce nighttime heat loss during the heating season and daytime heat gain during the cooling season should be provided. Because of the limited availability of movable insulation specifically designed for Attached Sunspaces, it may be necessary to site-design and site-fabricate an insulation system for a particular application. Prior to detailing the collector component assembly, the insulation manufacturer's specifications should be consulted to ensure adequate space has been provided for proper installation and operation. For further material information see Section 4.4300.

STORAGE FLOOR

o Mass for thermal storage can be provided in the Attached Sunspace floor. Concrete slabs-on-grade, masonry pavers laid directly on the ground, or pavers on slabs-on-grade can be used. For further information on applicable materials and configurations see Direct Gain Storage Floor Key Pages 3.1170 and following.

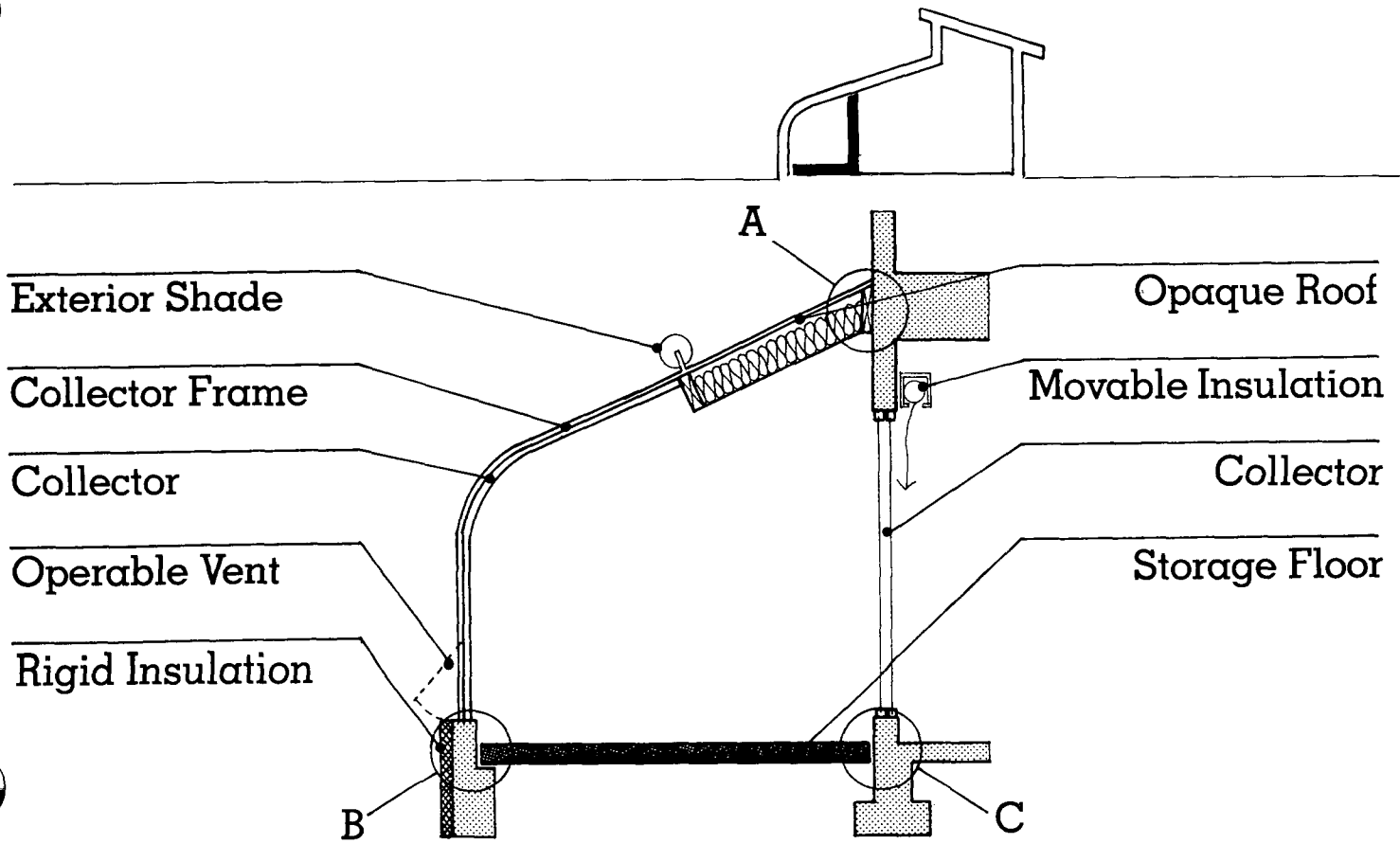
RIGID INSULATION

o In the cooler climates it is generally recommended that rigid insulation be placed under masonry floors which are acting as storage components in Open Wall Attached Sunspaces.

Attached Sunspace
Direct Gain Subsystem

3.3102

Key



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	Connection at "A"	Connection at "B"	Connection at "C"
COLLECTOR			
Site-built		3.3208,3.3210	
Prefabricated	3.3216	3.3218,3.3220,3.3222	3.3228,3.3230,3.3232
STORAGE			
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Wall		3.3222	
CONTROL			
Movable Insulation	3.3200,3.3202,3.3204 3.3206,3.3216	3.3208,3.3210,3.3222	
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Shading	3.3200,3.3202,3.3212 3.3214,3.3216		

GENERAL CONSTRUCTION

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o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

EXTERIOR SHADES

o Exterior movable shades will reduce solar heat gain during the cooling season. Such shades are typically aluminum, wood, or fabric such as canvas. For further information see Section 4.4100.

COLLECTOR FRAME

o The collector frame can be site-built or prefabricated.

o Site-built systems are generally framed in wood, which should be treated to resist the effects of moisture. Special attention should be paid in these systems to properly sealing and caulking the glazing material.

o Prefabricated systems (e.g. standard greenhouses) are generally framed in metal. The frame specified in any such system should be equipped with thermal breaks. For further information see Sections 3.3000 and 4.1200.

COLLECTOR

o Double glazing is generally recommended to ensure optimum thermal performance. A 1/2" airspace between the glazing layers is recommended where feasible.

o The glazing material can be glass or plastic. For specific material information see Section 4.1100.

OPERABLE VENT

o It is recommended that the Sunspace be vented to the outside during the cooling season. Intake vents should be as low in the Sunspace wall as possible, while exhaust vents should be high, either near the ridge or high in the gable ends. For further information see Section 3.3000.

RIGID INSULATION

o The use of rigid insulation is recommended to reduce perimeter heat losses.

o Insulation should have an R-value which meets or exceeds the requirements of local building/energy codes for foundations.

o Insulation must be protected above grade. Stucco or other protective coating can be used. Consult insulation manufacturer for recommendations.

OPAQUE ROOF

o It is recommended that a portion of the Sunspace roof be opaque where it connects to the main house. This opaque section will serve to shade the Sunspace during the cooling season. It can be specified as part of a prefabricated system or it can be site-built. For further information on calculating the length of the opaque roof overhang see Section 3.3000.

o The opaque roof section should be insulated to a level which meets or exceeds local building/energy code requirements for roofs.

MOVABLE INSULATION

o Movable insulation to reduce nighttime heat loss during the heating season and daytime heat gain during the cooling season should be provided. Prior to detailing the collector component assembly, the insulation manufacturer's specifications should be consulted to ensure adequate space has been provided for proper installation and operation. For further material information see Section 4.4300.

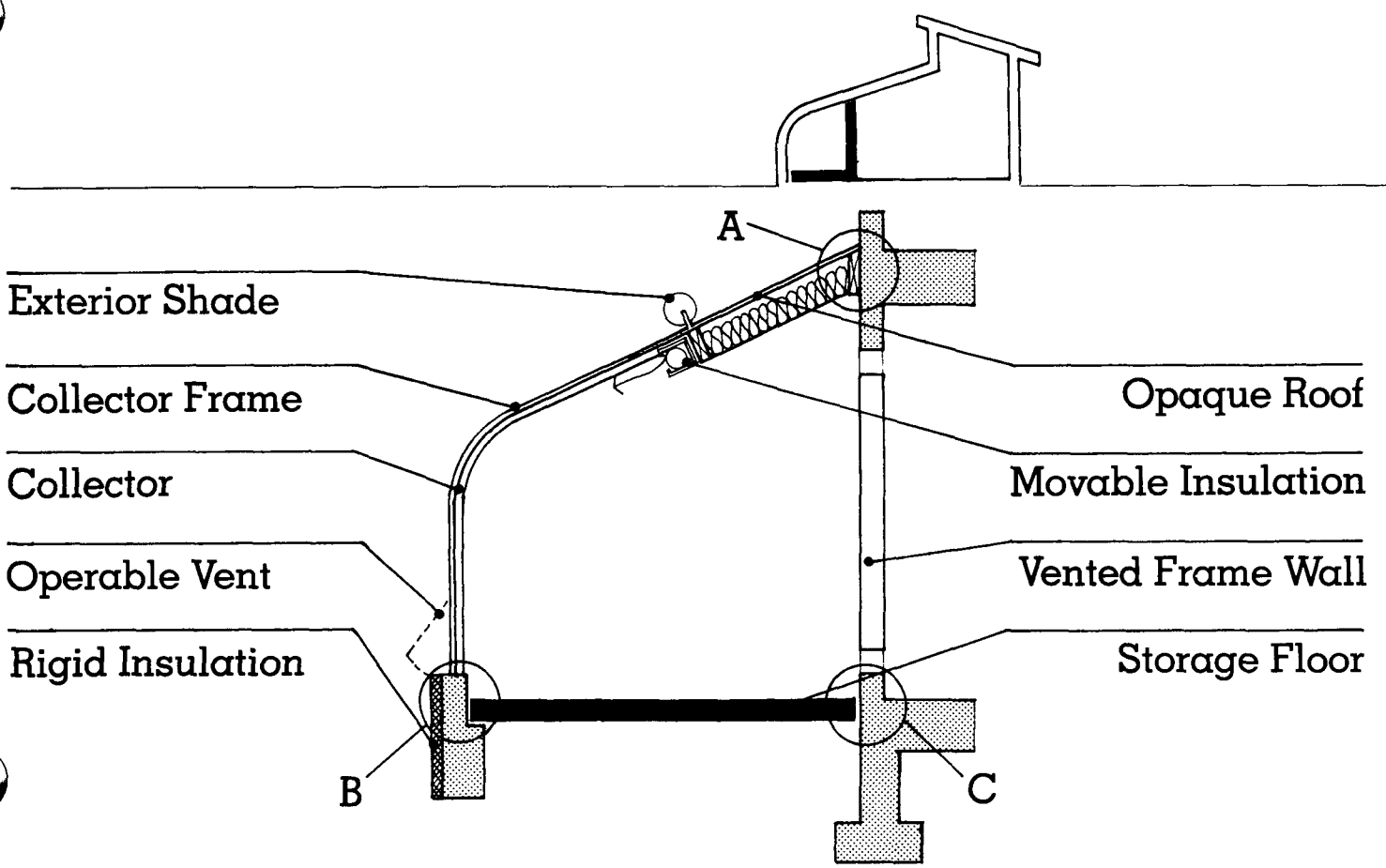
COLLECTOR

o Collector components such as patio doors (as shown) or solar windows provide direct solar gain into the adjacent living spaces. For further information on Direct Gain collectors and storage see Key Page 3.1100.

STORAGE FLOOR

o Mass for thermal storage can be provided in the Attached Sunspace floor. Concrete slabs-on-grade, masonry pavers laid directly on the ground, or pavers on slabs-on-grade can be used. For further information on applicable materials and configurations see Direct Gain Storage Floor Key Pages 3.1170 and following.

Attached Sunspace
Air Exchange Subsystem



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Prefabricated		3.3218,3.3220,3.3222	
STORAGE			
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Shading	3.3200,3.3202,3.3212 3.3214,3.3216		

Attached Sunspace
Construction Notes

GENERAL CONSTRUCTION

o This Key Page diagram and its construction notes represent a particular mode of operation for an Attached Sunspace. The reader is advised to review Section 3.3000 before selecting and constructing this particular Sunspace system.

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

EXTERIOR SHADES

o Exterior movable shades will reduce solar heat gain during the cooling season. Such shades are typically aluminum, wood, or fabric such as canvas. For further information see Section 4.4100.

COLLECTOR FRAME

o The collector frame can be site-built or prefabricated.

o Site-built systems are generally framed in wood, which should be treated to resist the effects of moisture. Special attention should be paid in these systems to properly sealing and caulking the glazing material.

o Prefabricated systems (e.g. standard greenhouses) are generally framed in metal. The frame specified in any such system should be equipped with thermal breaks. For further information see Sections 3.3000 and 4.1200.

COLLECTOR

o Double glazing is generally recommended to ensure optimum thermal performance. A 1/2" airspace between the glazing layers is recommended where feasible.

o The glazing material can be glass or plastic. For specific material information see Section 4.1100.

OPERABLE VENT

o It is recommended that the Sunspace be vented to the outside during the cooling season. Intake vents should be as low in the Sunspace wall as possible, while exhaust vents should be high, either near the ridge or high in the gable ends. For further information see Section 3.3000.

RIGID INSULATION

o The use of rigid insulation is recommended to reduce perimeter heat losses.

o Insulation must be protected above grade. Stucco or other protective coating can be used. Consult insulation manufacturer for recommendations.

OPAQUE ROOF

o It is recommended that a portion of the Sunspace roof be opaque where it connects to the main house. This opaque section will serve to shade the Sunspace during the cooling season. It can be specified as part of a prefabricated system or it can be site-built. For further information on calculating the length of the opaque roof overhang see Section 3.3000.

o The opaque roof section should be insulated to a level which meets or exceeds local building/energy code requirements for roofs.

MOVABLE INSULATION

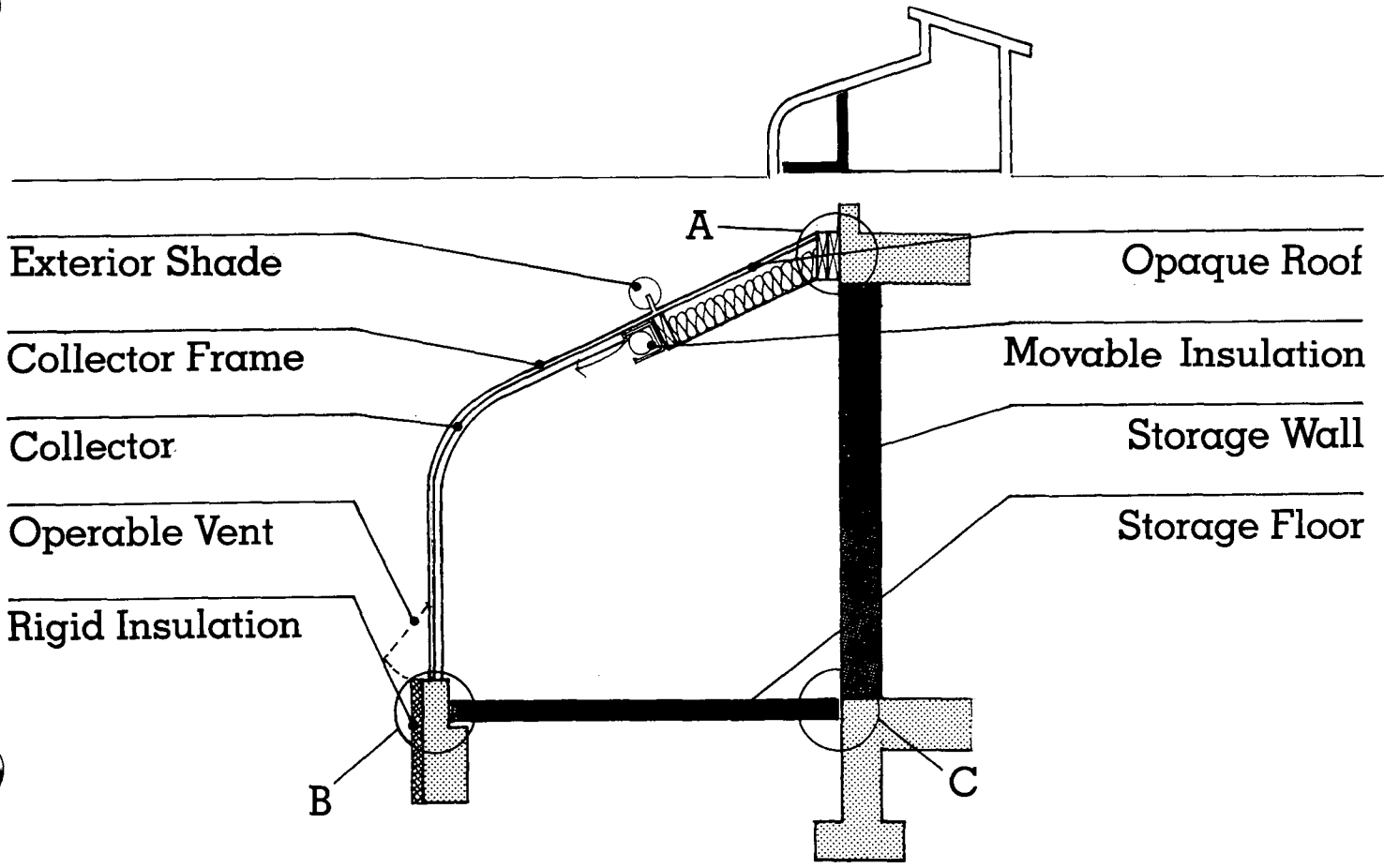
o Movable insulation to reduce nighttime heat loss during the heating season and daytime heat gain during the cooling season should be provided. Because of the limited availability of movable insulation specifically designed for Attached Sunspaces, it may be necessary to site-design and site-fabricate an insulation system for a particular application. Prior to detailing the collector component assembly, the insulation manufacturer's specifications should be consulted to ensure adequate space has been provided for proper installation and operation. For further material information see Section 4.4300.

VENTED FRAME WALL

o The wall between the Attached Sunspace and the adjacent living area can be standard wood or metal frame construction. Vents in the wall provide convected warm air to the living space during the heating season.

STORAGE FLOOR

o Mass for thermal storage can be provided in the Attached Sunspace floor. Concrete slabs-on-grade, masonry pavers laid directly on the ground, or pavers on slabs-on-grade can be used. For further information on applicable materials and configurations see Direct Gain Storage Floor Key Pages 3.1170 and following.



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STORAGE			
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CONTROL			
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Reflector		3.3222	
Shading	3.3200,3.3202,3.3212 3.3214,3.3216		

GENERAL CONSTRUCTION

o This Key Page diagram and its construction notes represent a particular mode of operation for an Attached Sunspace. The reader is advised to review Section 3.3000 before selecting and constructing this particular Sunspace system.

o Construction notes and recommendations presented in this section are intended as general guidelines to proper construction. They are not intended to supersede regional variations in standard practice or local building code requirements.

EXTERIOR SHADES

o Exterior movable shades will reduce solar heat gain during the cooling season. Such shades are typically aluminum, wood, or fabric such as canvas. For further information see Section 4.4100.

COLLECTOR FRAME

o The collector frame can be site-built or prefabricated.

o Site-built systems are generally framed in wood, which should be treated to resist the effects of moisture. Special attention should be paid in these systems to properly sealing and caulking the glazing material.

o Prefabricated systems (e.g. standard greenhouses) are generally framed in metal. The frame specified in any such system should be equipped with thermal breaks. For further information see Sections 3.3000 and 4.1200.

COLLECTOR

o Double glazing is generally recommended to ensure optimum thermal performance. A 1/2" airspace between the glazing layers is recommended where feasible.

o The glazing material can be glass or plastic. For specific material information see Section 4.1100.

OPERABLE VENT

o It is recommended that the Sunspace be vented to the outside during the cooling season. Intake vents should be as low in the Sunspace wall as possible, while exhaust vents should be high, either near the ridge or high in the gable ends. For further information see Section 3.3000.

RIGID INSULATION

o The use of rigid insulation is recommended to reduce perimeter heat losses.

o Insulation must be protected above grade. Consult insulation manufacturer for recommendations.

OPAQUE ROOF

o It is recommended that a portion of the Sunspace roof be opaque where it connects to the main house. This opaque section will serve to shade the Sunspace during the cooling season. It can be specified as part of a prefabricated system or it can be site-built. For further information on calculating the length of the opaque roof overhang see Section 3.3000.

o The opaque roof section should be insulated to a level which meets or exceeds local building/energy code requirements for roofs.

MOVABLE INSULATION

o Movable insulation to reduce nighttime heat loss during the heating season and daytime heat gain during the cooling season should be provided. Because of the limited availability of movable insulation specifically designed for Attached Sunspaces, it may be necessary to site-design and site-fabricate an insulation system for a particular application. Prior to detailing the collector component assembly, the insulation manufacturer's specifications should be consulted to ensure adequate space has been provided for proper installation and operation. For further material information see Section 4.4300.

STORAGE WALL

o The wall between the Attached Sunspace and the adjacent living area can be used for thermal storage. For information on wall materials and configurations see Thermal Storage Wall Key Pages 3.2120 and following.

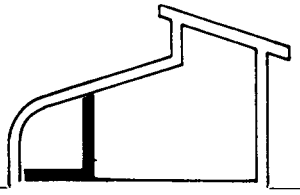
STORAGE FLOOR

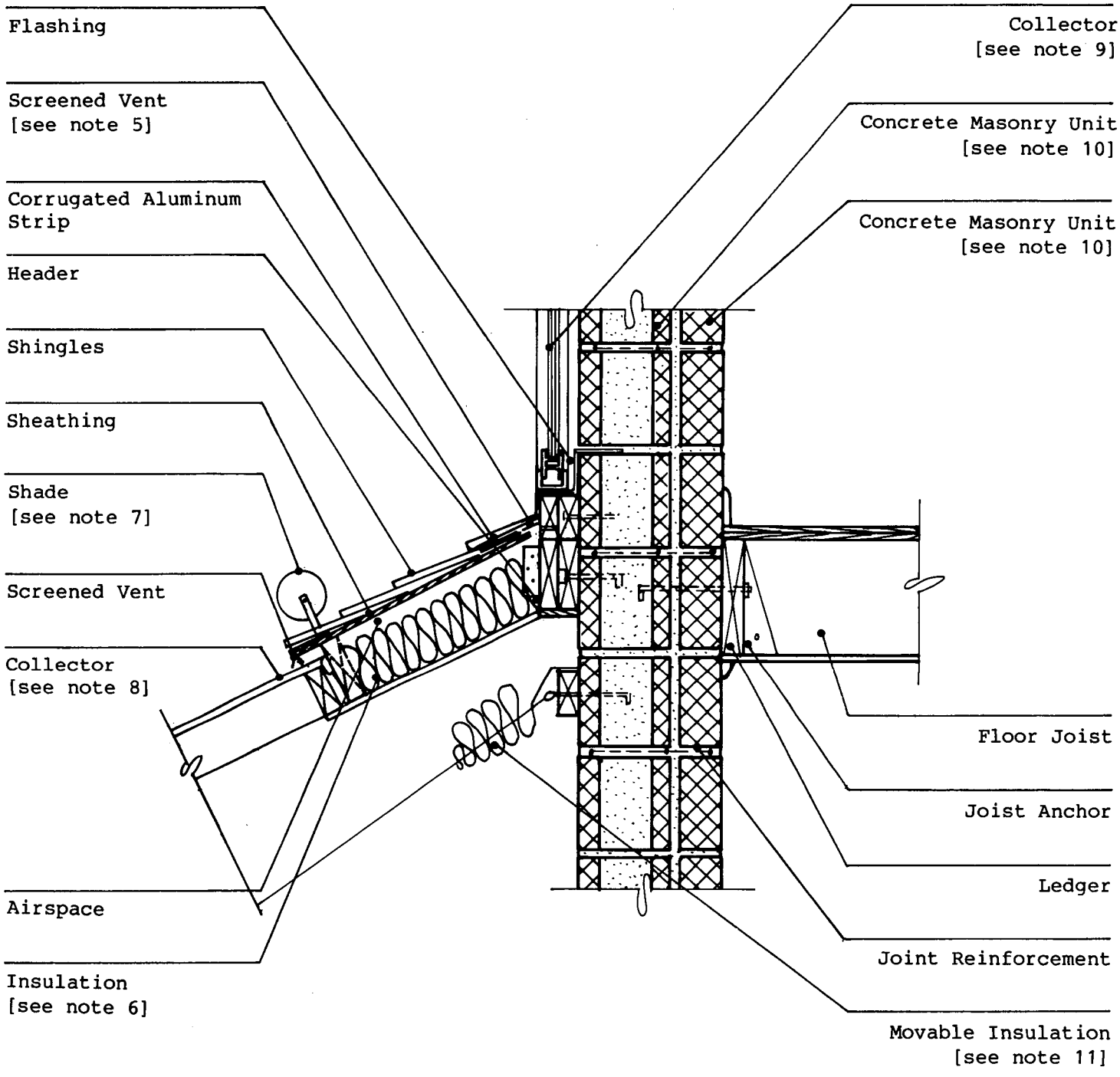
o Mass for thermal storage can be provided in the Attached Sunspace floor. Concrete slabs-on-grade, masonry pavers laid directly on the ground, or pavers on slabs-on-grade can be used. For further information on applicable materials and configurations see Direct Gain Storage Floor Key Pages 3.1170 and following.

Attached Sunspace
Site-Built Collector
CMU Storage Wall

3.3200

Detail

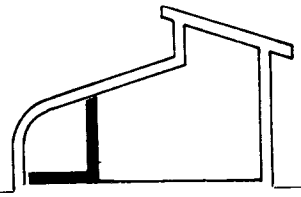


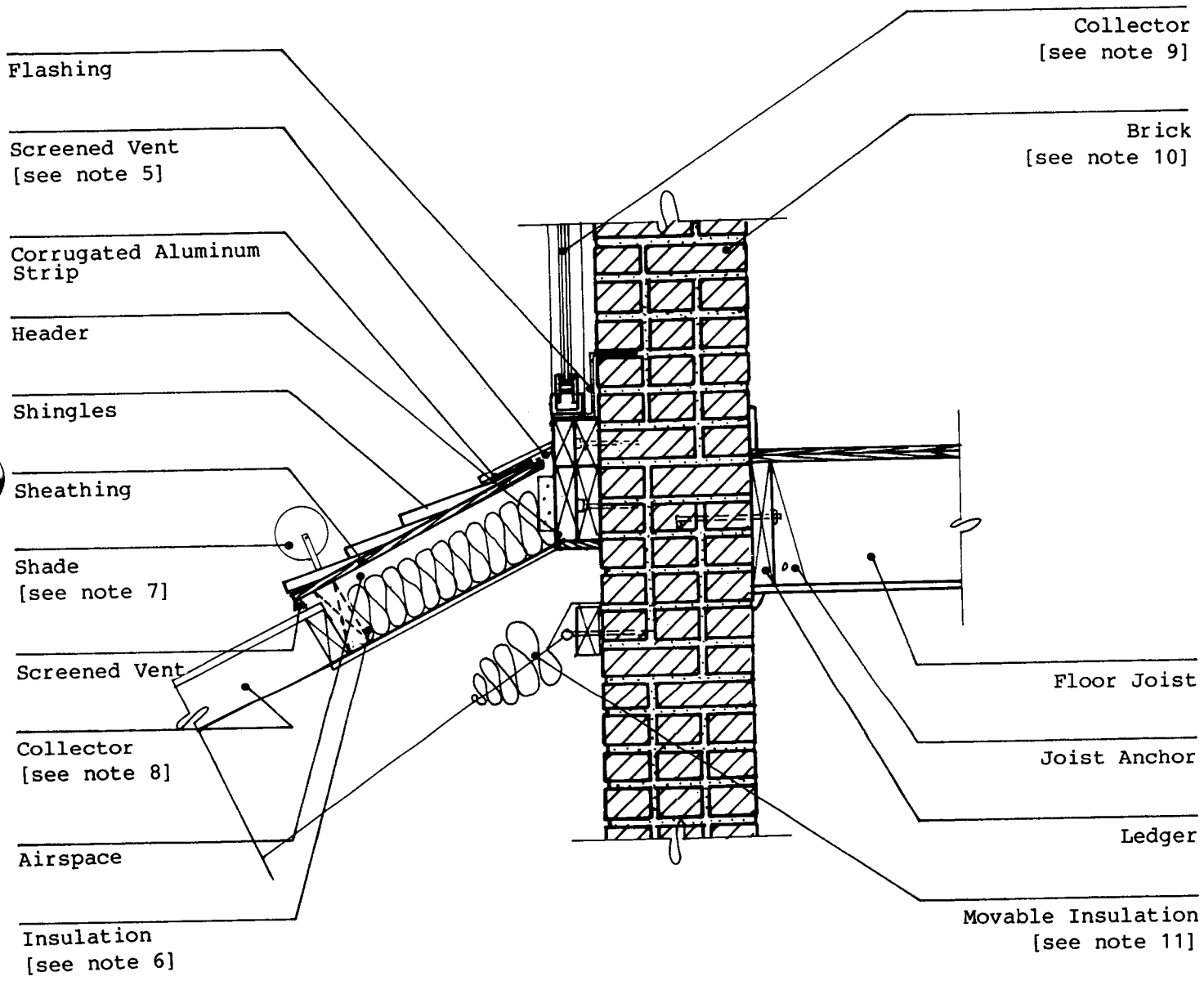


[1] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice.
[2] Sizing of framing members to be determined by weight of glazing material, loading requirements, and desired clear spans. All structural elements must be designed to meet local building codes and/or accepted practice.
[3] High humidity levels in Attached Sunspaces used as working greenhouses may necessitate treating wood framing members with preservative. Avoid preservatives harmful to plants.
[4] Vents to remove excess heat during cooling season should be provided. Roof or gable end vents are suitable. For further information, see Key Page 3.3106.
[5] Opaque roof section must be vented to ensure proper performance of insulation.
[6] Insulation levels at opaque roof section should meet or exceed requirements of local building/energy codes for roof components.
[7] Exterior roll-down shades are generally recommended for sun control. For further information see Key Page 3.3106.
[8] A variety of materials can be specified for the collector glazing. For further material information see Section 4.1100.
[9] A Thermal Storage Wall at the second floor can be incorporated into the design as an extension of the Attached Sunspace mass wall. For further information on Thermal Storage Wall materials and configurations see Key Page 3.2100 and following.
[10] Alternate storage wall materials can be specified at the builders' option. For further information on Thermal Storage Wall materials and configurations see Key Page 3.2120 and following.
[11] Movable insulation should be provided to improve thermal performance. A movable insulating curtain, suspended from cables, is suitable for Attached Sunspace applications. For further information see Key Page 3.3106.

Attached Sunspace
Site-Built Collector
Brick Storage Wall

Detail





[1] Placement of reinforcing, metal ties, flashing and weep holes to be determined by local building codes and/or accepted practice.

[2] Sizing of framing members to be determined by weight of glazing material, loading requirements, and desired clear spans. All structural elements must be designed to meet local building codes and/or accepted practice.

[3] High humidity levels in Attached Sunspaces used as working greenhouses may necessitate treating wood framing members with preservative. Avoid preservatives harmful to plants.

[4] Vents to remove excess heat during cooling season should be provided. Roof or gable end vents are suitable. For further information, see Key Page 3.3106.

[5] Opaque roof section must be vented to ensure proper performance of insulation.

[6] Insulation levels at opaque roof section should meet or exceed requirements of local building/energy codes for roof components.

[7] Exterior roll-down shades are generally recommended for sun control. For further information see Key Page 3.3106.

[8] A variety of materials can be specified for the collector glazing. For further material information see Section 4.1100.

[9] A Thermal Storage Wall at the second floor can be incorporated into the design as an extension of the Attached Sunspace mass wall. For further information on Thermal Storage Wall materials and configurations see Key Page 3.2100 and following.

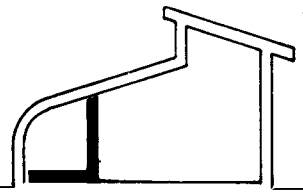
[10] Alternate storage wall materials can be specified at the builders' option. For further information on Thermal Storage Wall materials and configurations see Key Page 3.2128 and following.

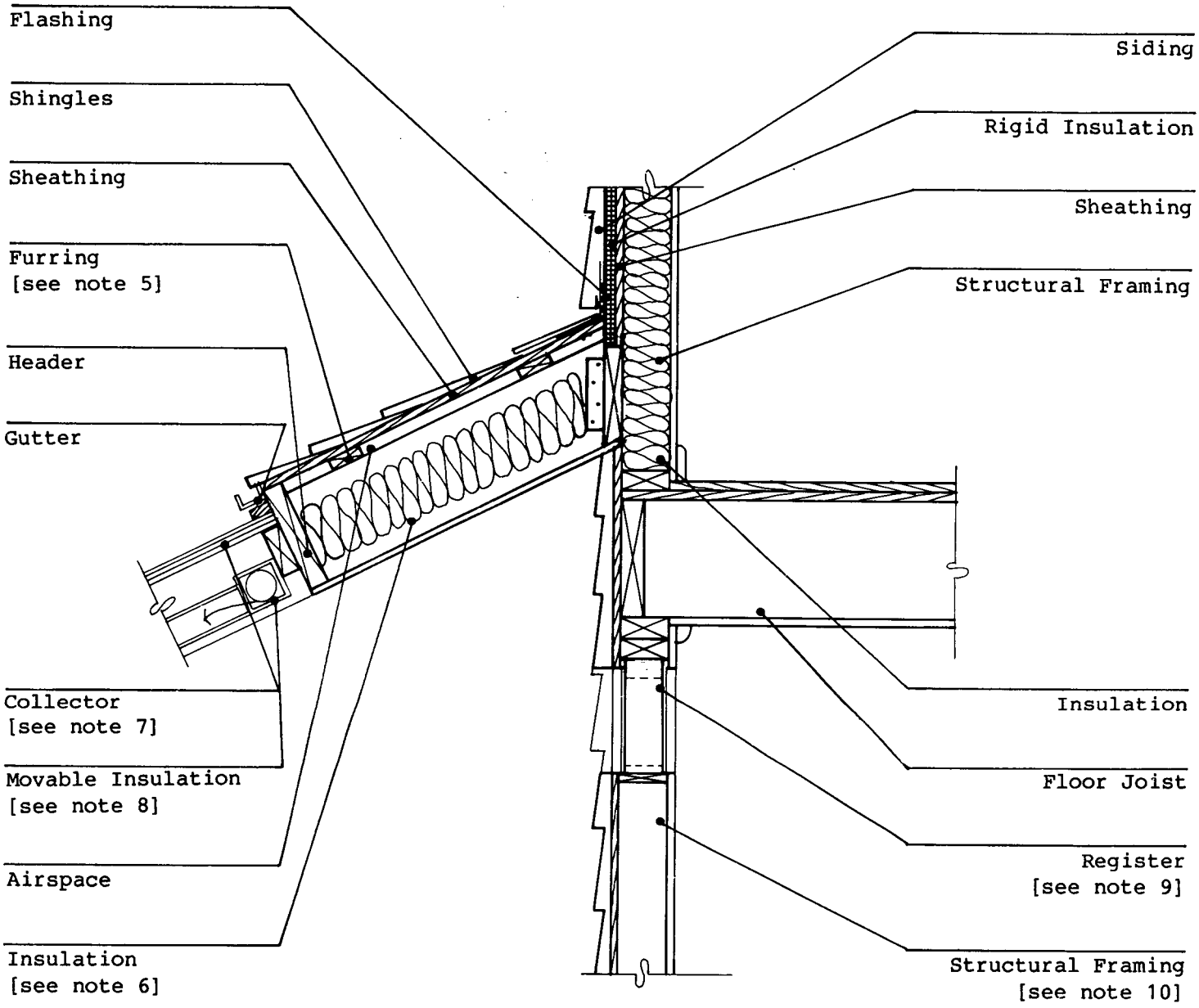
[11] Movable insulation should be provided to improve thermal performance. A movable insulating curtain, suspended from cables, is suitable for Attached Sunspace applications. For further information see Key Page 3.3106.

Attached Sunspace
Site-Built Collector
Frame Wall/Vent

3.3204

Detail





Attached Sunspace
Construction Notes

[1] Sizing of framing members to be determined by weight of glazing material, loading requirements, and desired clear spans. All structural elements must be designed to meet local building codes and/or accepted practice.

[2] High humidity levels in Attached Sunspaces used as working greenhouses may necessitate treating wood framing members with preservative. Avoid preservatives harmful to plants.

[3] Vents to remove excess heat during cooling season should be provided. Roof or gable end vents are suitable. For further information, see Key Page 3.3104.

[4] Insulation levels in walls must meet or exceed requirements of local building/energy codes.

[5] Opaque roof section must be vented to ensure proper performance of insulation. Vents may be located at sides of roof construction. Furring allows air to circulate.

[6] Insulation levels at opaque roof section should meet or exceed requirements of local building/energy codes for roof components.

[7] A variety of materials can be specified for the collector glazing. For further material information see Section 4.1100.

[8] Movable insulation should be provided to improve thermal performance. For further information see Key Page 3.3104.

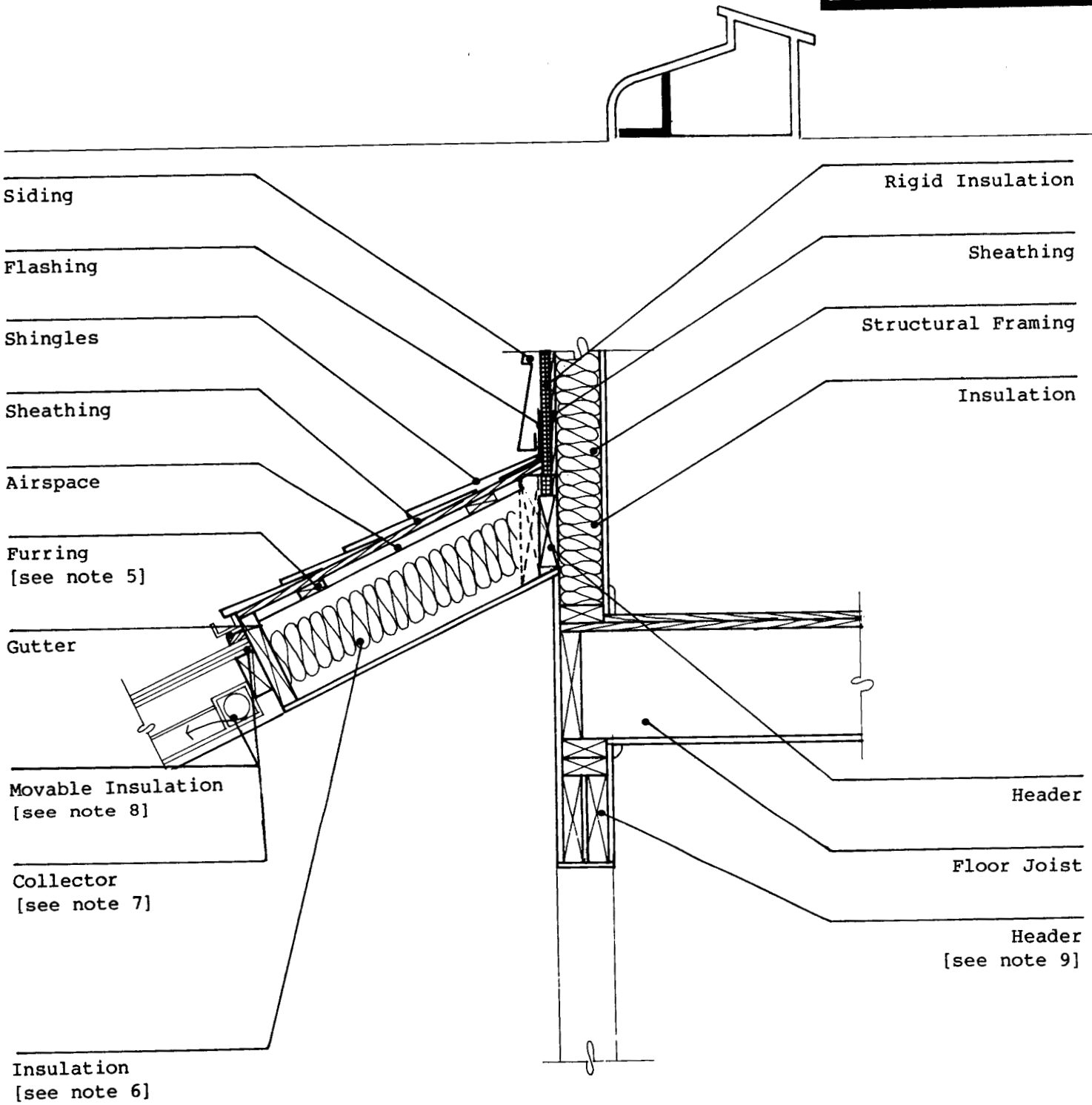
[9] Vents to draw warm air from top of Attached Sunspace into adjacent living area.

[10] Insulation is not required in the structural frame wall separating the Attached Sunspace and living spaces. For further information, see Section 3.3000.

Attached Sunspace
Site-Built Collector
Framed Opening

3.3206

Detail



[1] Sizing of framing members to be determined by weight of glazing material, loading requirements, and desired clear spans. All structural elements must be designed to meet local building codes and/or accepted practice.

[2] High humidity levels in Attached Sunspaces used as working greenhouses may necessitate treating wood framing members with preservative. Avoid preservatives harmful to plants.

[3] Vents to remove excess heat during cooling season should be provided. Roof or gable end vents are suitable. For further information, see Key Page 3.3100.

[4] Insulation levels in walls must meet or exceed requirements of local building/energy codes.

[5] Opaque roof section must be vented to ensure proper performance of insulation. Vents may be located at sides of roof construction. Furring allows air to circulate.

[6] Insulation levels at opaque roof section should meet or exceed requirements of local building/energy codes for roof components.

[7] A variety of materials can be specified for the collector glazing. For further material information see Section 4.1100.

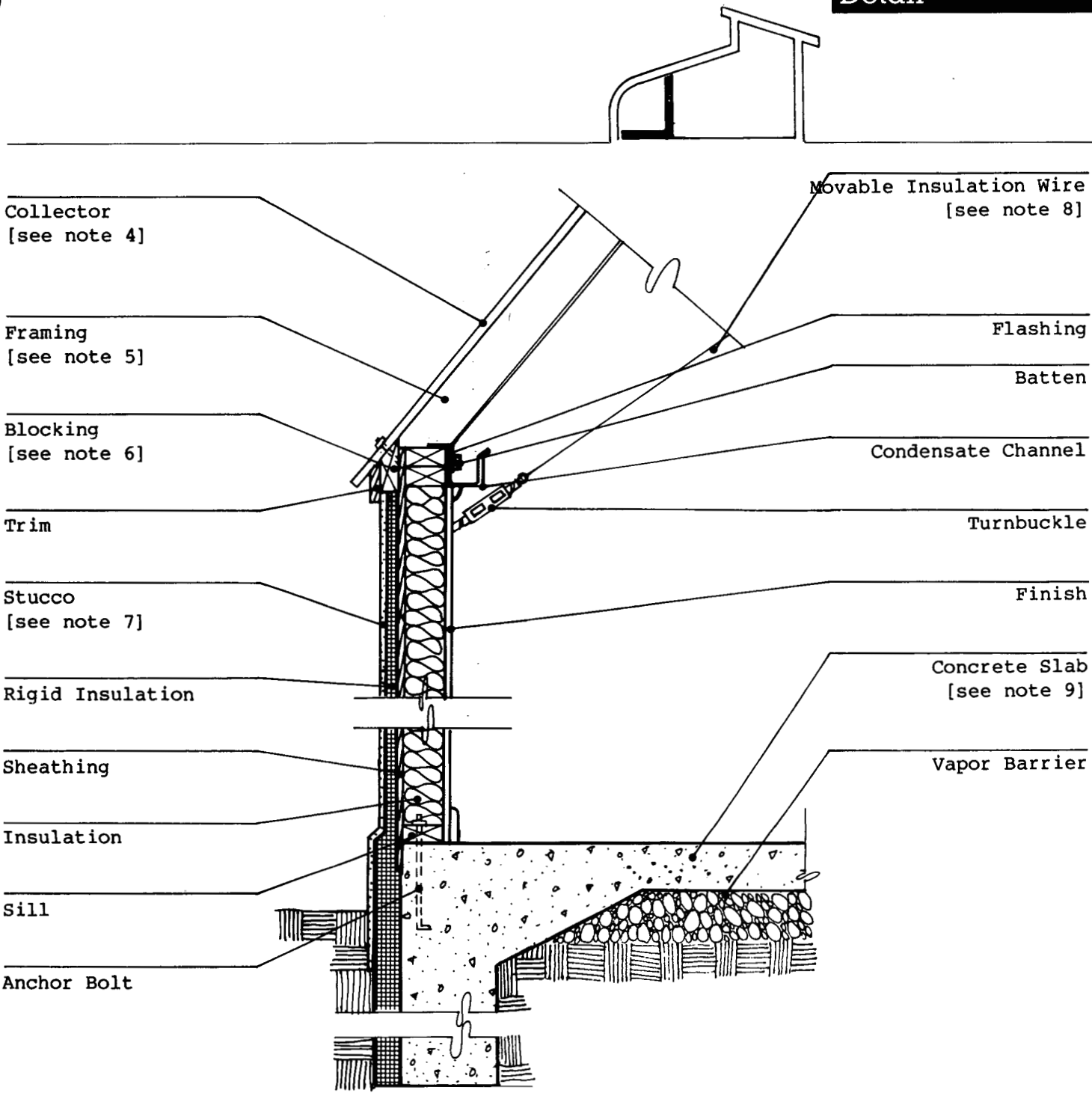
[8] Movable insulation should be provided to improve thermal performance. For further information see Key Page 3.3100

[9] Sunspace and adjacent living areas open directly to each other for natural direct air exchange between the two spaces. Headers over opening to be designed for loading and clear span per local building codes and/or accepted practice. For further information see Section 3.3000.

Attached Sunspace
Site-Built Collector
Frame Front Wall

3.3208

Detail



Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.

[2] Provide adequate drainage in Attached Sunspace floor, particularly where extensive planting is planned.

[3] High humidity levels in Attached Sunspaces used as working greenhouses may necessitate treating wood framing members with preservative. Avoid preservatives harmful to plants.

[4] A variety of materials can be specified for the collector glazing. For further material information see Section 4.1100.

[5] Sizing of framing members to be determined by weight of glazing material, loading requirements, and desired clear spans. All structural elements must be designed to meet local building codes and/or accepted practice.

[6] If corrugated plastic glazing is specified provide continuous blocking cut to conform to the corrugations.

[7] Cement plaster (stucco) finish applied on wire lath over exterior insulation. Other finishes may be specified at builder's option, but rigid insulation must be protected where exposed above grade. Consult insulation manufacturer for recommended installation procedures.

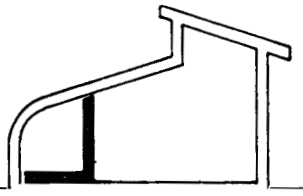
[8] Movable insulation should be provided to improve thermal performance. A movable insulating curtain, suspended from cables, is suitable for Attached Sunspace applications. For further information see Section 3.3000.

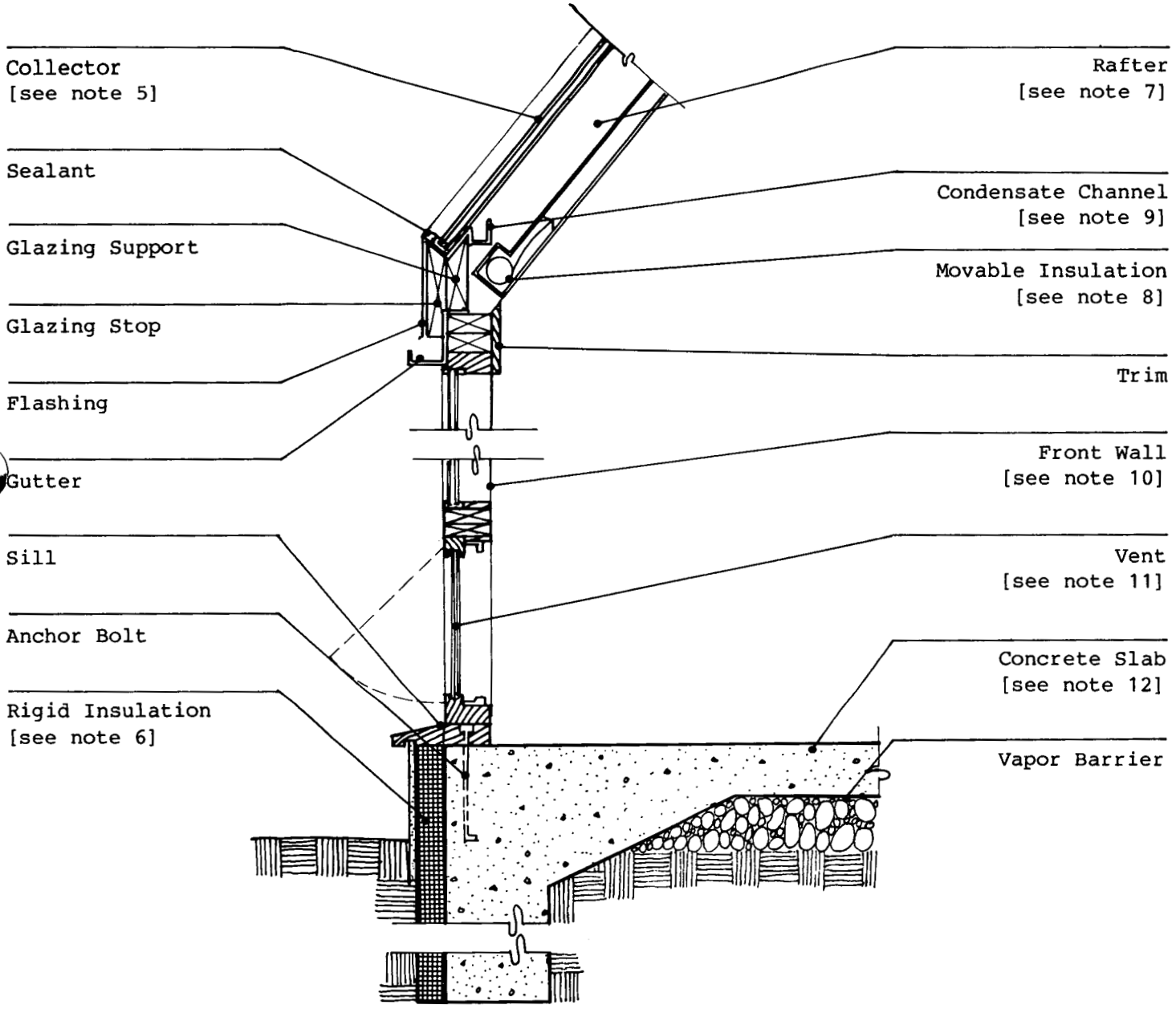
[9] Concrete slab-on-grade used as Storage component in Attached Sunspace. Alternate Storage floor materials may be specified at builder's option. For further information, including recommended construction techniques, see Key Page 3.1170 and following.

Attached Sunspace
Site-Built Collector
Glazed Front Wall

3.3210

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.

[2] Insulation levels must meet or exceed local building/energy code requirements for foundation insulation.

[3] High humidity levels in Attached Sunspaces used as working greenhouses may necessitate treating wood framing members with preservative. Avoid preservatives harmful to plants.

[4] Provide adequate drainage in Attached Sunspace floor, particularly where extensive planting is planned.

[5] A variety of materials can be specified for the collector glazing. For further material information see Section 4.1100.

[6] Cement plaster (stucco) finish applied on wire lath over exterior insulation. Other finish may be specified at builder's option, but rigid insulation must be protected where exposed above grade. Consult insulation manufacturer for recommended installation procedures.

[7] Sizing of framing members to be determined by weight of glazing material, loading requirements, and desired clear spans. All structural elements must be designed to meet local building codes and/or accepted practice.

[8] Movable insulation should be provided to improve thermal performance. For further information see Section 3.3000.

[9] Condensate channel formed by turning up metal flashing.

[10] Structure and height of Attached Sunspace front wall may vary depending upon design and use. Wall may be glazed or insulated opaque frame wall.

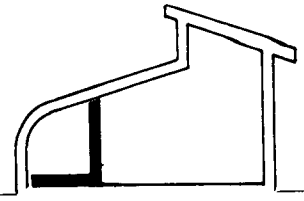
[11] Operable glazed unit serves as vent during the cooling season. For further information, see Key Pages 3.3100 through 3.3106.

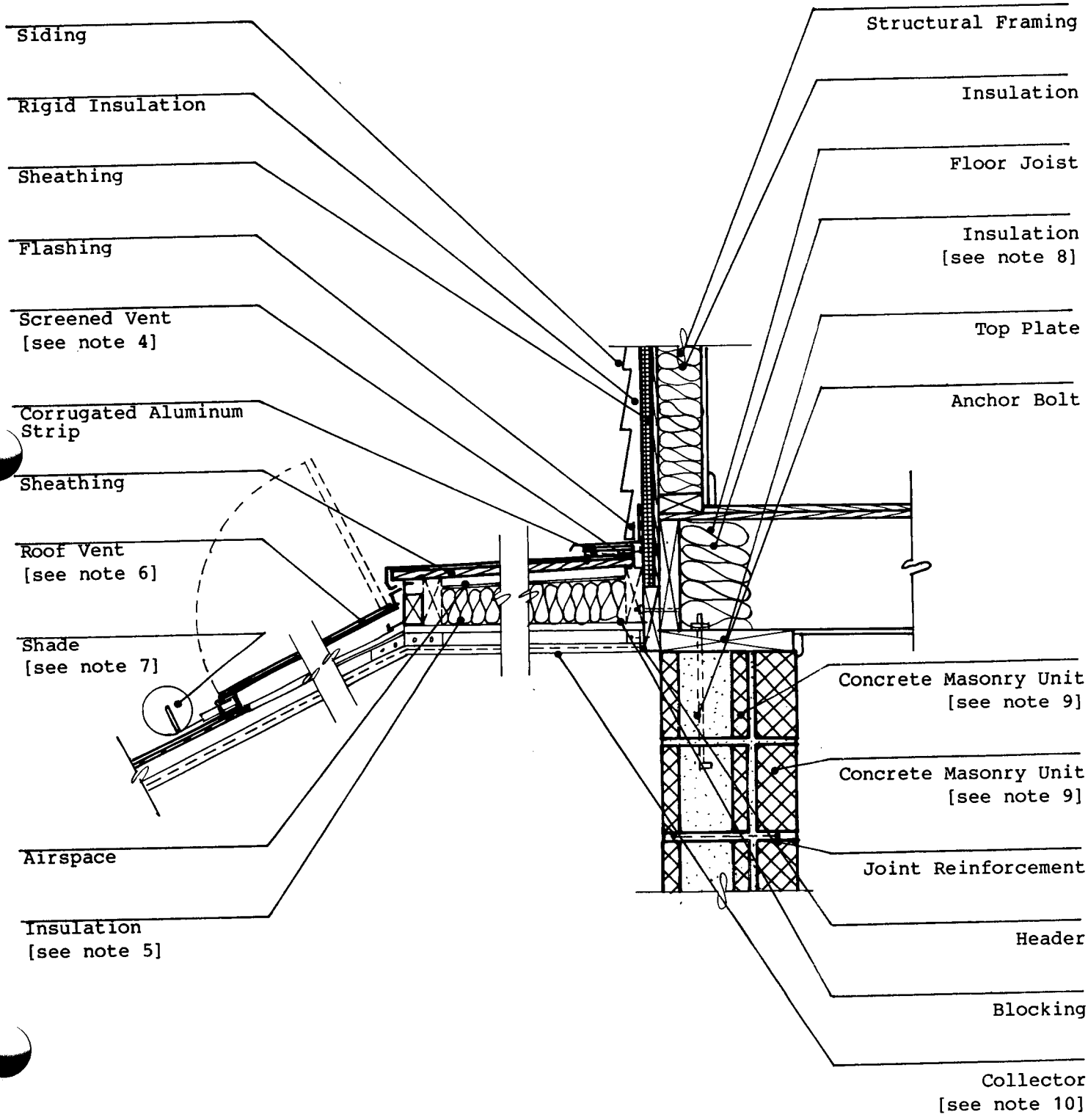
[12] Concrete slab-on-grade used as Storage component in Attached Sunspace. Alternate Storage floor materials may be specified at builder's option. For further information, including recommended construction techniques, see Key Page 3.1170 and following.

Attached Sunspace
Prefabricated Collector
CMU Storage Wall

3.3212

Detail



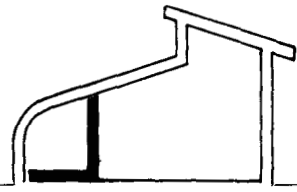


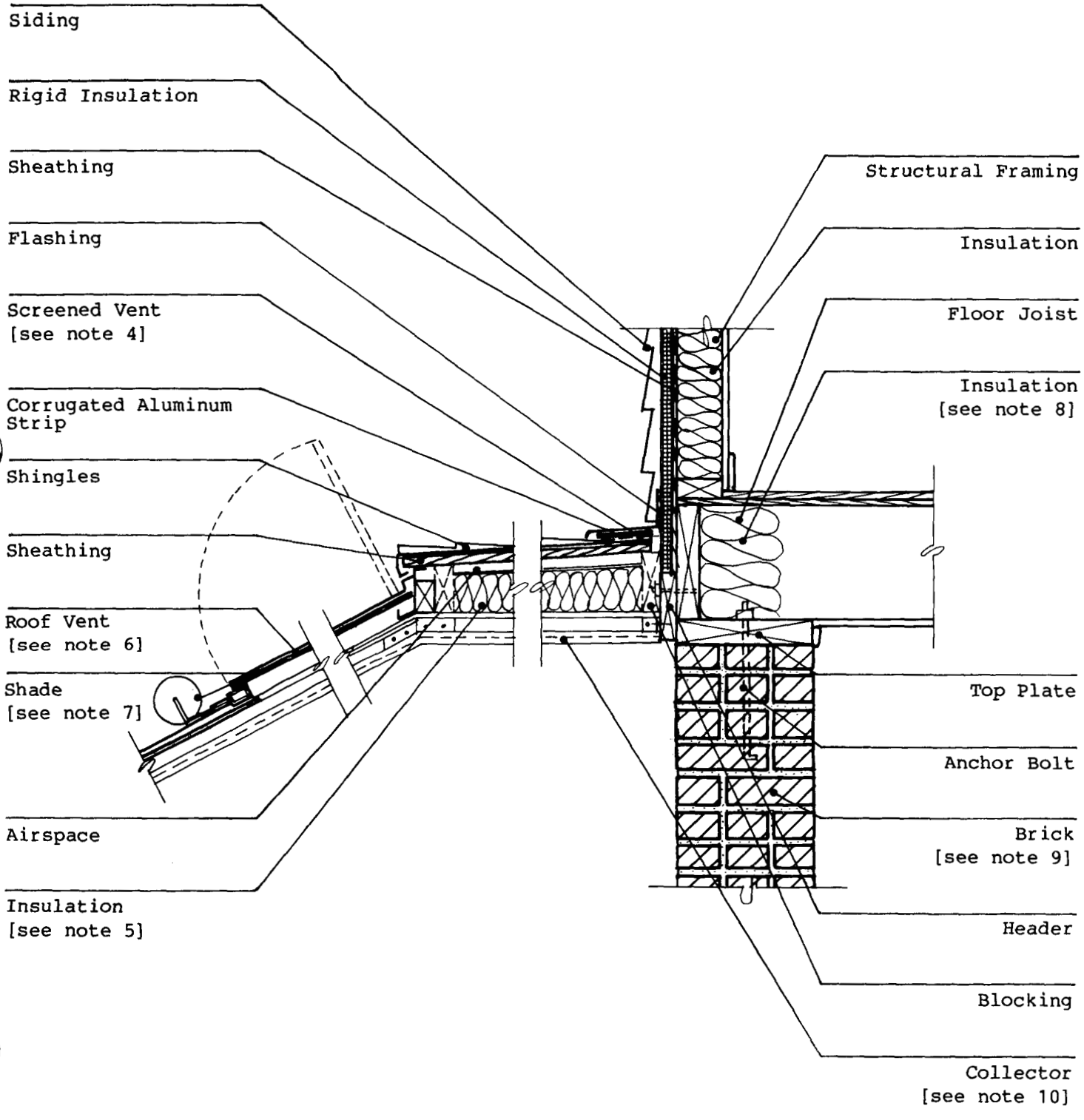
[1] Placement of reinforcing and anchor bolts to be determined by local building codes and/or accepted practice.
[2] Framing members and structural connections at main house to be designed to greenhouse manufacturer's specifications, local building codes and/or accepted practice.
[3] High humidity levels in Attached Sunspaces used as working greenhouses may necessitate treating wood framing members with preservative. Avoid preservatives harmful to plants.
[4] Opaque roof section must be vented to ensure proper performance of insulation.
[5] Insulation levels at opaque roof section should meet or exceed requirements of local building/energy codes for roof components.
[6] Attached Sunspace should be vented to the outside during cooling season. Some greenhouse manufacturers provide roof vents. Side vents are also available and are suitable. Consult manufacturer for specific information.
[7] Exterior roll-down shades are generally recommended for sun control. For further information see Key Page 3.3106.
[8] Provide insulation at edge joist.
[9] Alternate storage wall materials can be specified at the builders' option. For further information on Thermal Storage Wall materials and configurations see Key Page 3.2120 and following.
[10] Prefabricated greenhouse used as Attached Sunspace Collector component. For further information, see Section 4.1100.

Attached Sunspace
Prefabricated Collector
Brick Storage Wall

3.3214

Detail





Construction Notes

[1] Placement of reinforcing and anchor bolts to be determined by local building codes and/or accepted practice.

[2] Framing members and structural connections at main house to be designed to greenhouse manufacturer's specifications, local building codes and/or accepted practice.

[3] High humidity levels in Attached Sunspaces used as working greenhouses may necessitate treating wood framing members with preservative. Avoid preservatives harmful to plants.

[4] Opaque roof section must be vented to ensure proper performance of insulation.

[5] Insulation levels at opaque roof section should meet or exceed requirements of local building/energy codes for roof components.

[6] Attached Sunspace should be vented to the outside during cooling season. Some greenhouse manufacturers provide roof vents. Side vents are also available and are suitable. Consult manufacturer for specific information.

[7] Exterior roll-down shades are generally recommended for sun control. For further information see Key Page 3.3106.

[8] Provide insulation at edge joist.

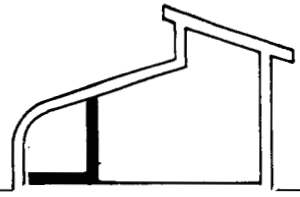
[9] Alternate storage wall materials can be specified at the builders' option. For further information on Thermal Storage Wall materials and configurations see Key Page 3.2128 and following.

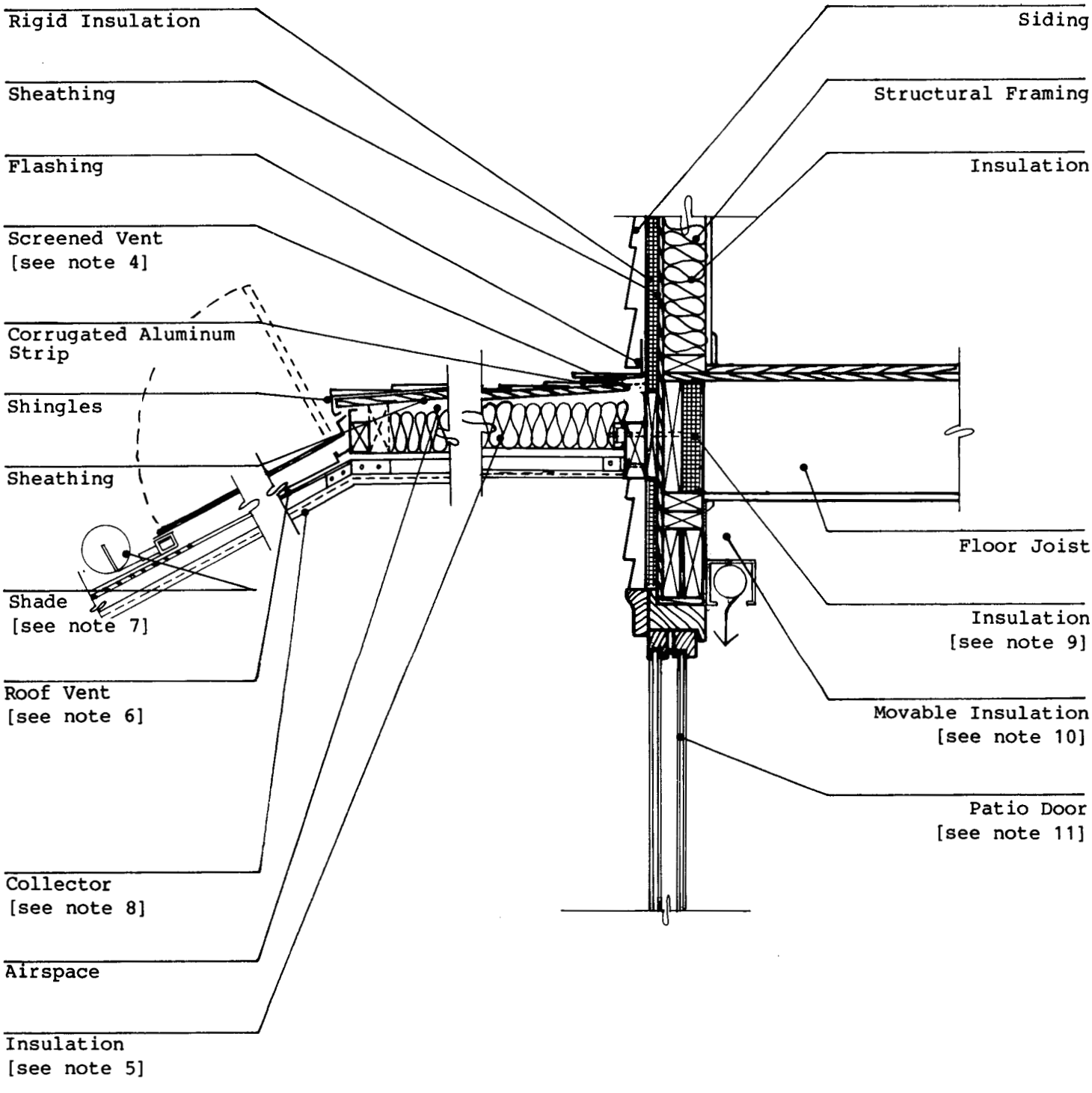
[10] Prefabricated greenhouse used as Attached Sunspace Collector component. For further information, see Section 4.1100.

Attached Sunspace
Prefabricated Collector Frame Wall/Patio Door

3.3216

Detail





[1] Framing members and structural connections at main house to be designed to greenhouse manufacturer's specifications, local building codes and/or accepted practice.

[2] High humidity levels in Attached Sunspaces used as working greenhouses may necessitate treating wood framing members with preservative. Avoid preservatives harmful to plants.

[3] Insulation levels in walls must meet or exceed requirements of local building/energy codes.

[4] Opaque roof section must be vented to ensure proper performance of insulation.

[5] Insulation levels at opaque roof section should meet or exceed requirements of local building/energy codes for roof components.

[6] Attached Sunspace should be vented to the outside during cooling season. Some greenhouse manufacturers provide roof vents. Side vents are also available and are suitable. Consult manufacturer for specific information.

[7] Exterior roll-down shades are generally recommended for sun control. For further information see Key Page 3.3102.

[8] Prefabricated greenhouse used as Attached Sunspace Collector component. For further information on this and other Collector systems, see Section 4.1100.

[9] Provide insulation at edge joist.

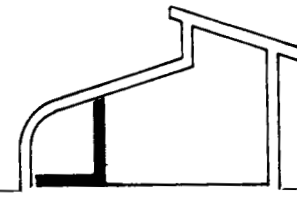
[10] Movable insulation should be provided to improve thermal performance. For further information see Key Page 3.3102.

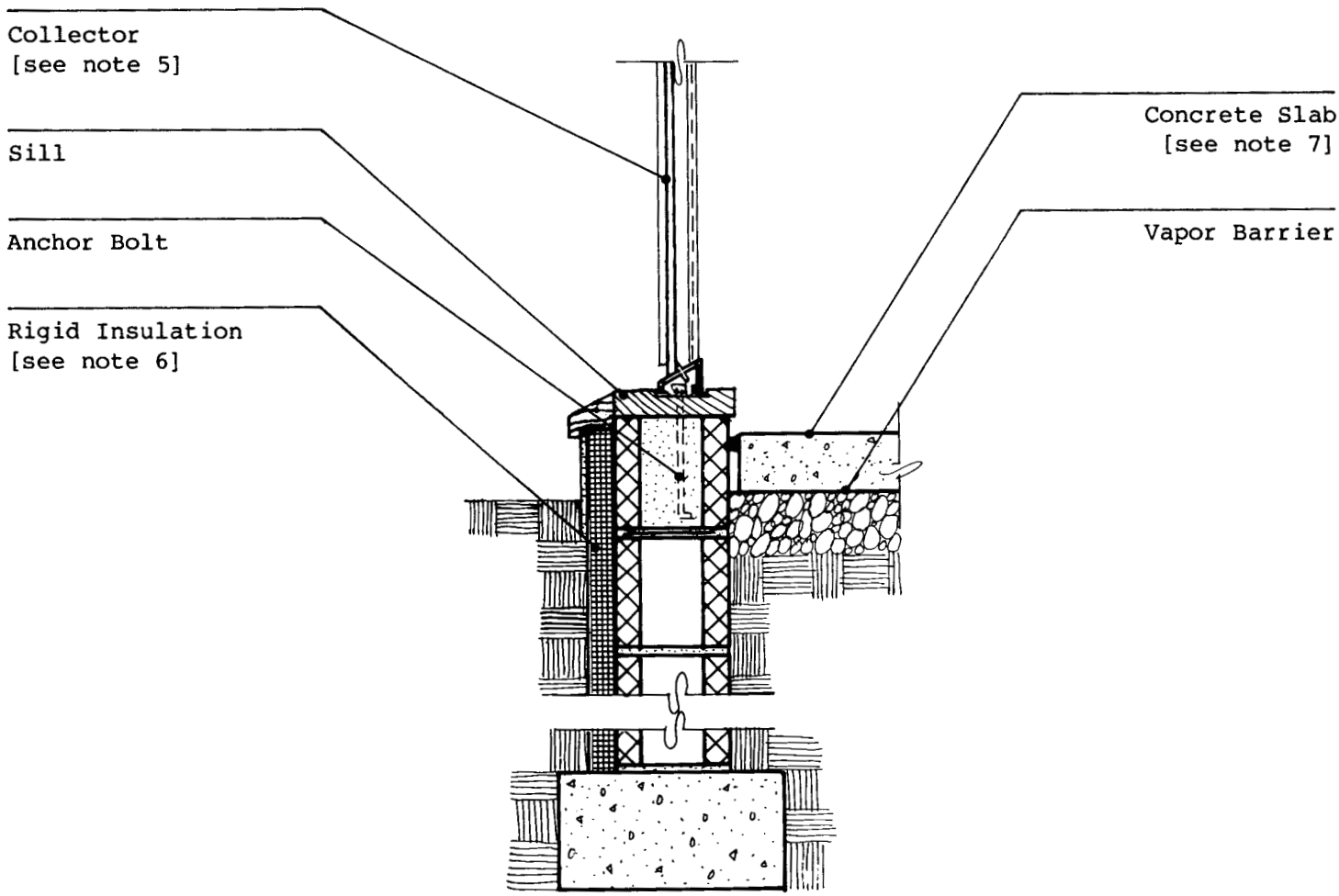
[11] Patio door at adjacent living space may be single or double glazed. Installation per manufacturer's specification. For further information,see Key Page 3.3102.

Attached Sunspace
Prefabricated Collector
Sill At Grade

3.3218

Detail



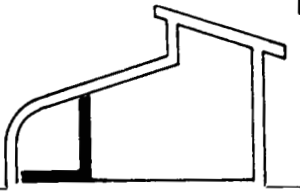


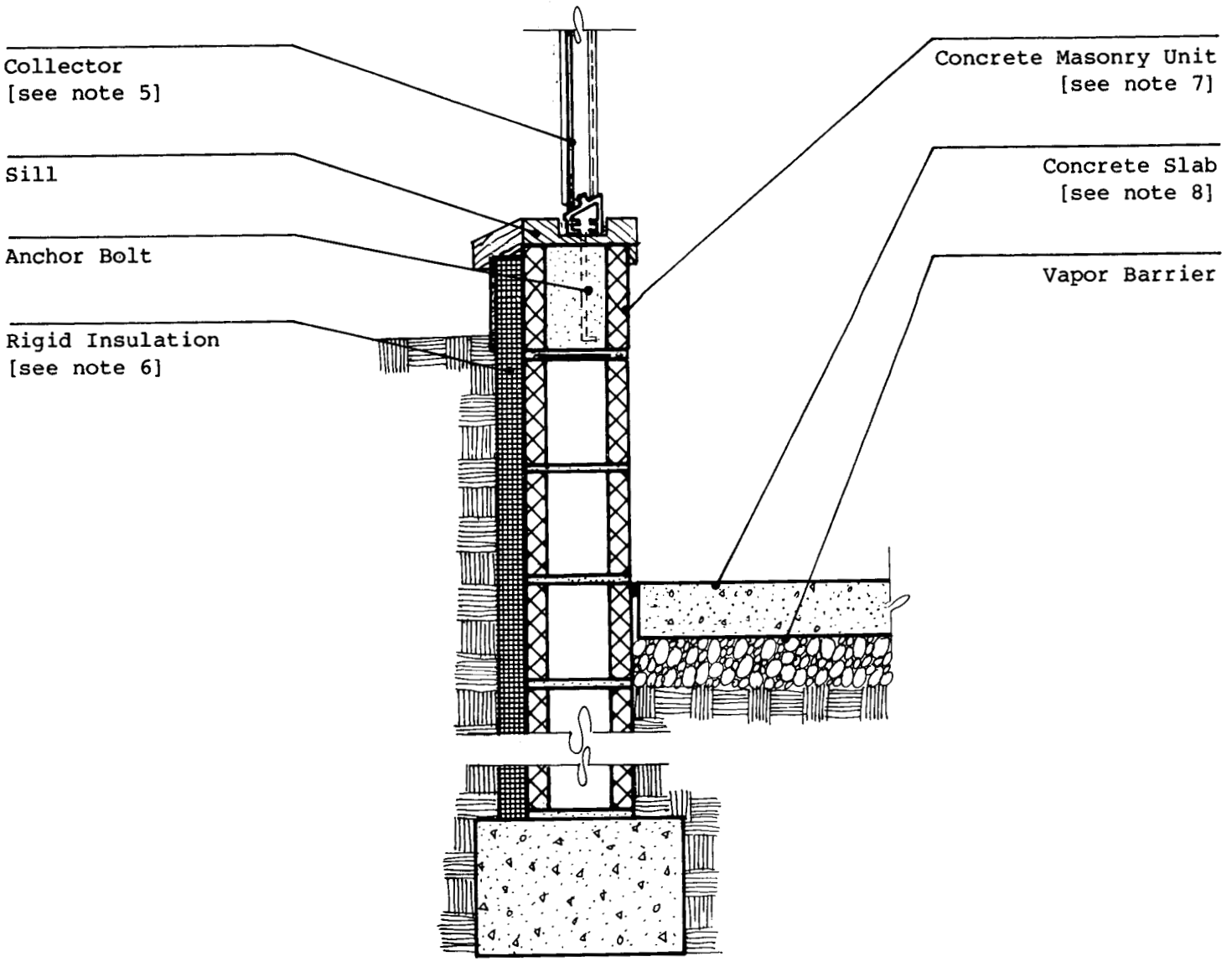
[1] Footing and foundation size, reinforcing, and depth below grade per manufacturer's specifications, site conditions and/or local building code requirements.
[2] Insulation levels must meet or exceed local building/energy code requirements for foundation insulation.
[3] Connection at sill to be per manufacturer's specifications, local building codes and/or accepted practice.
[4] Provide adequate drainage in Attached Sunspace floor, particularly where extensive planting is planned.
[5] Prefabricated greenhouse used as Attached Sunspace Collector component. For further information see Section 4.1100.
[6] Cement plaster (stucco) finish applied on wire lath over exterior insulation. Other finish may be specified at builder's option, but rigid insulation must be protected where exposed above grade. Consult insulation manufacturer for recommended installation procedures.
[7] Concrete slab-on-grade used as Storage component in Attached Sunspace. Alternate Storage floor materials may be specified at builder's option. For further information, including recommended construction techniques, see Key Page 3.1170 and following.

Attached Sunspace
Prefabricated Collector
Sill At Grade/"Pit" Sunspace

3.3220

Detail



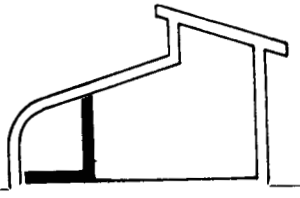


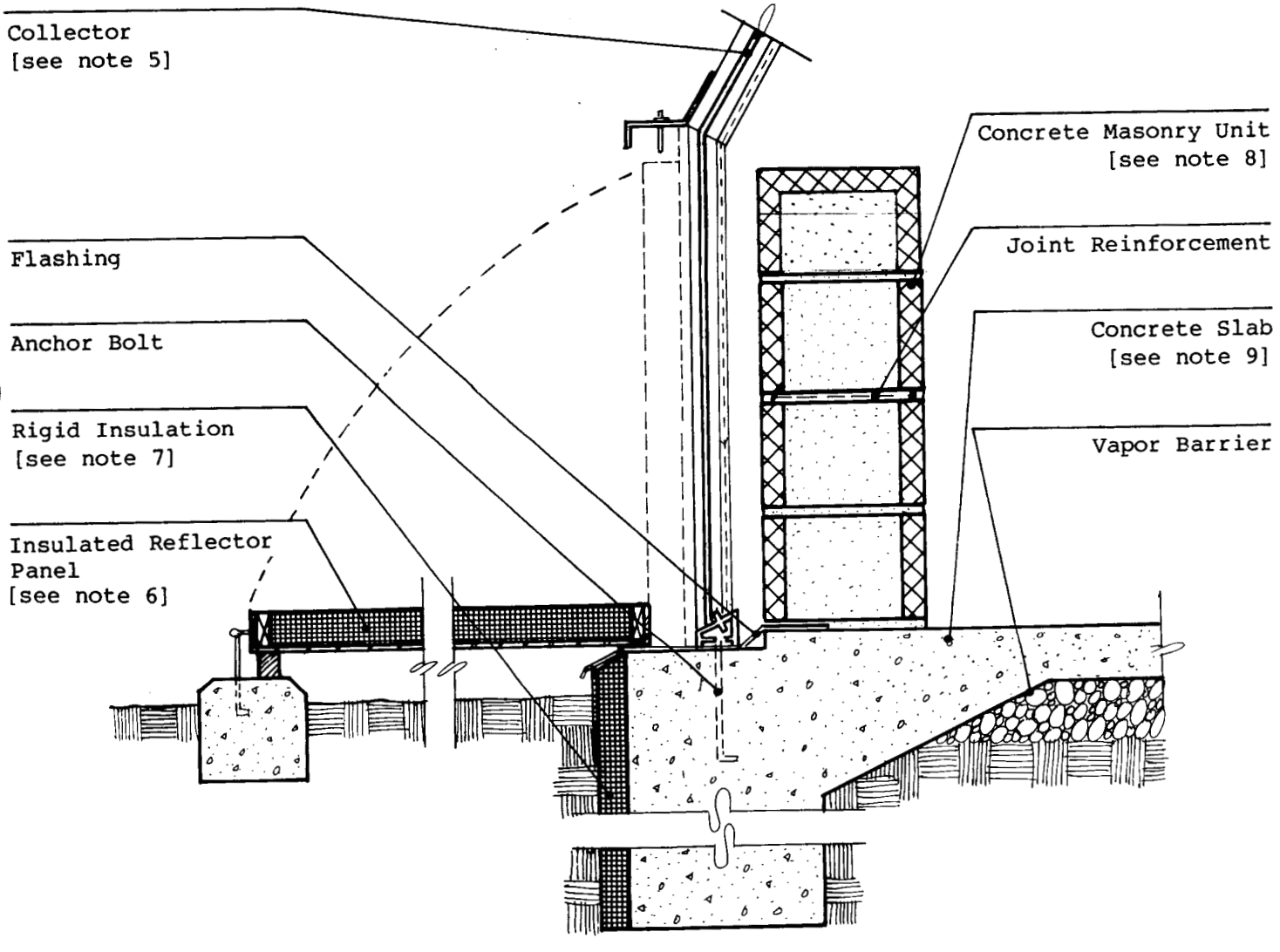
[1] Footing and foundation size, reinforcing, and depth below grade per manufacturer's specifications, site conditions and/or local building code requirements.
[2] Insulation levels must meet or exceed local building/energy code requirements for foundation insulation.
[3] Connection at sill to be per manufacturer's specifications, local building codes and/or accepted practice.
[4] Provide adequate drainage in Attached Sunspace floor, particularly where extensive planting is planned.
[5] Prefabricated greenhouse used as Attached Sunspace Collector component. For further information, see Section 4.1100.
[6] Cement plaster (stucco) finish applied on wire lath over exterior insulation. Other finishes may be specified at builder's option, but rigid insulation must be protected where exposed above grade. Consult insulation manufacturer for recommended installation procedures.
[7] Wall of "Pit" Attached Sunspace must be designed to resist lateral earth pressure. Reinforcing, thickness, provisions for weep holes, longitudinal drains and waterproofing to be determined by site conditions, local building codes and/or accepted practice.
[8] Concrete slab-on-grade used as Storage component in Attached Sunspace. Alternate Storage floor materials may be specified at builder's option. For further information, including recommended construction techniques, see Key Page 3.1170 and following.

Attached Sunspace
Prefabricated Collector
Sill At Grade/Mass Wall

3.3222

Detail



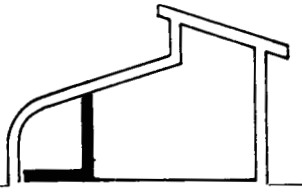


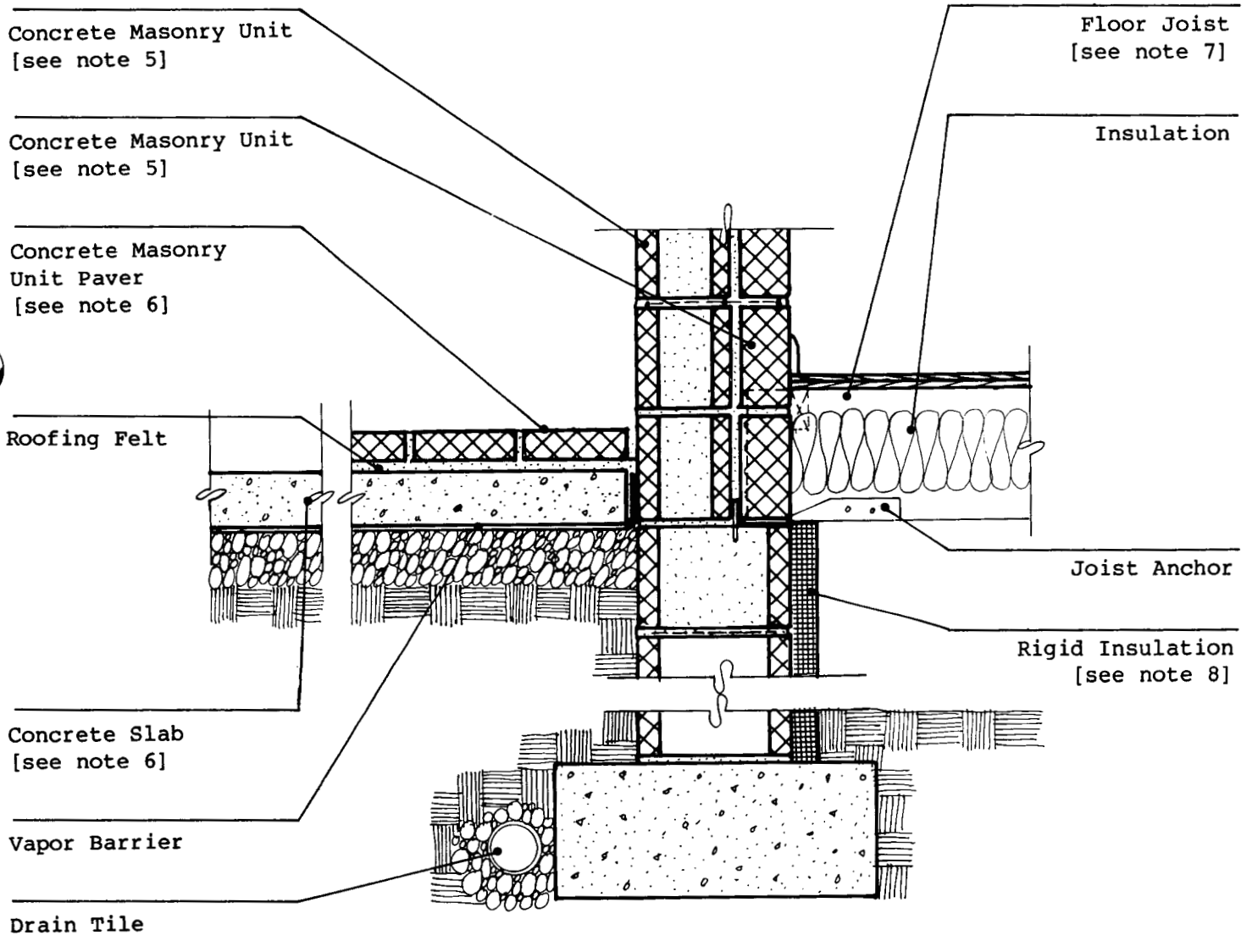
[1] Footing and foundation size, reinforcing, and depth below grade per manufacturer's specifications, site conditions and/or local building code requirements.
[2] Insulation levels must meet or exceed local building/energy code requirements for foundation insulation.
[3] Connection at sill to be per manufacturer's specifications, local building codes and/or accepted practice.
[4] Provide adequate drainage in Attached Sunspace floor, particularly where extensive planting is planned.
[5] Prefabricated greenhouse used as Attached Sunspace Collector component. For further information, see Section 4.1100.
[6] Exterior insulated panel. In closed position, panel serves to improve the thermal performance of the Sunspace system. In the open position shown, panel with reflective surface will enhance solar gain at Collector. Reflected light can be of high intensity and should be directed onto Storage mass.
[7] Cement plaster (stucco) finish applied on wire lath over exterior insulation. Other finishes may be specified at builder's option, but rigid insulation must be protected where exposed above grade. Consult insulation manufacturer for recommended installation procedures.
[8] Masonry half wall used for Storage must be solid or hollow with fully grouted cores. Other configurations can be specifed at builder's option.
[9] Concrete slab-on-grade used as Storage component in Attached Sunspace. Alternate Storage floor materials may be specified at builder's option. For further information, including recommended construction techniques, see Key Page 3.1170 and following.

Attached Sunspace
CMU Storage Wall
CMU Paver/Slab-On-Grade

3.3224

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.

[2] Placement of reinforcing, metal ties and joist anchors to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels at floor must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated.

[4] Provide adequate drainage in Attached Sunspace floor, particularly where extensive planting is planned.

[5] Alternate storage wall materials can be specified at the builders' option. For further information on Thermal Storage Wall materials and configurations see Key Page 3.2120 and following.

[6] For information on floors used as a Storage component, see Key Page 3.1170 and following.

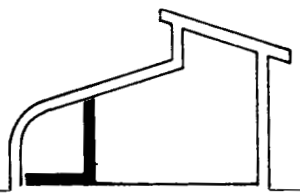
[7] Floor joists must bear on solid masonry not less than 4 inch thick. Fire-cut joists as required.

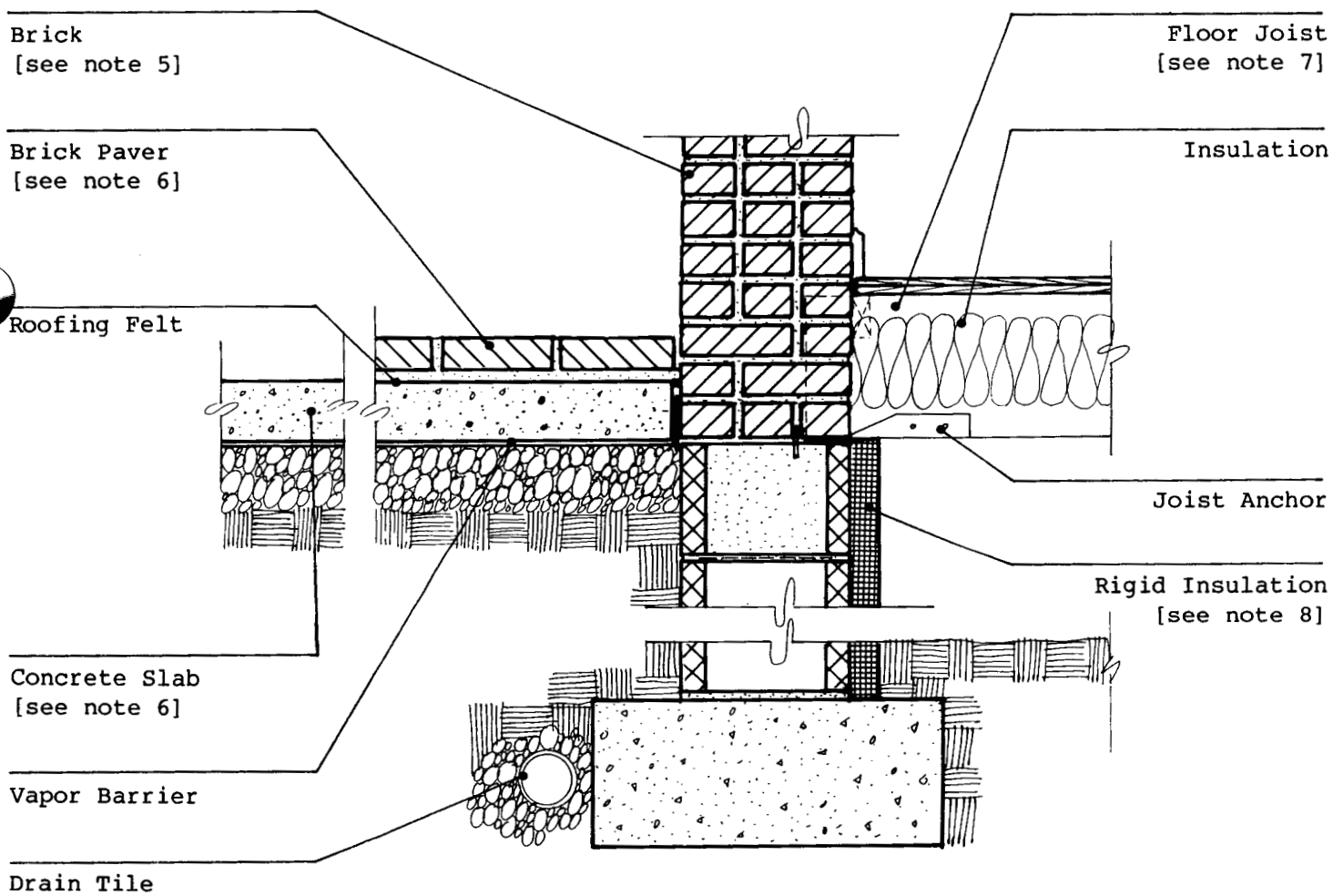
[8] It is recommended that wall at crawl space/unheated basement foundation be insulated to prevent heat losses through wall. Insulation levels should meet or exceed building/energy code requirements for foundation insulation.

Attached Sunspace
Brick Storage Wall
Brick Paver/Slab-On-Grade

3.3226

Detail





[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.

[2] Placement of reinforcing, metal ties and joist anchors to be determined by local building codes and/or accepted practice. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[3] Insulation levels at floor must meet or exceed requirements of local building/energy codes. The storage mass should not be insulated.

[4] Provide adequate drainage in Attached Sunspace floor, particularly where extensive planting is planned.

[5] Alternate storage wall materials can be specified at the builders' option. For further information on Thermal Storage Wall materials and configurations see Key Page 3.2128 and following.

[6] For information on floors used as a Storage component, including recommended construction techniques, see Key Page 3.1170 and following.

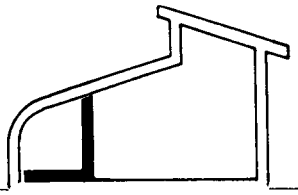
[7] Floor joists must bear on solid masonry not less than 4 inch thick. Fire-cut joists as required.

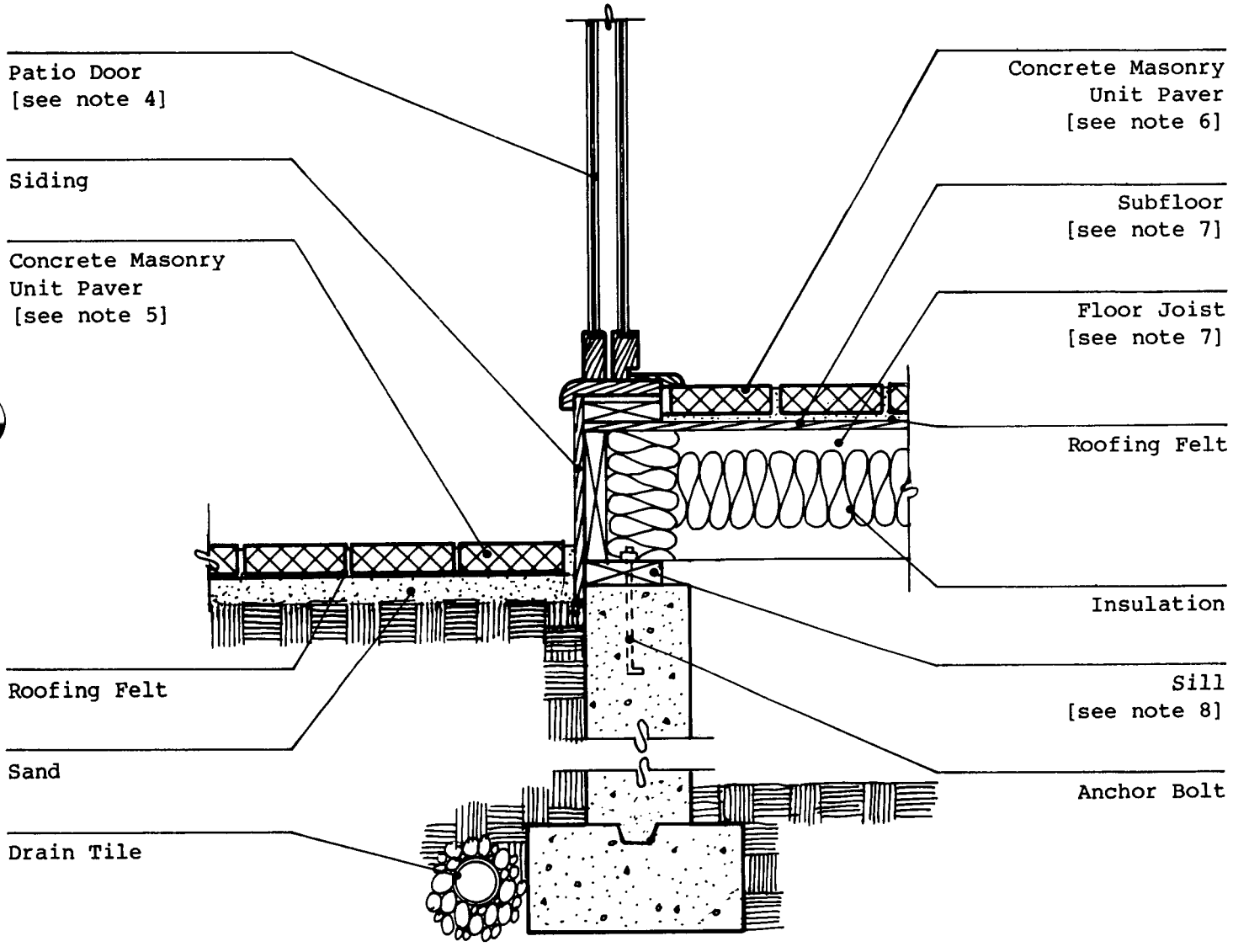
[8] It is recommended that the wall at the crawl space/unheated basement foundation be insulated to prevent heat losses through wall. Insulation levels should meet or exceed building/energy code requirements for foundation insulation.

Attached Sunspace
Frame Wall/Patio Door
CMU Paver On Grade

3.3228

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.

[2] Insulation levels in floors must meet or exceed requirements of local building/energy codes.

[3] Provide adequate drainage in Attached Sunspace floor, particularly where extensive planting is planned.

[4] Patio door at adjacent living space may be single or double glazed. Installation per manufacturer's specification. For further information,see Key Page 3.3102.

[5] For information on floors used as a Storage component, see Key Page 3.1170 and following.

[6] For information on CMU pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1172.

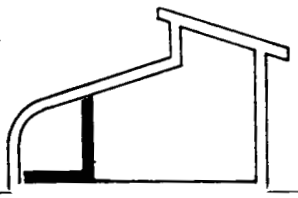
[7] Consideration must be given to the additional weight of pavers. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists; grade and thickness of subfloor. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

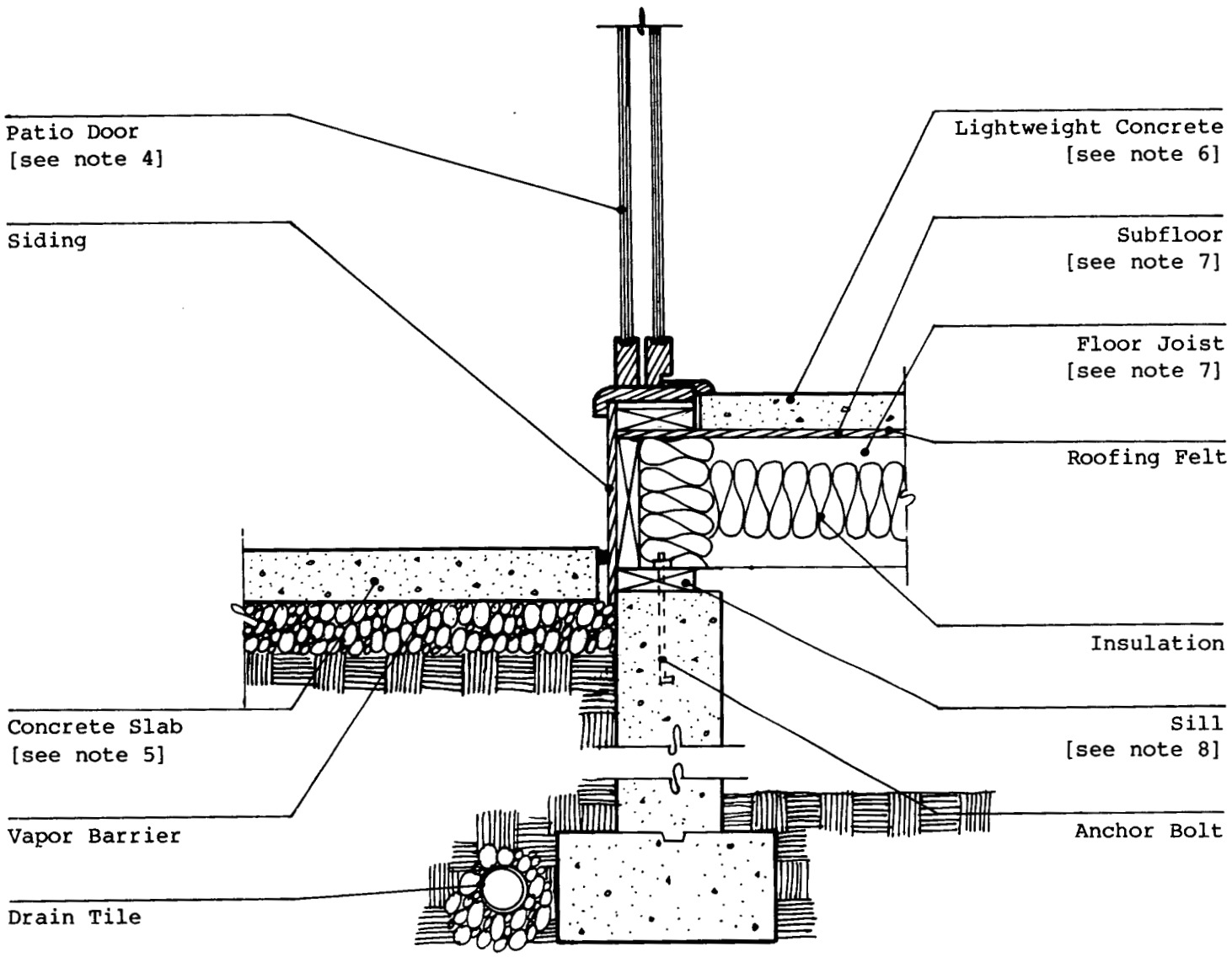
[8] Continuous sill sealer is recommended to provide protection against infiltration.

Attached Sunspace
Frame Wall/Patio Door
Concrete Slab-On-Grade

3.3230

Detail





[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[2] Insulation levels in floors must meet or exceed requirements of local building/energy codes.

[3] Provide adequate drainage in Attached Sunspace floor, particularly where extensive planting is planned.

[4] Patio door at adjacent living space may be single or double glazed. Installation per manufacturer's specification. For further information, see Key Page 3.3102.

[5] Concrete slab-on-grade used as Storage component in Attached Sunspace. Alternate Storage floor materials may be specified at builder's option. For further information, including recommended construction techniques, see Key Page 3.1174.

[6] For information on Concrete used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1176.

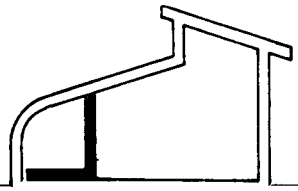
[7] Consideration must be given to the additional weight of Concrete. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists, grade and thickness of subfloor.

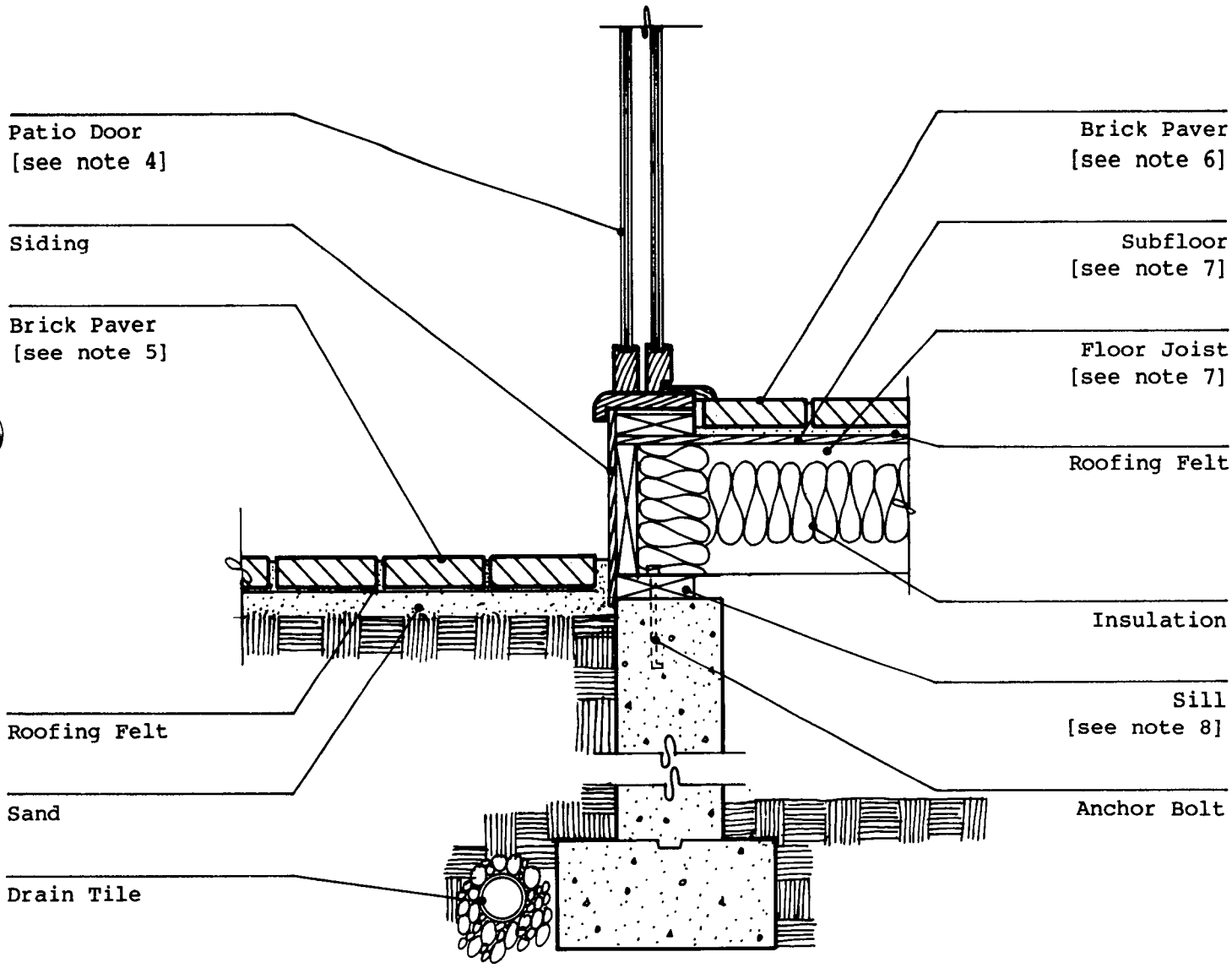
[8] Continuous sill sealer is recommended to provide protection against infiltration.

Attached Sunspace
Frame Wall/Patio Door
Brick Paver On Grade

3.3232

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code.

[2] Insulation levels in floors must meet or exceed requirements of local building/energy codes.

[3] Provide adequate drainage in Attached Sunspace floor, particularly where extensive planting is planned.

[4] Patio door at adjacent living space may be single or double glazed. Installation per manufacturer's specification. For further information, see Key Page 3.3102.

[5] For information on floors used as a Storage component, see Key Page 3.1170 and following.

[6] For information on Brick pavers used for Direct Gain storage, including recommended installation procedures, see Key Page 3.1180.

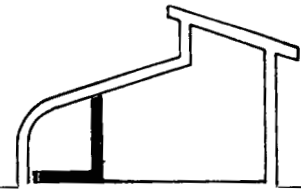
[7] Consideration must be given to the additional weight of pavers. Consult structural design loading tables and local codes to determine suitable grade and spacing of joists, grade and thickness of subfloor. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

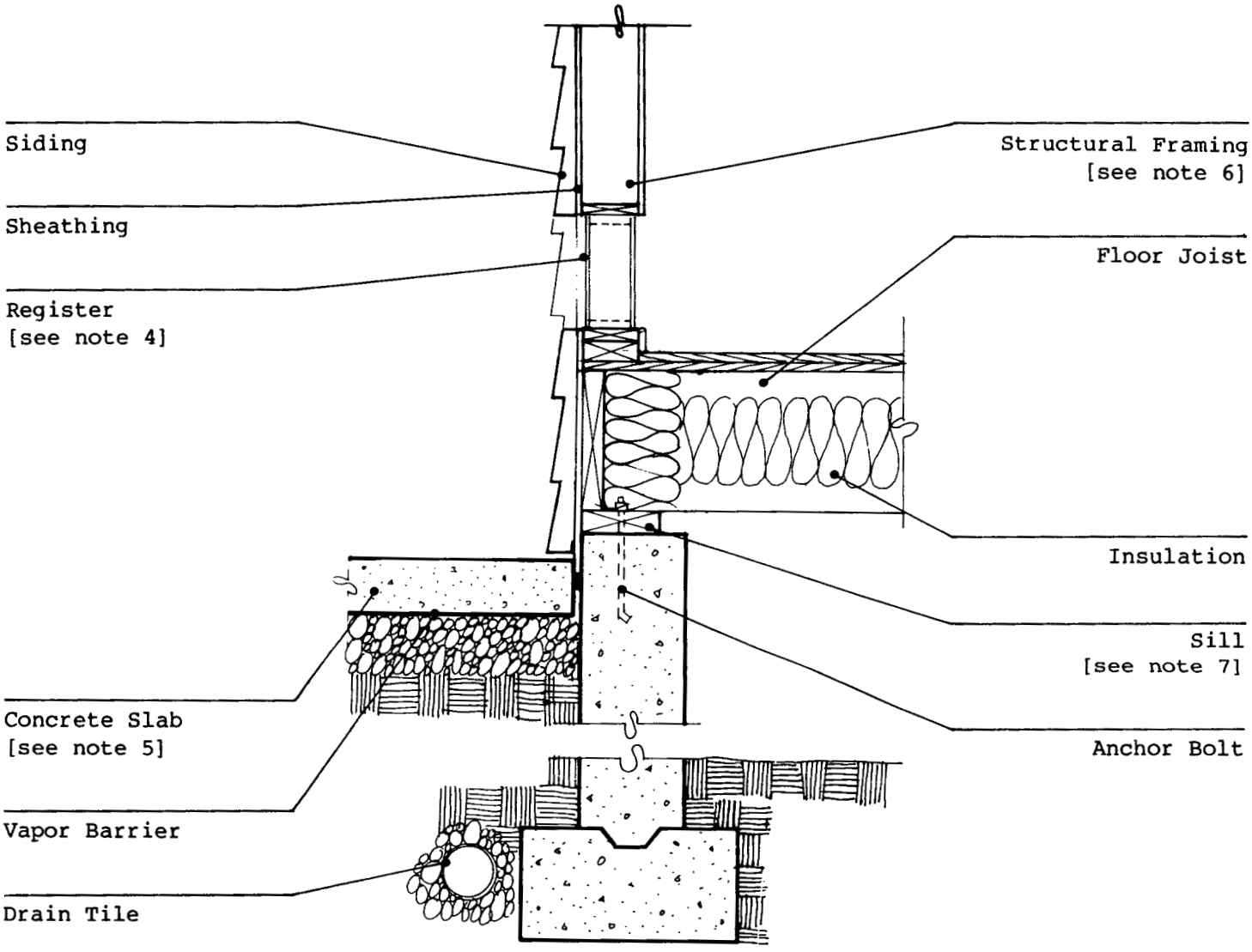
[8] Continuous sill sealer is recommended to provide protection against infiltration.

Attached Sunspace
Frame Wall/Vent
Concrete Slab-On-Grade

3.3234

Detail





Construction Notes

[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[2] Insulation levels in floors must meet or exceed requirements of local building/energy codes.

[3] Provide adequate drainage in Attached Sunspace floor, particularly where extensive planting is planned.

[4] Vent to draw air from adjacent living space into Attached Sunspace.

[5] Concrete slab-on-grade used as Storage component in Attached Sunspace. Alternate Storage floor materials may be specified at builder's option. For further information, including recommended construction techniques, see Key Page 3.1174.

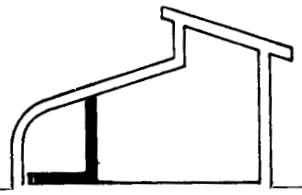
[6] Insulation is not required in structural frame wall separating the Attached Sunspace and the other living spaces. For further information, see Section 3.3000.

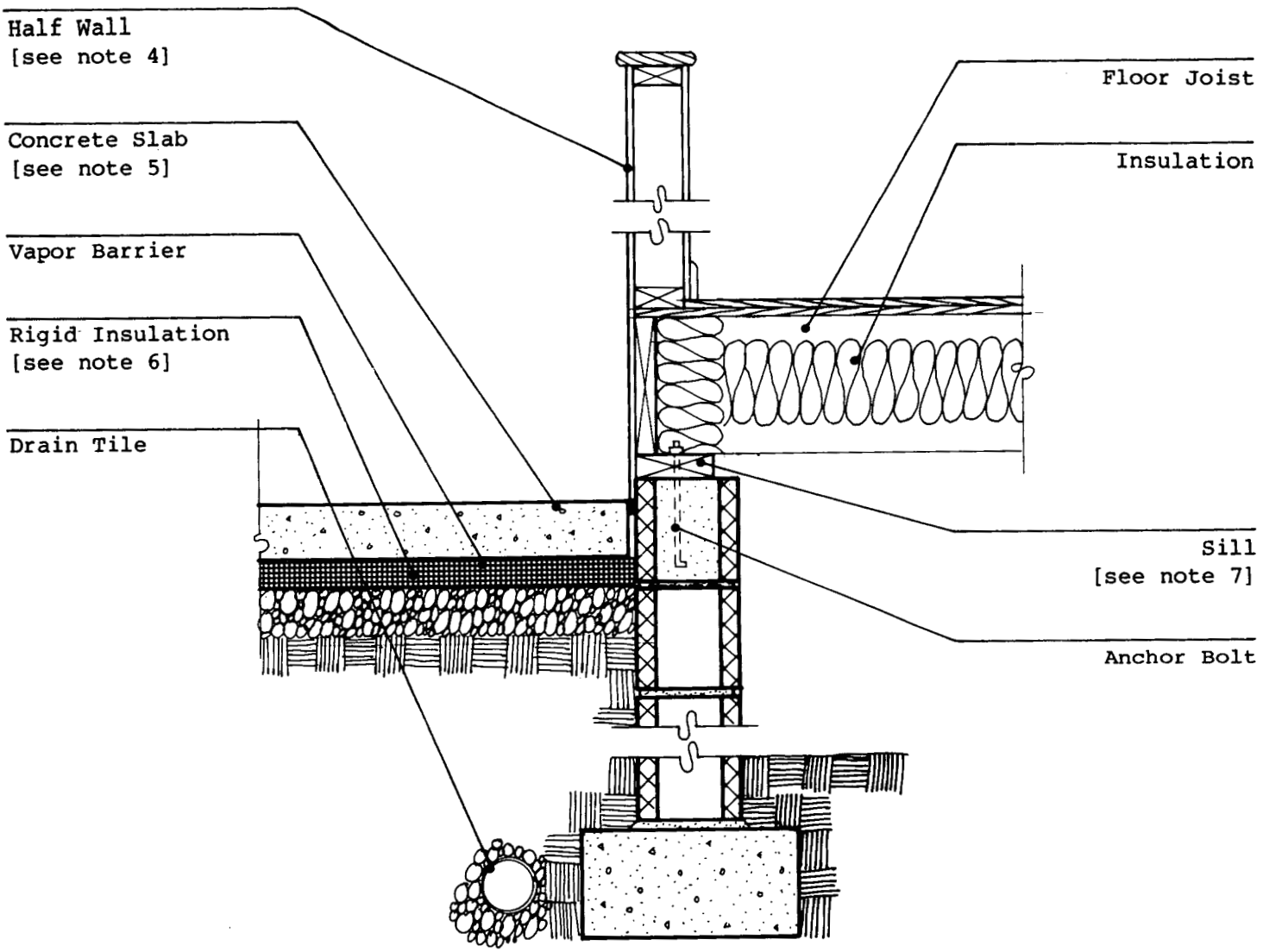
[7] Continuous sill sealer is recommended to provide protection against infiltration.

Attached Sunspace
Framed Opening/Low Wall
Concrete Slab-On-Grade

3.3236

Detail





[1] All footings must bear on undisturbed soil. Adjust footing size, reinforcing and depth below grade as required by site conditions and/or local code. Expansion joints should be provided, as required, at the connection between masonry floors and stud or masonry walls to prevent cracking.

[2] Insulation levels in floors must meet or exceed requirements of local building/energy codes.

[3] Provide adequate drainage in Attached Sunspace floor, particularly where extensive planting is planned.

[4] Sunspace and adjacent living areas open directly to each other for natural direct air exchange. Low wall will not restrict free circulation of air between the two spaces. Consult local codes for structural requirements. For further information see Key Page 3.3100.

[5] Concrete slab-on-grade used as a Storage component in Attached Sunspace. Alternate Storage floor materials may be specified at builder's option. For further information, including recommended construction techniques, see Key Page 3.1174.

[6] Continuous insulation should be provided under the slab in cooler climates. For further information, see Section 3.1000.

[7] Continuous sill sealer is recommended to provide protection against infiltration.

[8] It is recommended that wall at crawl space/unheated basement foundation be insulated to prevent heat losses through wall. Insulation levels should meet or exceed building/energy code requirements for foundation insulation.

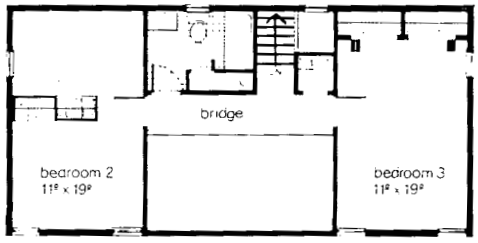
Attached Sunspace
TVA Solar House 5

3.3900

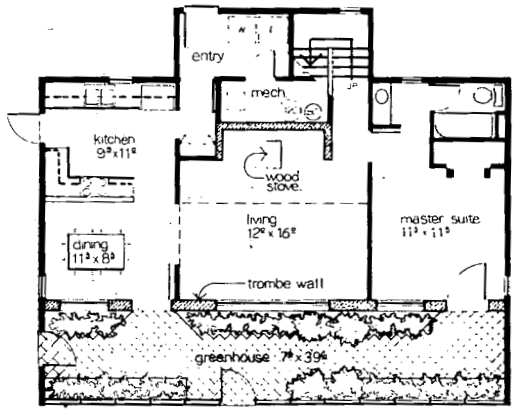
Case Study



The 7'-0" wide Attached Sunspace located along the entire south side adds approximately 300 square feet to this 2-level, 1,550 square foot house designed for a flat or gently sloping site. The main entry is located on the south, through the Sunspace. The Sunspace system uses a mass wall at the adjacent living space to store and transfer heat. Heat is also transmitted directly into living areas through windows located in the mass wall. Summer ventilation is augmented by exhausting heat through the attic.



upper flr. 656 sf



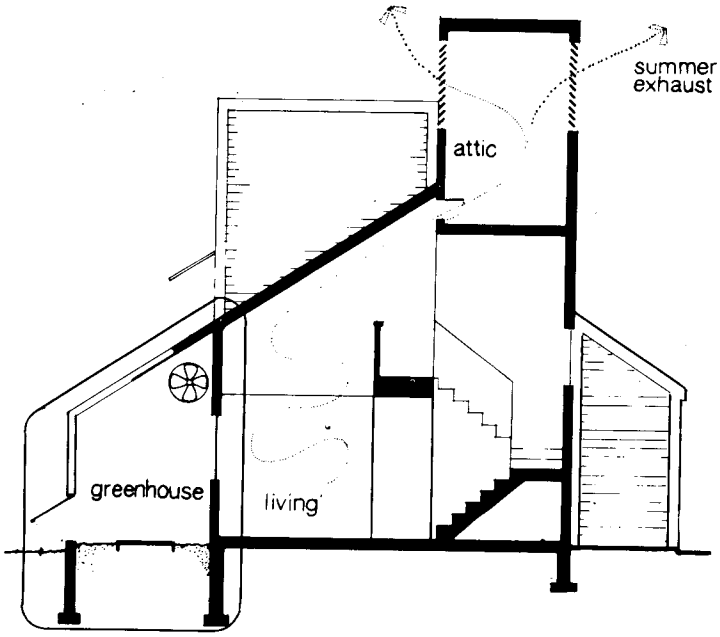
lower flr. = 938 sf
upper level + 656 sf
* w/o garage 1594 sf
greenhouse + 320 sf
1914 sf

north

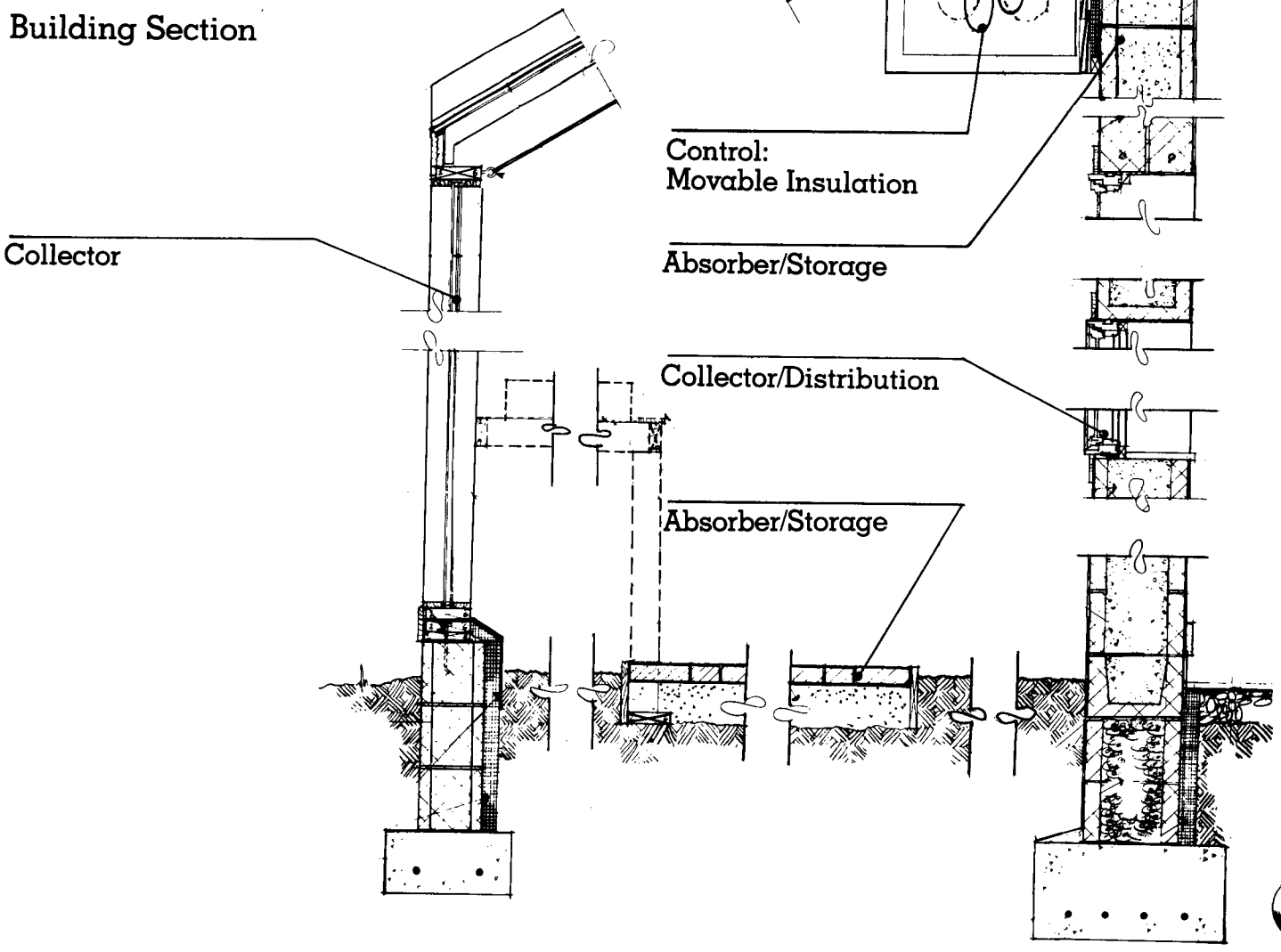
Sponsor

Solar Applications Branch
Architectural Design Branch
Tennessee Valley Authority
Knoxville, Tennessee

These plans and specifications are in the developmental stage. TVA advises that no deviations be made from these plans and specifications. TVA makes no statement, representation, claim or warranty with respect to these plans and specifications. TVA makes no other warranty of any kind whatever, expressed or implied, and all implied warranties of merchantability and fitness for a particular purpose are hereby disclaimed by TVA.



Building Section



Attached Sunspace Detail: Section

Attached Sunspace
PCA Two-Story Solar House

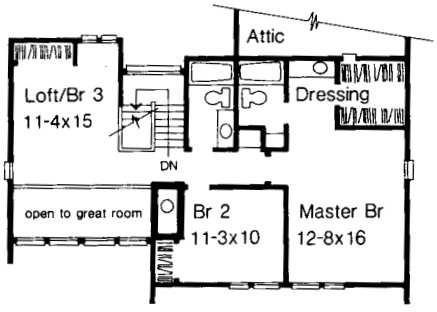
3.3902

Case Study

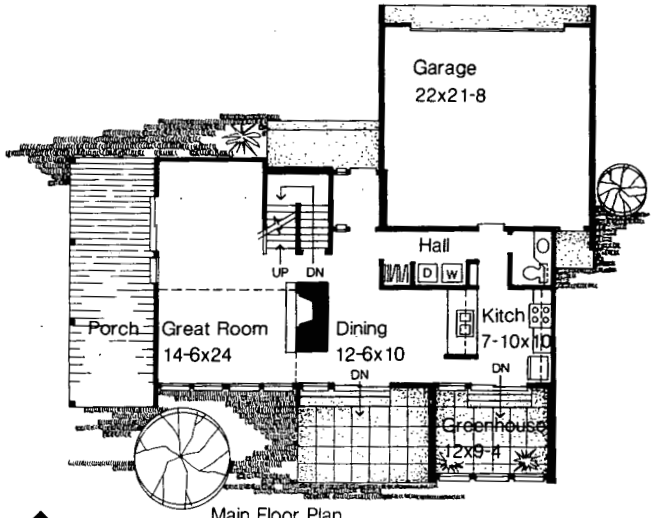


This house is designed to make maximum use of passive solar energy at minimum construction, equipment, and operation costs. Design features such as the double door front entrance vestibule, energy efficient fireplace, and minimum glazing on the north increase the energy efficiency of this home.

Both Direct Gain and Attached Sunspace systems have been incorporated into the design of this 1,800 square foot home which can be adapted to sites throughout the country.



Upper Floor Plan
882 sq.ft.



Main Floor Plan
877 sq.ft.

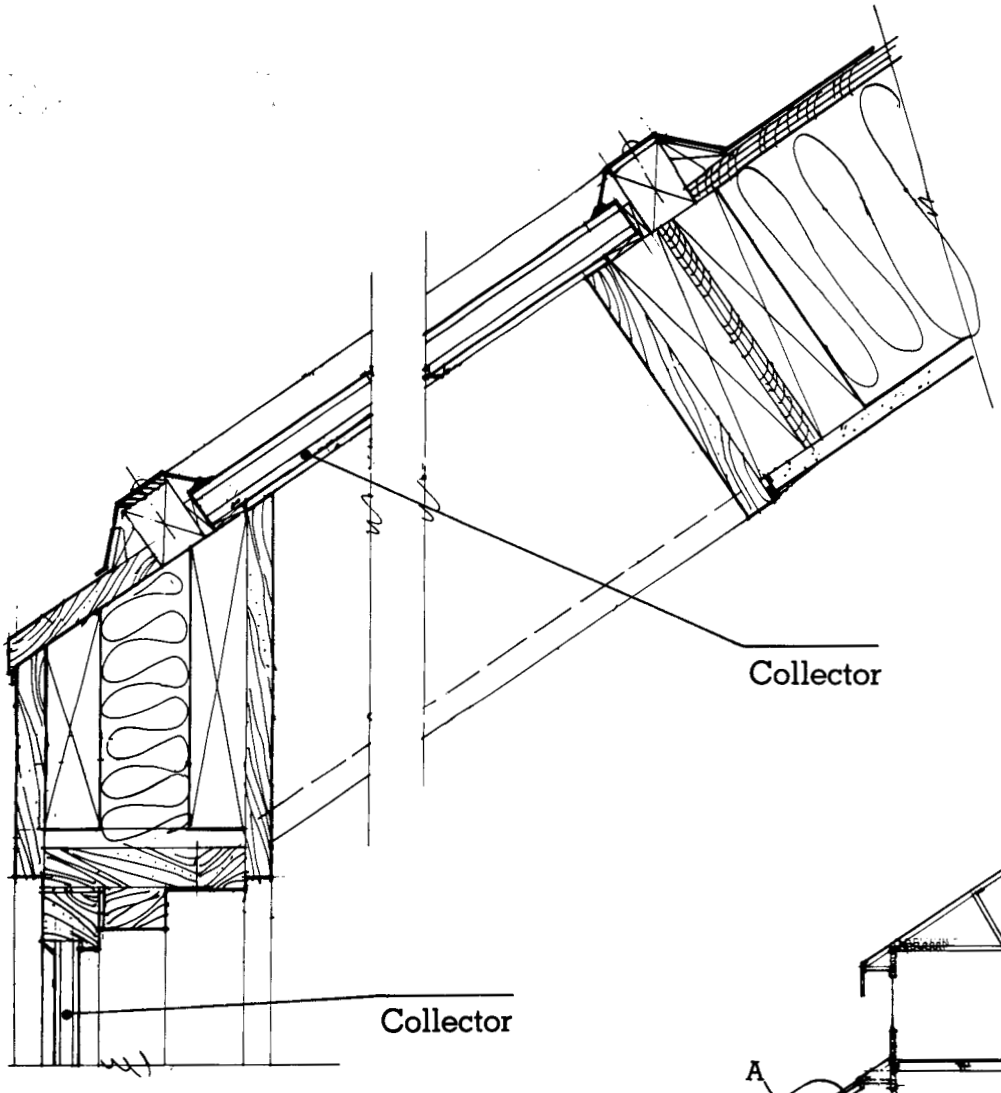
North

Designer

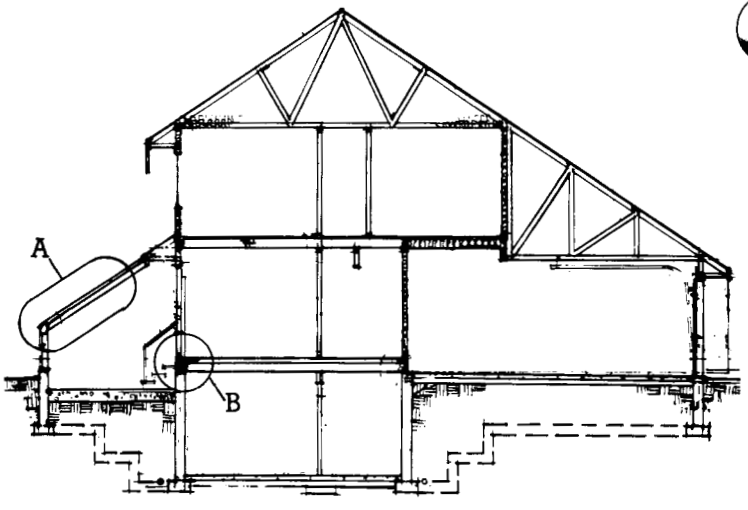
John D. Bloodgood Architects, P.C.
Des Moines, Iowa

Sponsor

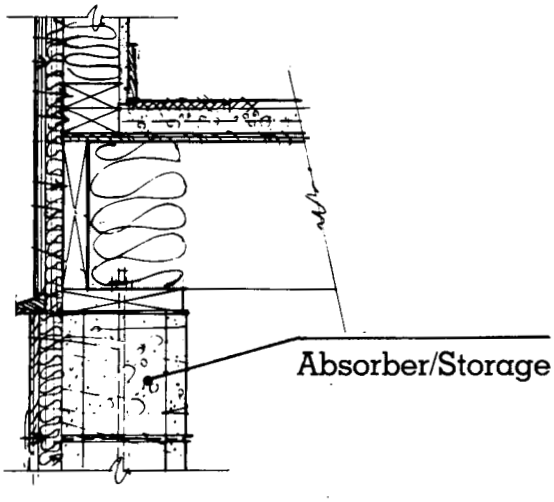
Portland Cement Association
Skokie, Illinois



A Skylight Detail: Section



Building Section



B Floor Detail: Section

This section of the Handbook presents construction and thermal performance information on the materials used in the details in Section 3.0000. For the most part these materials, as they are shown on the details, are intended to represent typical rather than specific products and/or dimensions.

Once a particular detail has been chosen and sized according to the rules of thumb in Section 3.0000, more specific information on the materials involved can be obtained from this section of the Handbook. This information will in turn aid in the final selection of particular products for a particular passive installation.

To simplify this material selection and specification process the section is divided into subsections by component type including: (1) collector components; (2) storage components; and, (3) control components. Each component section is further subdivided with discussions focusing on issues relevant to that component type.

(Author's Note: subsections covering both Absorber and Distribution components, as well as a more comprehensive review of Control components, are the subject of a future update of the Handbook.)

The Collector components section includes: (1) a review of the basic characteristics of passive solar collectors; (2) a discussion of the types of glazing materials available for use in passive installations, including a series of tables which offer general performance comparisons between a number of specific glazing products; (3) a description of the major framing systems used with collectors; and, (4) a brief discussion of caulking and sealants appropriate for passive solar applications.

The Storage components section is divided into three subsections covering the three storage materials presented in the details in Section 3.0000: (1) Concrete Masonry; (2) Concrete; and, (3) Brick.

Each of these subsections includes: (1) a general description of the material's basic composition and typical dimensions; (2) a discussion of relevant construction issues including finishes (exterior and interior), color, and texture; and, (3) a definition and discussion of the specific physical properties which affect the thermal performance of each material. Tables are presented which provide data which can be used in the analytical tools described in Appendix C and from which general performance comparisons can be made.

The Control components section is similarly divided into subsections covering: (1) Shading; (2) Reflecting; and, (3) Insulating components.

The discussion in each of these subsections focuses on the general functional characteristics of each component and their modes of operation in the various passive systems.

(Author's Note: Specific construction and thermal performance information for actual products is not presented as it is intended that such information will form the basis of future updates of the Handbook.)

This section of the Handbook presents basic information about passive solar collectors. It begins with a review of standard collector types and their physical configurations, which in turn is followed by a discussion of the materials from which collectors can be made. Included in this discussion is information concerning the physical and thermal performance characteristics of these materials and construction tips for their use in passive installations, with much of the material summarized in a series of tables.

The collector is that portion of a passive solar system which admits and traps solar energy (see Section 2.1000). This energy is absorbed by other elements in the system and then stored for later use or distributed through adjacent living spaces. The collector thus forms an integral part of every passive heating system.

A collector is composed of three basic components:

- Glazing - composed of some form of glass or plastic which allows radiant energy to strike the absorption/storage component while restricting the outflow of the heat energy;
- Collector Frame - which supports the glazing material; and,
- Caulking and Sealants - ensuring that the entire installation is weathertight and able to operate at peak efficiency.

These elements can be combined in a large variety of configurations whose performance in passive solar installations is dependent upon: the orientation and tilt of the collector; the thermal properties of the specific glazing material employed (see tables below); the net area (exclusive of frame) of the material being used for collection; the size and type of frame being used; the effectiveness of the caulking and/or sealants being used; and the overall configuration of the collector (glazing material and frame).

Types of Collectors

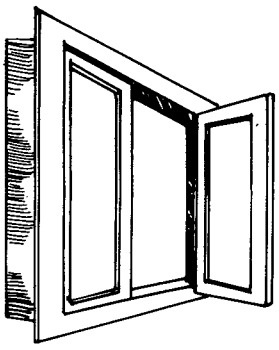
There are an almost limitless number of possible designs for passive solar collectors, from simple, off-the-shelf windows in typical residential configurations to solid walls of glass or plastic which can cover the entire side of a house. Some of the more common configurations and their possible applications are reviewed in Figure 4.1.

It must be remembered that the glazing material in these configurations does not need to be glass. Any one of a variety of materials (some of which are reviewed below) can be used depending on performance levels desired and individual preference.

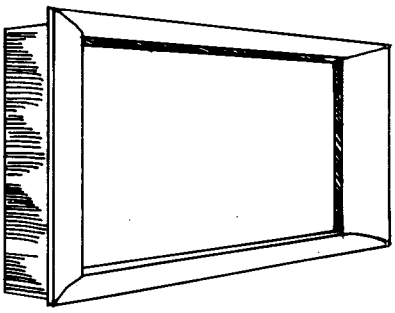
As a general rule in any passive application, using large individual units to cover a given collector area (e.g., one large picture window as opposed to several smaller units) will decrease the overall amount of framing and will thus increase the net collector area exposed to the sun. From the standpoint of energy conservation, this arrangement will also reduce the amount of perimeter framing exposed to the environment and consequently reduce the amount of heat loss due to infiltration through the framing. Similarly, using a unit with less crack length as in a single hung versus a double hung window, will also reduce infiltration. Considerations such

as these must be weighed against other criteria such as cost, ease of maintenance, user preference, and availability, to arrive at the optimum collector configuration for a given application.

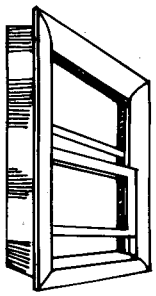
Collector Types Figure 4.1



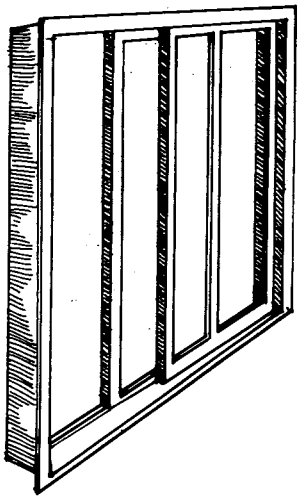
Casement



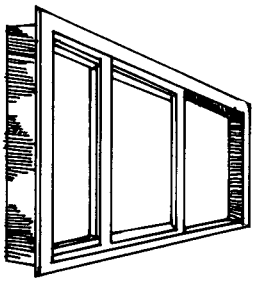
Picture



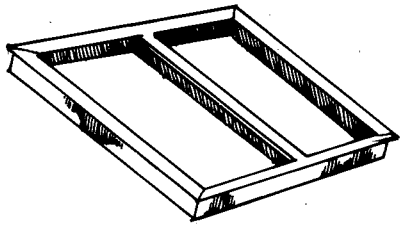
Double Hung



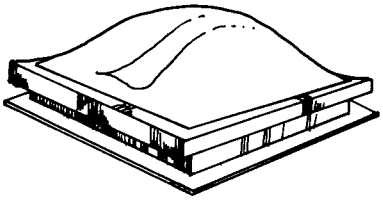
Patio Door



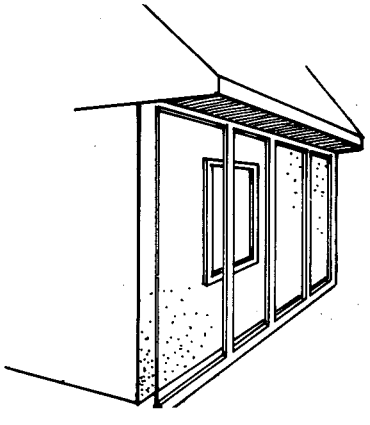
Sliding



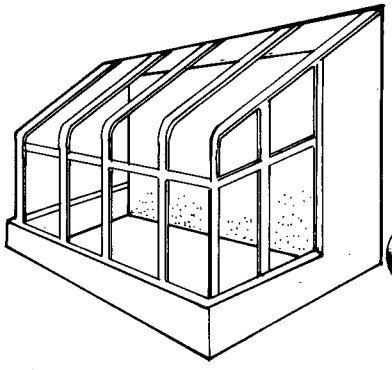
Skylight



Skylight



Window Wall



Greenhouse

Information regarding the thermal properties and physical characteristics of a variety of commonly used passive solar glazing materials is presented in Tables 4.1 through 4.5.

At present, glass is the most commonly used of these elements. The other materials described (acrylics, polycarbonates, fiberglass reinforced polyester, polyethylene, et al.) can substitute directly for glass if they are in panel or sheet form, or they can be combined with glass or another more rigid material if they are thin films.

The tables are not intended to be comprehensive and certain specific products have been left out because of a lack of sufficient data. The information presented is intended to serve as an indicator of general product performance. More detailed information (e.g., specific product sizes and availability) should be obtained directly from the manufacturer before any product is actually specified.

The tables are relatively self-explanatory. They are organized according to generic types, and within each type specific products are presented. Table 4.5 provides an overview of the advantages and disadvantages of each generic glazing type and describes the various passive systems in which each specific product can be used. It should be noted that the information presented in this table is very general in nature and is intended to serve only as a rough guideline to product selection. It is not intended to substitute for a builder's or designer's experience with local conditions and/or specific products. Tables 4.3 and 4.4 present a variety of relevant physical characteristics for each product. The technical data presented in these two tables are provided primarily for use with the various analytical tools described in Appendix C.

When assessing a material's suitability for a specific situation, special attention should be paid to a product's "weatherability" and its "maximum operating temperature". Thermal Storage Walls, in particular, can generate extremely high (150 °F) working temperatures and can put severe strain on certain collector materials.

Glazing: Applications Table 4.1

	Direct Gain			Thermal Storage Wall	Attached Sunspace
	Windows	Clerestories	Skylights		
GLASS					
Single Glazed Float Glass	*	*		*	*
Double Glazed Float Glass	*	*		*	*
ACRYLIC					
Plexiglas (Rohm & Haas)	*	*	*		*
Lucite (Du Pont)	*	*	*		*
Exolite (CY/RO)	*	*	*		*
POLYCARBONATE					
Lexan (G.E.)	*	*	*	*	*
Tuffack Twinwall (Rohm & Haas)	*	*	*	*	*
Cyrolon SDP (CY/RO)	*	*	*	*	*
FIBERGLASS REINFORCED POLYESTER					
Lascolite (Lasco Industries)	*	*	*	*	*
Filon w/Tedlar (Vistron Corp.)	*	*	*	*	*
Sunlite Premium II (Kalwall)	*	*	*	*	*
POLYESTER FILM					
Mylar Type W (Du Pont)	*	*			*
Flexiguard(3M)	*	*			*
POLYETHYLENE FILM					
Monsanto 602 (Monsanto)	*	*			*
Teflon (Du Pont)	*	*			*
POLYVINYL FLUORIDE FILM					
Tedlar (Du Pont)	*	*			*

Glazing: Characteristics Table 4.2

	Fixed	Operable	Transparent	Translucent
GLASS				
Single Glazed Float Glass	*	*	*	
Double Glazed Float Glass	*	*	*	
ACRYLIC				
Plexiglas (Rohm & Haas)	*	*	*	
Lucite (Du Pont)	*	*	*	
Exolite (CY/RO)	*	*		*
POLYCARBONATE				
Lexan (G.E.)	*	*	*	
Tuffack Twinwall (Rohm & Haas)	*	*		*
Cyrolon SDP (CY/RO)	*	*		*
FIBERGLASS REINFORCED POLYESTER				
Lascolite (Lasco Industries)	*			*
Filon w/Tedlar (Vistron Corp.)	*			*
Sunlite Premium II (Kalwall)	*			*
POLYESTER FILM				
Mylar Type W (Du Pont)	*			*
Flexiguard(3M)	*			*
POLYETHYLENE FILM				
Monsanto 602 (Monsanto)	*		*	
Teflon (Du Pont)	*		*	
POLYVINYL FLUORIDE FILM				
Tedlar (Du Pont)	*		*	

Glazing: Physical Properties Table 4.3

	Thickness	U-Value	Solar Trans.	Infrared Trans.	Maximum Operating Temperature
GLASS					
Single Glazed Float Glass	.090 -.125	1.13	.91	.01	400
Double Glazed Float Glass	.625	.52 -.65	.77 -.85		
ACRYLIC					
Plexiglas (Rohm & Haas)	.125	1.06	.90	.02	180-200
Lucite (Du Pont)	.125	1.06	.92	.02	180-200
Exolite (CY/RO)	.630	.58	.83	.02	160
POLYCARBONATE					
Lexan (G.E.)	.125	1.05	.81 -.89	.02	250-270
Tuffack Twinwall (Rohm & Haas)	.220	.62	.77		195
Cyrolon SDP (CY/RO)	.630	.58	.74		240
FIBERGLASS REINFORCED POLYESTER					
Lascolite (Lasco Industries)	varies	.73	.86		200-300
Filon w/Tedlar (Vistron Corp.)	varies	.95	.86		200-300
Sunlite Premium II (Kalwall)	.040	.55	.87	.02	200-300
POLYESTER FILM					
Mylar Type W (Du Pont)	.003 -.014	1.05	.85	.16 -.32	350
Flexiguard(3M)	.007		.89	.095	275
POLYETHYLENE FILM					
Monsanto 602 (Monsanto)	.004		.85	.70	140
Teflon (Du Pont)	.001		.96	.57	300
POLYVINYL FLUORIDE FILM					
Tedlar (Du Pont)	.004		.95	.30	225

Glazing: Physical Properties Table 4.4

	Thermal Expansion	Ease of Handling	Weather-ability	Estimated Lifetime	Shading Coef.
GLASS					
Single Glazed Float Glass	.47	P	E	25+	1.0
Double Glazed Float Glass	.47	P	E	25+	.79 -.90
ACRYLIC					
Plexiglas (Rohm & Haas)	4.10	E	E	10-20	
Lucite (Du Pont)	3.90	E	E	10-20	
Exolite (CY/RO)	4.00	E	E	10-20	
POLYCARBONATE					
Lexan (G.E.)	3.75	E	F	15-17	
Tufflack Twinwall (Rohm & Haas)	3.30	E	F	5-7	
Cyrolon SDP (CY/RO)	4.00	E	F		.83
FIBERGLASS REINFORCED POLYESTER					
Lascolite (Lasco Industries)	1.60	VG	G	10-20	
Filon w/Tedlar (Vistron Corp.)	2.30	VG	G	10-20	
Sunlite Premium II (Kalwall)	1.36	E	G	20	
POLYESTER FILM					
Mylar Type W (Du Pont)	1.50	F	F	4	
Flexiguard(3M)		F	G	10	
POLYETHYLENE FILM					
Monsanto 602 (Monsanto)		F	P	1	
Teflon (Du Pont)	30.00	P	E	25	
POLYVINYL FLUORIDE FILM					
Tedlar (Du Pont)	2.80	F	E	10-20	

Glazing: Advantages and Disadvantages Table 4.5

	ADVANTAGES	DISADVANTAGES
GLASS	o excellent selective transmission o transparent o good weatherability o heat, air-pollution and u-v resistant o low thermal expansion o easily obtained	o expensive o breaks easily o heavy o often difficult to install in large sheets
ACRYLIC	o high optical clarity, strength and weatherability o lightweight and easy to handle o impact resistant o insulation and transmission similar to glass	o expensive o prone to surface abrasion o buckles and cracks if not properly installed o significant expansion and contraction characteristics o will sag at high temperatures
POLYCARBONATE	o very high impact strength o similar to acrylics, but less solar transmission	o scratches easily o not rigid o becomes brittle and changes color after prolonged exposure to the sun
FIBERGLASS REINFORCED POLYESTER	o low cost, easy to handle o high strength and durability with coatings such as Tedlar o available flat or with corrugations	o solar transmittance reduced when u-v coatings are added o will yellow and 'blossom' without coatings o medium lifespan
POLYESTER FILM	o low cost o high surface hardness	o medium lifespan o u-v degradation if not coated o relatively high longwave transmittance
POLYETHYLENE FILM	o very inexpensive o light, flexible, easy to install o good inner glazing properties	o short lifespan (less than one year) o poor resistance to long-wave radiation o wind and temperature can cause sag
POLYVINYL FLUORIDE FILM	o excellent weatherability and strength o high solar transmittance o can be bonded to fiberglass as a u-v resistant screen	o expensive o available only in thin films o relatively high longwave transmittance

The framing system is the second basic component of a passive collector and, like the glazing material, it will affect the overall thermal performance of the installation. There are two broad categories into which framing systems can be divided: those which are commercially available and to varying degrees pre-cut and pre-assembled, and those which are site-built.

Commercially Available

Commercially available frames can be either wood (pre-assembled) or metal (pre-assembled, or pre-cut and site-assembled). They are fabricated with their collection material (usually glass) already installed or pre-cut for easy assembly, and are most commonly used in Direct Gain and some Attached Sunspace applications. These units are modular and can be used to develop overall collector systems of virtually any size or configuration. Fixed units can be combined with operable ones to allow for ventilation as well as solar heat gain.

Wood frame units are generally more expensive than metal units and, if not sufficiently protected, are more prone to weathering effects such as shrinkage and swelling. They are, however, better insulators than their metal counterparts, which are typically poor insulators unless provided with thermal breaks. Metal units are generally stronger and more weather resistant.

Commercially available frame/glazing assemblies have the advantage of being easily available off-the-shelf and are typically of a consistent quality. However, in those passive installations which require some degree of non-standard construction, commercially available units may pose problems which a site-built system designed for a specific installation will be able to avoid.

For example, the collectors on Thermal Storage Walls require exterior operation for periodic cleaning and seasonal ventilation. Few commercially available collectors can be operated in this fashion as their hardware is designed for interior operation.

If they are not adapted for special use, they will need to be mounted with their interior face (and finish) on the outside, exposed to the weather, in order to be operable from the exterior. Patio doors with key locks can operate successfully in these conditions, but for most other "off-the-shelf" collectors it will be necessary to make special arrangements with the manufacturer to install the necessary hardware on the outside of the stock products. In the case of site-built collector assemblies, such maintenance and operability problems should be considered prior to designing and building the framing system.

Site Built

An alternative to using commercially available units is to design a system to be constructed on-site using available glazing materials (e.g., patio door replacement glass, acrylic panels, or polycarbonate sheets) and wood framing specially fabricated for the job. This type of "one-off" approach is particularly appropriate in applications such as Thermal Storage Walls which already involve departures from standard residential construction. Care must be taken to ensure that proper fasteners are used to attach the glazing to the frame (glazing manufacturer's specifications must be

referenced) and it is recommended that the collector material be held in place by a wood stop or metal extrusion screwed to the wood mullion. A generous amount of space (1/2" is recommended) should be left between the edge of the sheet of glazing and the framing mullion to allow for the expansion and contraction caused by the high temperatures that are characteristic of Thermal Storage Wall systems. Green wood should not be used in a site-fabricated mullion system and any wood used should be treated with a wood sealant. If wood is used as a face piece to hold the collector material in place, it should be at least 3/4" thick to avoid curling at the edges.

Commercially Available and Site Built Composite Systems

In certain applications, such as Thermal Storage Walls, it may be advantageous to insert preframed, commercially available glazing units into a specially designed, site-constructed collector frame. For example, preframed patio doors might be installed in a larger Thermal Storage Wall collector frame which has been site-constructed of wood and attached directly to the wall. The choice of an appropriate glazing/frame system combination will depend on local conditions, aesthetic preference, and cost.

All collector installations need to be carefully caulked and sealed. In the case of non-vented Thermal Storage Walls (where temperatures can be in excess of 150°F), they may need to be recaulked after the first several months of operation to ensure efficient future performance. The seal should be airtight but able to be broken in case the panel must be removed. For a discussion of various construction sealants and their performance see Tables 4.6 and 4.7.

Caulking Table 4.6

Name*	Cost	Adhesion	Elongation (%)	Life (yrs)	Cont. Service Temp. (°C)	Resistance to UV
Urethane (1 part)	$2-3	Excellent	300-450	20+	-50 to 135	Good
Silicone	$3-4	Good (excellent w/ primer)	100-200	20+	-60 to 205	Excellent
Acrylic Terpolymers	$3-4	Excellent		20+	85 maximum	Very Good
Hypalon (1 part)	$2	Very Good	15-50	15-20	-20 to 110	Good
Polysulfide (1 part)	$2-4	Excellent	200-350 (2 part)	20+	-50 to 120	Very Good
Butyl Rubber	$1-2	Very Good	75-125	7-10	-40 to 135	Fair
Acrylic Latex	$1-2	Excellent except w/ metal	25-60	2-14	-30 to 100	Fair
Oil	$1	Fair - Good	5	1-7	-25 to 85	Poor

Reprinted from Energy Efficient Building and Rebuilding: The Profit Opportunities (see Bibliography reference No. 22).

* Specific product material properties may vary from those listed in this table. Consult manufacturers literature for specific information.

Caulking Table 4.7

Name*	Shrinkage Free	Cure Time (days)	Paint	Thinner	Use Primer On
Urethane (1 part)	Excellent	14	If desired	MEK, acetone, lacquer thinner	Not required
Silicone	Excellent	5	Possible Difficulties	Paint thinner Naptha, toluol	Not required
Acrylic Terpolymers					Not required
Hypalon (1 part)	Good	60-180	If desired	Toluene, xylene, xylol	Not required
Polysulfide	Excellent	4-7	If desired	TCE,toluene MEK	Special primer on all but metal
Butyl Rubber	Fair	7	Recommended	Paint thinner Naptha	Not required
Acrylic Latex	Fair	3	Recommended	Water	Pourous surfaces
Oil	Fair	120-360	Necessary	Paint thinner	Pourous surfaces

Reprinted from Energy Efficient Building and Rebuilding: The Profit Opportunities (see Bibliography reference No. 22).

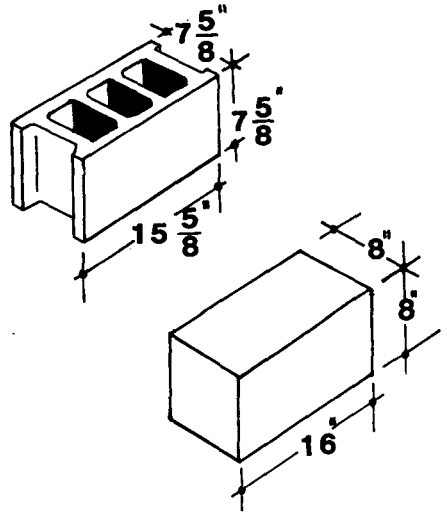
* Specific product material properties may vary from those listed in this table. Consult manufacturer's literature for specific information.

This section of the Handbook presents basic information on materials that can be used as passive solar STORAGE components. A storage component can generally be constructed of any one of a variety of materials which exhibit a high capacity to store heat. The most common residential construction materials which fit this criteria are those in the masonry family. Each material type appropriate for use in a storage component is discussed below in a separate subsection. These subsection divisions include Concrete Masonry Units, Concrete and Brick.

In each subsection the following information is presented: a definition of the material and a discussion of typically available shapes and sizes; a review of construction issues specifically related to the materials used in passive solar applications; and, an analysis of the thermal performance characteristics of the material, including charts summarizing specific thermal properties which can be used with the various Analysis Tools presented in Appendix C.

Concrete masonry units (concrete block, concrete brick, and concrete block paving units), referred to as "CMUs," are composed primarily of Portland cement, graded aggregates, and water. They are fabricated into specific shapes from machine-molded, very dry, no-slump concrete. The resulting elements are then exposed to an accelerated curing procedure and subsequently dried to reduce the moisture content to specified levels. Concrete masonry has traditionally been used as both a structural material in above and below grade walls and as an exposed finish material on walls and floors.

Concrete masonry construction is based on a modular dimensional system whose base module has been established as 4" vertically and 4" horizontally (nominal measurements). Standard dimensions for CMUs are equal to the nominal size minus the thickness of one 3/8" mortar joint. Thus, as illustrated below, the common 8" high by 16" long concrete block is actually 7 5/8" by 15 5/8":



Regardless of their dimensions CMUs are manufactured as either hollow or solid units. Due to their reduced weight and ease of handling, hollow units are used more frequently than solid ones. However, in most passive solar construction it is recommended that concrete masonry units used for storage be solid or hollow with grout-filled cores to increase the overall efficiency of the passive system.

A sampling of the large variety of sizes and shapes of concrete masonry units available in the market today is presented in Figures 4.2 through 4.11.

Construction

In most passive solar installations construction with concrete masonry will follow standard practice. The only major departures from typical construction are: (1) placing insulation on the outside of a CMU being used for Direct Gain storage (e.g., an exterior CMU wall); and, (2) the use of solid or grout-filled, as opposed to hollow, units to store heat. These changes require only minor modifications to the building process and are fully covered in the details in Section 3.0000. A specification for the grout to be used in CMU cores is included in Appendix A.

Finishes

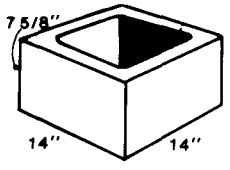
In Thermal Storage Wall and Attached Sunspace construction the exterior face of a CMU wall is used to absorb and store heat and is protected from the environment by the collector glazing. Unfinished concrete masonry of a dark color performs best in these conditions. In Direct Gain systems, however, the

Concrete Masonry Units

Figure 4.2

14" WIDE, 8" HIGH

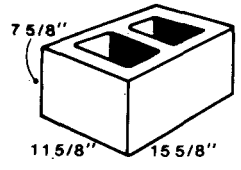
14"x 8"x 14" CHIMNEY BLOCK
10 1/8"x 10 1/8" HOLE



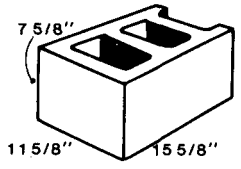
● – widely available
✱ – available only in some areas
o – Customized Face Block – check local producer for particular patterns, textures, and colors; available in 4", 6", 8", 10", 12", widths
Grille Block, Concrete Brick, Solid Block, and Paving Block – limited availability

12" WIDE, 8" HIGH

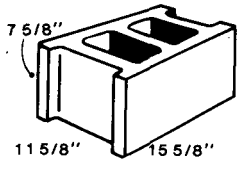
12"x 8"X 16"
DOUBLE ENDS●



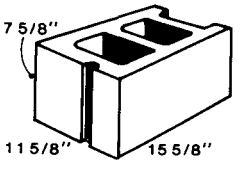
12"x 8"x 16"
REGULARS●



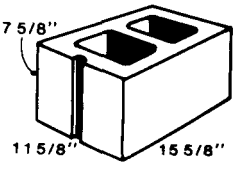
12"x 8"x 16"
STRETCHER●



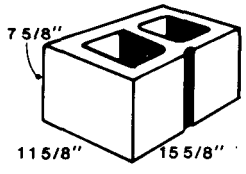
12"x 8"x 16"
STEEL SASH JAMB ●



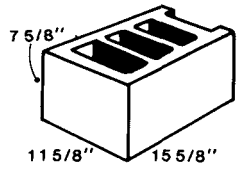
12"x 8"x 16" JAMB
3/4"x 3/4" SLOT●



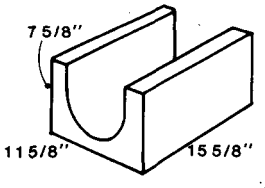
12"x 8"x 16"
TWIN ●



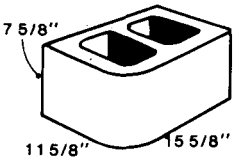
12"x 8"x 16"
3 CELLS ✱



12"x 8"x 16" SOLID
BOTTOM "U" BLOCK●

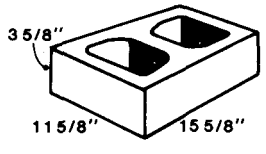


12"x 8"x 16"
SINGLE BULL NOSE ●

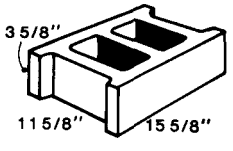


12" WIDE, 4" HIGH

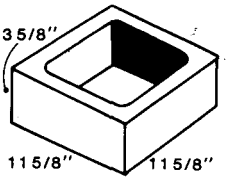
12"x 4"x 16"
DOUBLE END✱



12"x 4"x 16"
HALF-HI FOUNDATION ✱

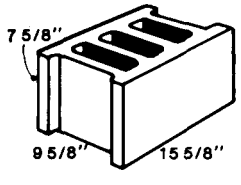


12"x 4"x 12"
SINGLE CORE ✱

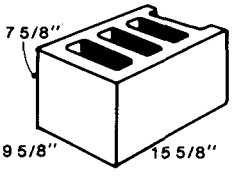


10" WIDE, 8" HIGH

10"x 8"x 16"
STRETCHER●

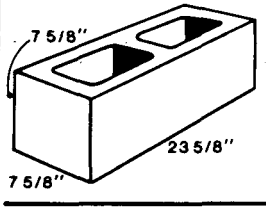


10"x 8"x 16"
CORNER●

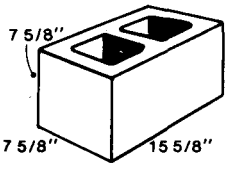


8" WIDE, 8" HIGH

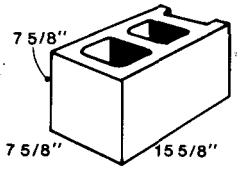
8"x 8"x 24"
DOUBLE END✱



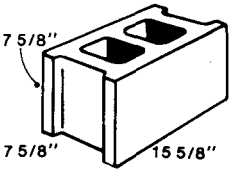
8"x 8"x 16"
DOUBLE END●



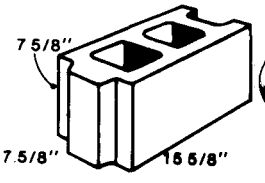
8"x 8"x 16" REGULAR
2 CELLS ●



8"x 8"x 16"
STRETCHER●



8"x8"x 16" MALE
CONTROL●

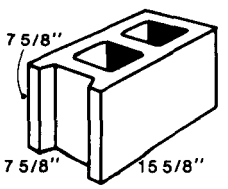


Concrete Masonry Units

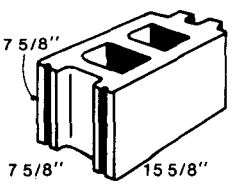
Figure 4.3

8" WIDE, 8" HIGH

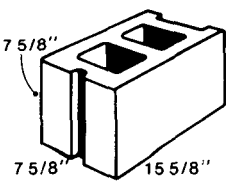
8"x8"x16" FEMALE CONTROL ✱



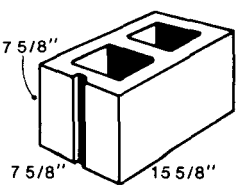
8"x8"x16" CONTROL JOINT ✱



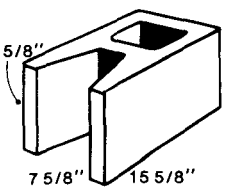
8"x8"x16" STEEL SASH JAMB ●



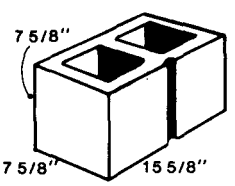
8"x8"x16" JAMB 3/4"x3/4" SLOT ●



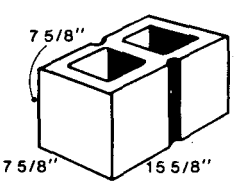
8"x8"x16" PLUMBING BLOCK ✱



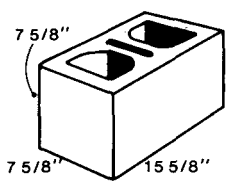
8"x8"x16" TWIN (ALSO IN 2 AND 3 SCORES) ✱



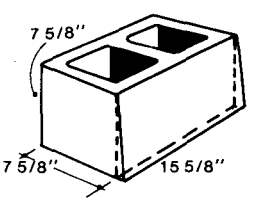
8"x8"x16" VERTICAL SCORE-3/8"x3/8" CUT ✱



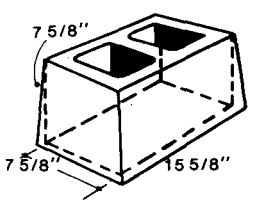
8"x8"x16" SPLITTABLE



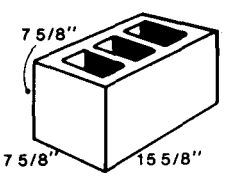
8"x8"x16" SIDING BLOCK ✱



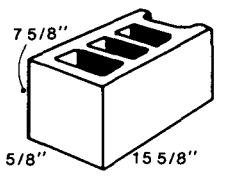
8"x8"x16" SIDING LEFT CORNER BLOCK ✱



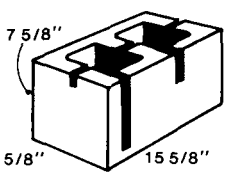
8"x8"x16" DOUBLE END 3 CELL ✱



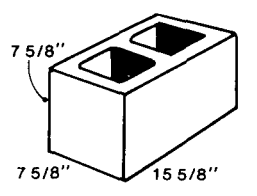
8"x8"x16" REGULAR 3 CELL ✱



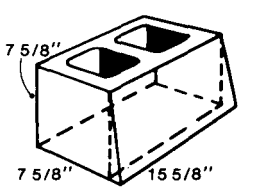
8"x8"x16" SOUND BLOCK 4"x8"x16" 6"x8"x16" ✱



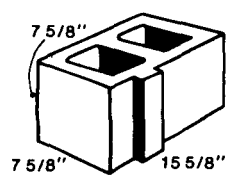
8"x8"x16" ●



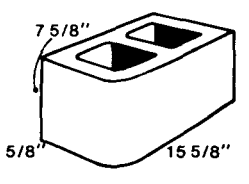
8"x8"x16" SIDING RIGHT CORNER BLOCK ✱



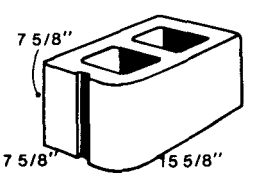
8"x8"x16" BOARD & BATTEN BLOCK ✱



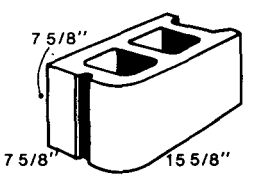
8"x8"x16" BULL NOSE ✱



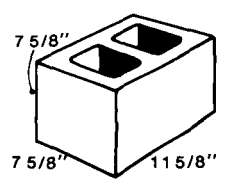
8"x8"x16" JAMB BLOCK BULLNOSE ●



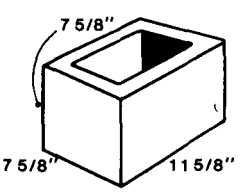
8"x8"x16" SINGLE CORNER SASH BULLNOSE ✱



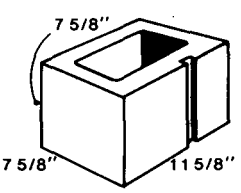
8"x8"x12" ●



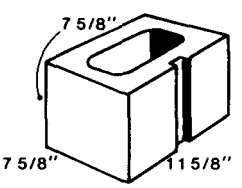
8"x8"x12" PLAIN ENDS ●



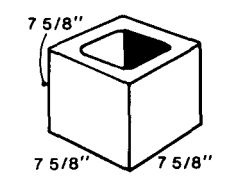
8"x8"x12" PLAIN END SASH HALF ✱



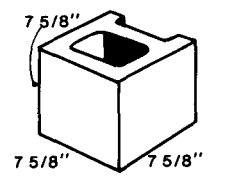
8"x8"x12" HALF JAMB ✱



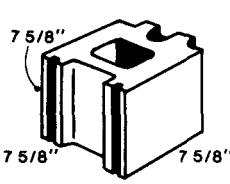
8"x8"x8" ●



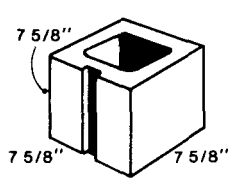
8"x8"x8" HALF BLOCK ●



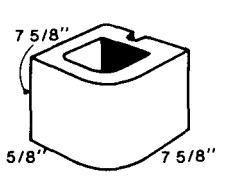
8"x8"x8" CONTROL JOINT ✱



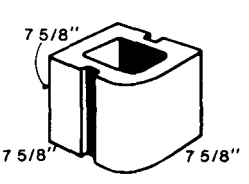
8"x8"x8" HALF JAMB HALF REGULAR ✱



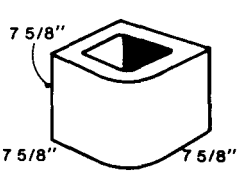
8"x8"x8" BULLNOSE ✱



8"x8"x8" JAMB BULLNOSE ✱



8"x8"x8" BULLNOSE ✱

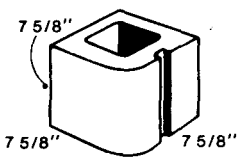


Concrete Masonry Units

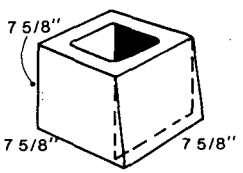
Figure **4.4**

8" WIDE, 8" HIGH

8"x8"x8" JAMB BULLNOSE ✱

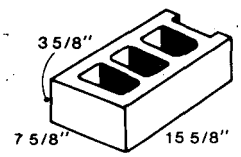


8"x8"x8" SIDING BLOCK ✱

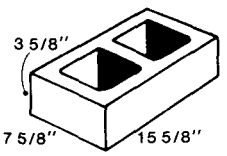


8" WIDE, 4" HIGH

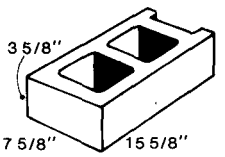
8"x4"x16" HALF HI 3 CELL ●



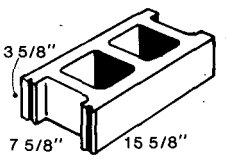
8"x4"x16" HALF HI DOUBLE END ●



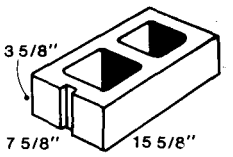
8"x4"x16" HALF HI ●



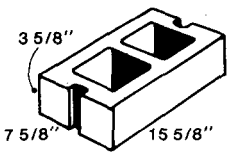
8"x4"x16" HALF HI STRETCHER ●



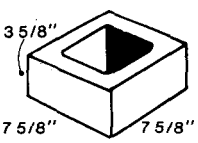
8"x4"x16" JAMB HALF HI ✱



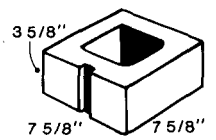
8"x4"x16" HALF HI SASH ✱



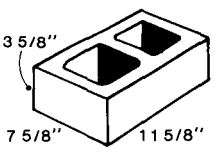
8"x4"x8" HALF HI ●



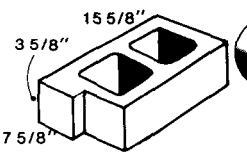
8"x4"x8" HALF HI ✱



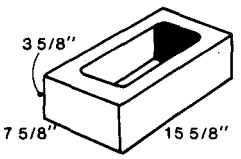
8"x4"x12" HALF HI ✱



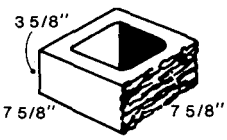
8"x4"x16" HALF HI FURRED JAMB ✱



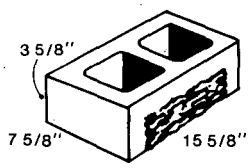
8"x4"x16" ASHLAR HALF HI I-CELL ✱



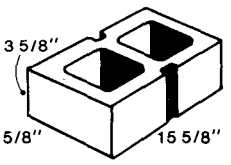
8"x4"x8" HALF HI SPLIT FACE ✱



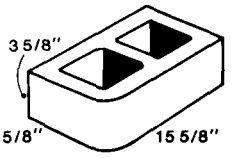
8"x4"x16" HALF HI SEMI-SPLIT FACE ✱



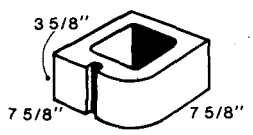
8"x4"x16" (SINGLE) HALF HI, DOUBLE TWIN, 4" ✱



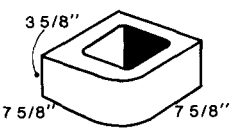
8"x4"x16" HALF HI BULLNOSE ✱



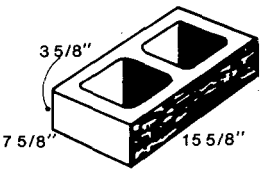
8"x4"x8" JAMB BULLNOSE HALF HI ●



8"x4"x8" HALF HI BULLNOSE ✱

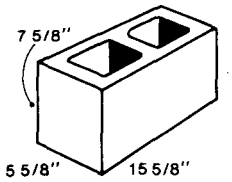


8"x4"x16" CORED SPLIT BLOCK ✱

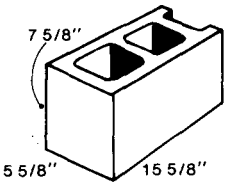


6" WIDE, 8" HIGH

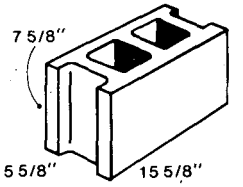
6"x8"x16" DOUBLE ENDS ●



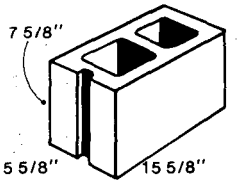
6"x8"x16" REGULARS AND PARTITIONS ●



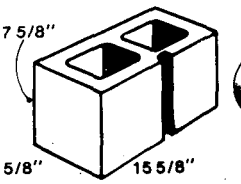
6"x8"x16" STRETCHER ●



6"x8"x16" JAMB 3/4"x3/4" SLOT ●



6"x8"x16" TWIN (ALSO WITH 2 AND 3 SCORES) ✱

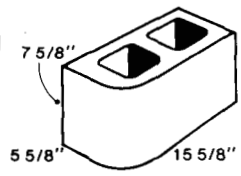


Concrete Masonry Units

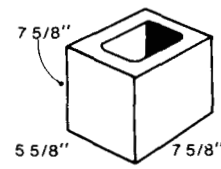
Figure **4.5**

6" WIDE, 8" HIGH

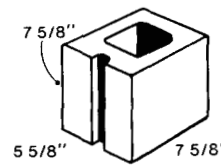
6"x8"x16" SINGLE BULL NOSE ✱



6"x8"x8" DOUBLE ENDS ●

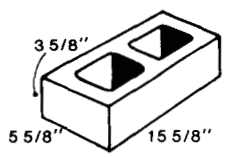


6"x8"x8" HALF JAMB AND HALF REGULAR ●

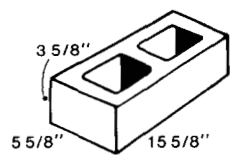


6" WIDE, 4" HIGH

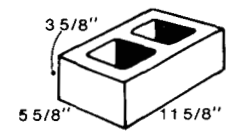
6"x4"x16" PARTITION DOUBLE ENDS ✱



6"x4"x16" DOUBLE ENDS ✱

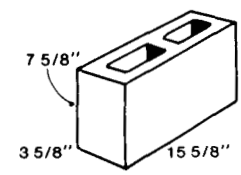


6"x4"x12" DOUBLE ENDS ✱

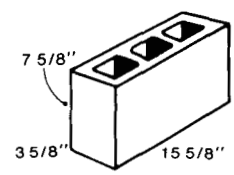


4" WIDE, 8" HIGH

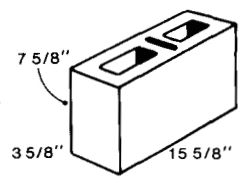
4"x8"x16" PARTITION ●



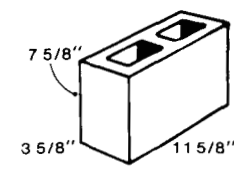
4"x8"x16" PARTITION 3 CELL ✱



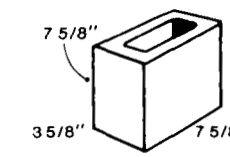
4"x8"x16" SPLITTABLE PARTITION ✱



4"x8"x12" DOUBLE ENDS ✱

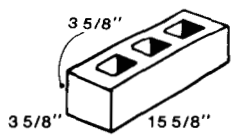


4"x8"x8" DOUBLE ENDS ●

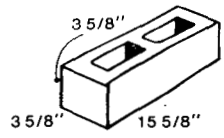


4" WIDE, 4" HIGH

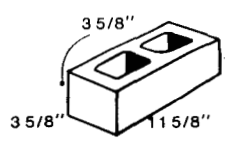
4"x4"x16" PARTITION DOUBLE ENDS 3 CELL ✱



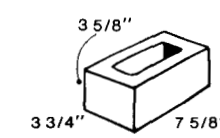
4"x4"x16" PARTITION DOUBLE ENDS ●



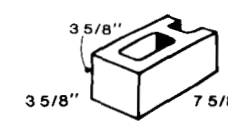
4"x4"x12" DOUBLE ENDS ✱



4"x4"x8" DOUBLE ENDS ✱

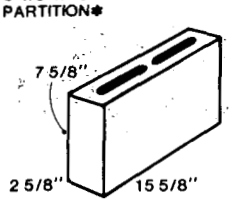


4"x4"x8" 1/2 PARTITION ●



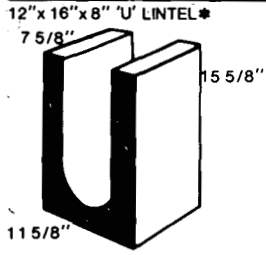
3" WIDE, 8" HIGH

3"x8"x16" PARTITION ✱

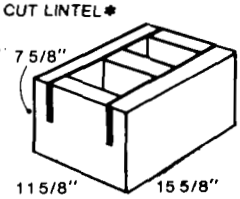


LINTEL BLOCK

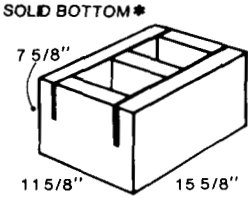
12"x16"x8" 'U' LINTEL ✱



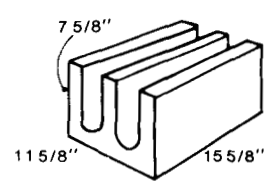
12"x8"x16" CUT LINTEL ✱



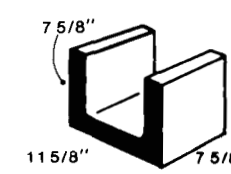
12"x8"x16" LINTEL SOLID BOTTOM ✱



12"x8"x16" LINTEL SOLID BOTTOM ●



12"x8"x8" 'U' BLOCK ●

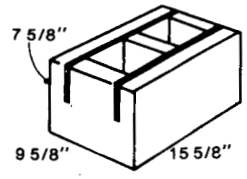


Concrete Masonry Units

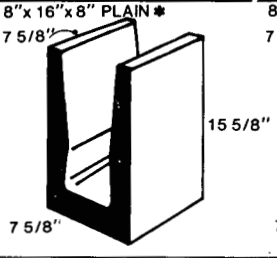
Figure **4.6**

LINTEL BLOCK

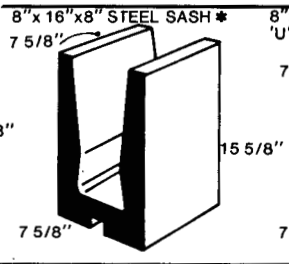
10"x 8"x 16" LINTEL OPEN BOTTOM ✱



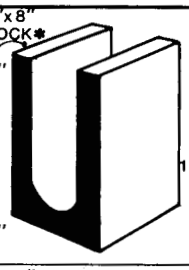
8"x 16"x 8" PLAIN ✱



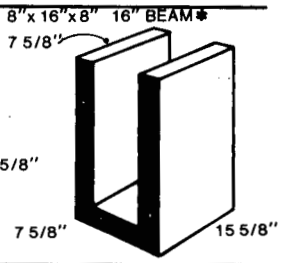
8"x 16"x8" STEEL SASH ✱



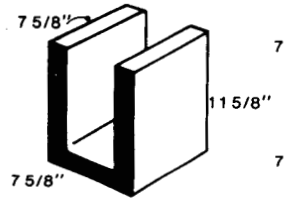
8"x 16"x 8" 'U' BLOCK ✱



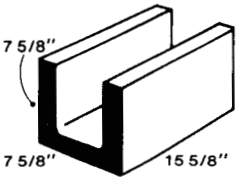
8"x 16"x 8" 16" BEAM ✱



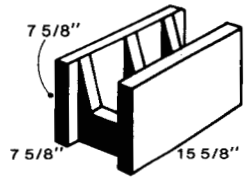
8"x 12"x 8" 12" BEAM ✱



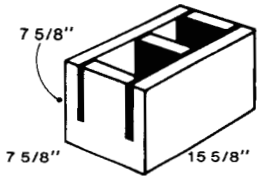
8"x 8"x 16" 'U' LINTEL ✱



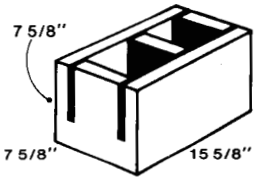
8"x 8"x 16" CORED LINTEL ✱



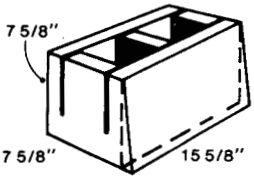
8"x 8"x 16" LINTEL SOLID BOTTOM ✱



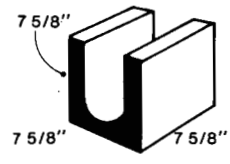
8"x 8"x 16" LINTEL ✱



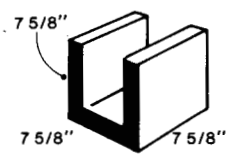
8"x 8"x 16" SIDING LINTEL ✱



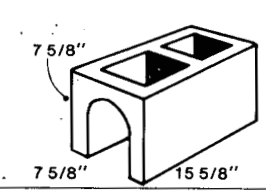
8"x 8"x 8" 'U' LINTEL ✱



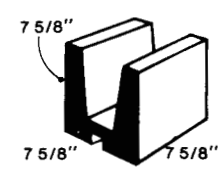
8"x 8"x 8" ✱



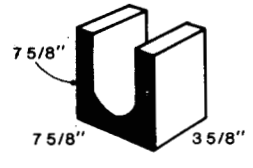
8"x 8"x 16" OPEN BOTTOM LINTEL ✱



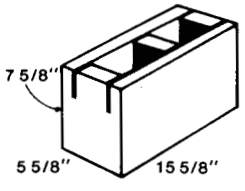
8"x 8"x 8" STEEL SASH ✱



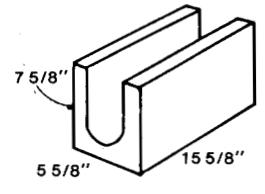
8"x 8"x 4" 'U' BLOCK ✱



6"x 8"x 16" CUT LINTEL ✱

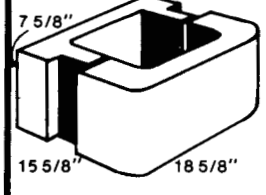


6"x 8"x 16" LINTEL SOLID BOTTOM ✱

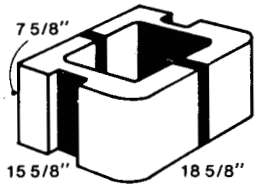


PILASTER BLOCK

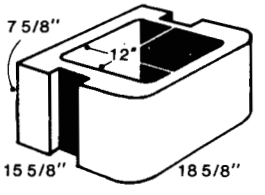
16"x 8"x 19" PILASTER SET ✱



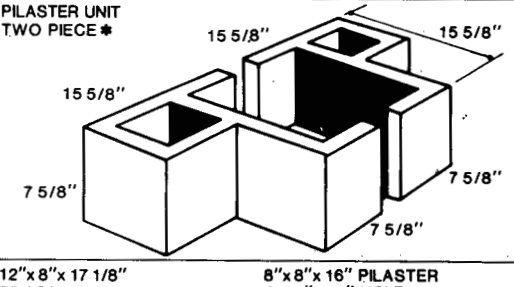
16"x 8"x 19" PILASTER SET ✱



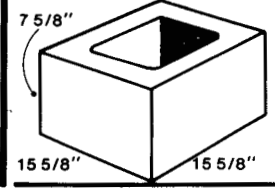
16"x 8"x 19" FLUSH WALL PILASTER ✱



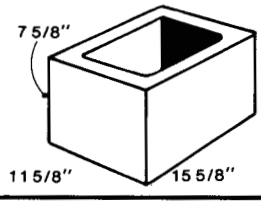
PILASTER UNIT TWO PIECE ✱



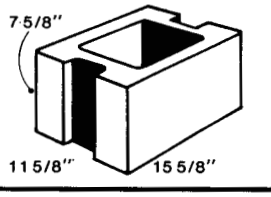
16"x 8"x 16" PILASTER & CHIMNEY BLOCK 9"x 9" HOLE ✱



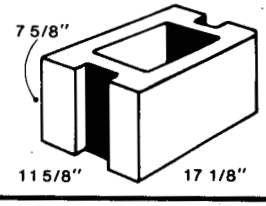
12"x 8"x 16" PILASTER 8 1/4"x 12" HOLE ✱



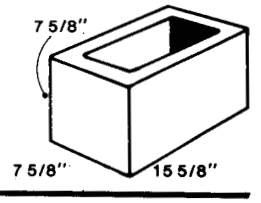
12"x 8"x 16" PILASTER



12"x 8"x 17 1/8" PILASTER ✱



8"x 8"x 16" PILASTER 4 1/2"x 11" HOLE ✱

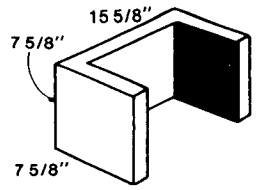


Concrete Masonry Units

Figure **4.7**

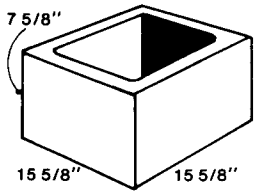
PILASTER BLOCK

8"x8"x16"
NO.37 PILASTER ✱

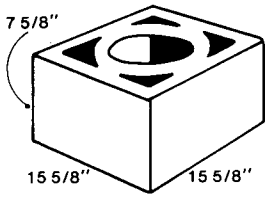


COLUMN AND FLUE BLOCK

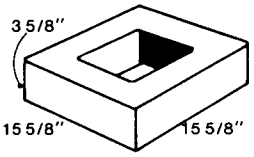
16"x8"x16"
COLUMN STYLE NO.1✱



16"x8"x16"
FLUE BLOCK✱

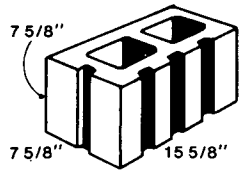


16"x4"x16"
FLUE BLOCK✱

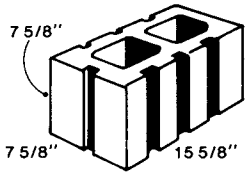


CUSTOMIZED FACE BLOCK

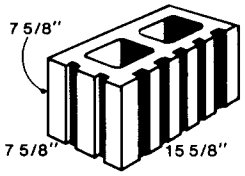
8"x8"x16"
VERTICAL PATTERN o



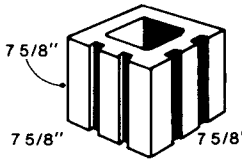
8"x8"x16"
VERTICAL PATTERN o



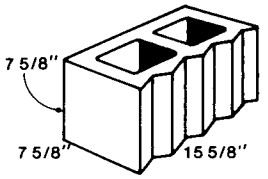
8"x8"x16"
VERTICAL PATTERN o



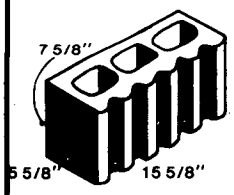
8"x8"x8"
VERTICAL PATTERN o



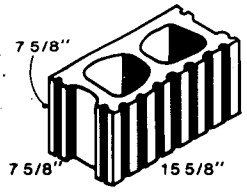
8"x8"x16"
FLUTED o



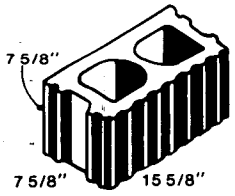
6"x8"x16"
ROUND FLUTED o



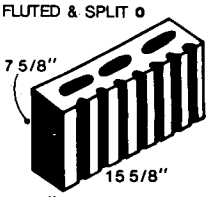
8"x8"x16"
FLUTED & SPLIT o



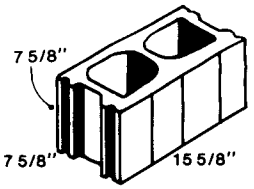
8"x8"x16"
FLUTED & SPLIT o



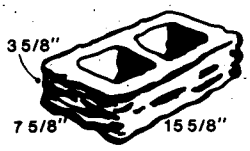
4"x8"x16"
FLUTED & SPLIT o



8"x8"x16" 3 SCORE o



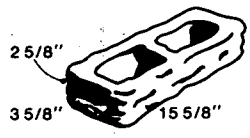
8"x4"x16"
SLUMP BLOCK o



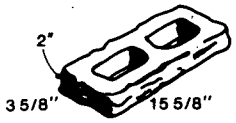
4"x4"x16"
SLUMP BLOCK o



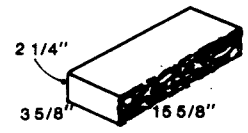
4"x3"x16"
SLUMP BLOCK o



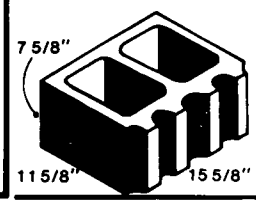
4"x2"x16"
SLUMP BLOCK o



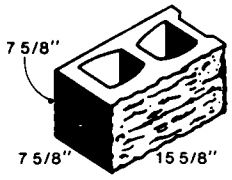
4"x2 1/4"x16"
SPLIT FACE o



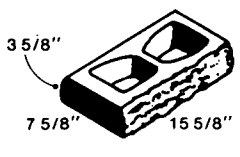
12"x8"x16"
SPLIT FLUTED o



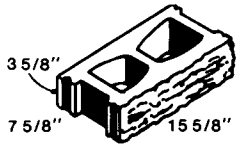
8"x8"x16" SPLIT o



8"x4"x16" SPLIT o

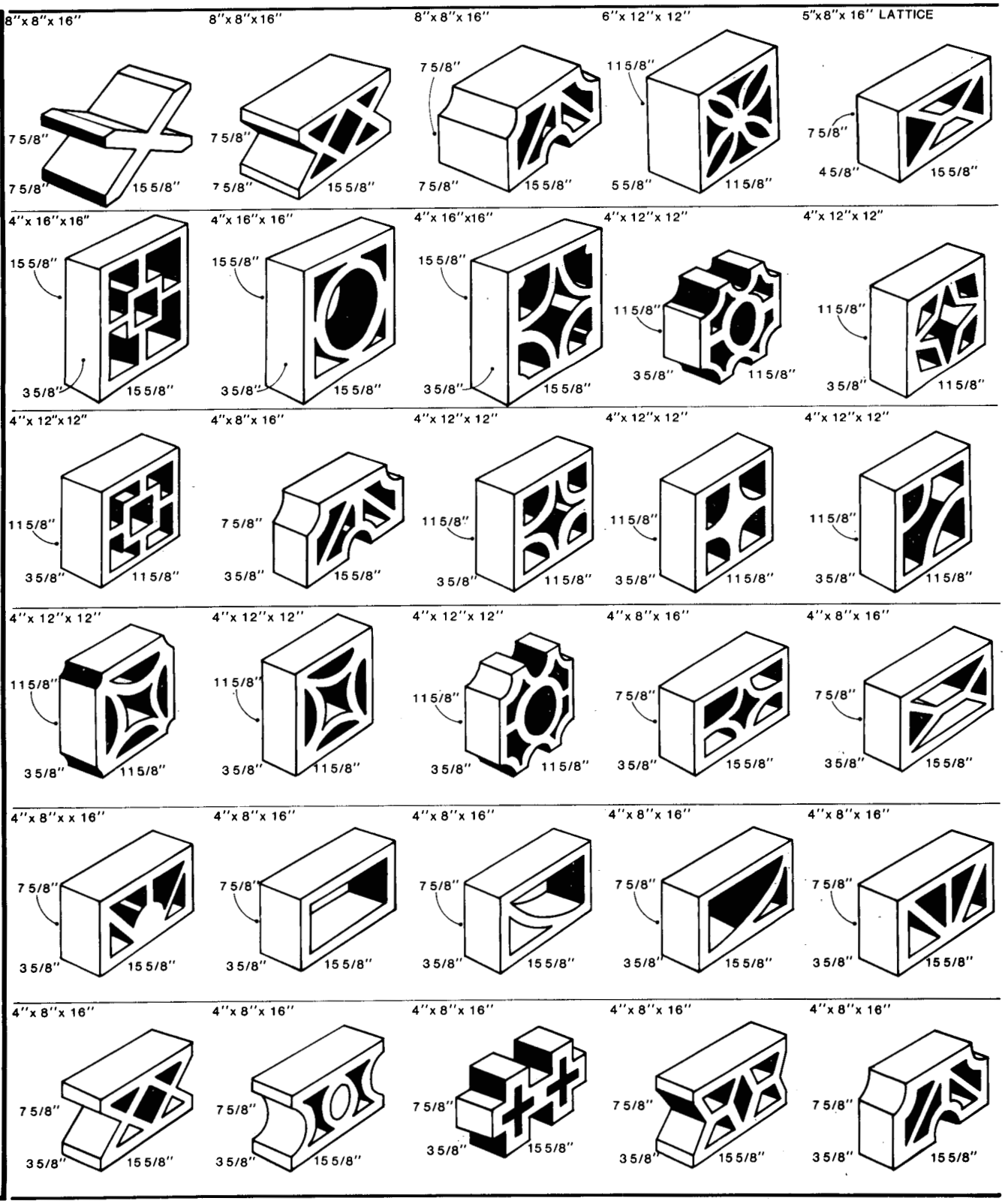


8"x4"x16" SPLIT o



Concrete Masonry Units Figure 4.8

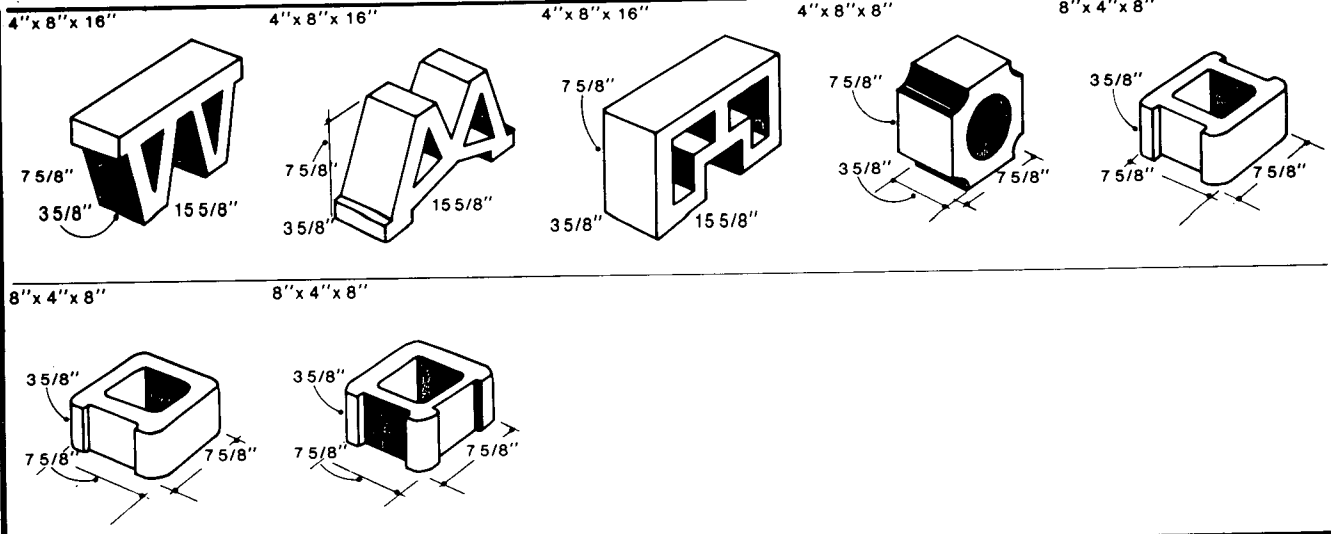
GRILLE BLOCK



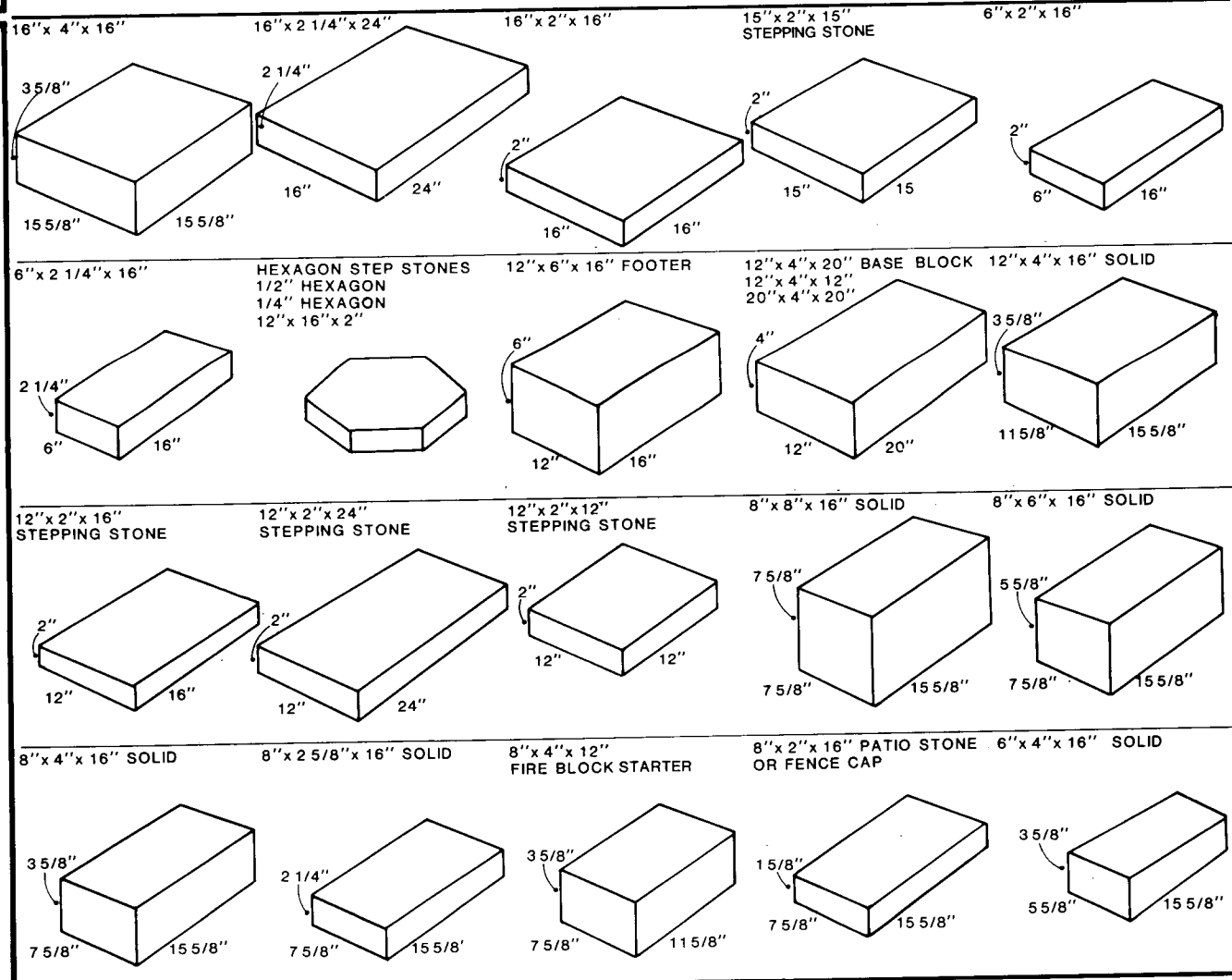
Concrete Masonry Units

Figure 4.9

GRILLE BLOCK



CONCRETE BRICK, SOLID BLOCK, AND PAVING BLOCK

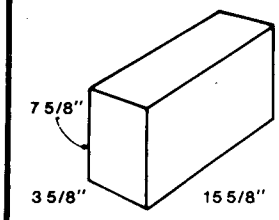


Concrete Masonry Units

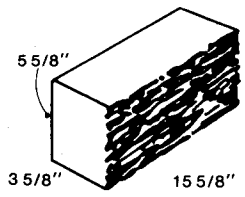
Figure 4.10

CONCRETE BRICK, SOLID BLOCK, AND PAVING BLOCK

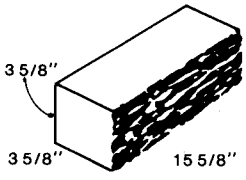
4"x 8"x 16" PARTITION SOLID



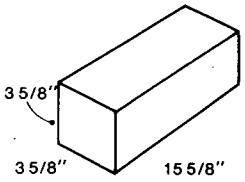
4"x 6"x 16" SPLIT FACE



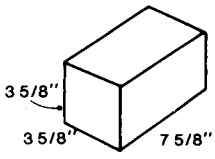
4"x 4"x 16" SPLIT FACE



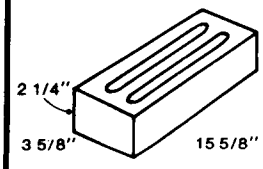
4"x 4"x 16" SOLID



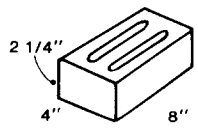
4"x 4"x 8" SOLID



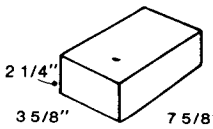
4"x 2 1/4"x 16" BRICK



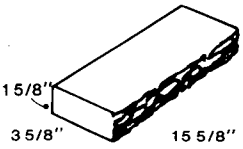
4"x 2 1/4"x 8" BRICK



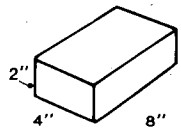
4"x 2 1/4"x 8" BRICK



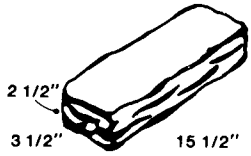
4"x 2"x 16" SPLIT FACE



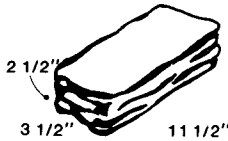
4"x 2"x 8" SOLID CONCRETE BRICK



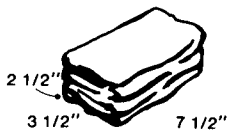
3 1/2"x 2 1/2"x 15 1/2" SLUMP BRICK-SOLID



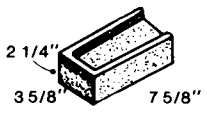
3 1/2"x 2 1/2"x 11 1/2" SLUMP BRICK-SOLID



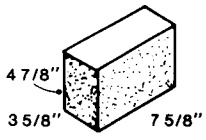
3 1/2"x 2 1/2"x 7 1/2" SLUMP BRICK - SOLID



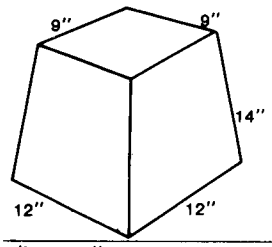
FROG BRICK



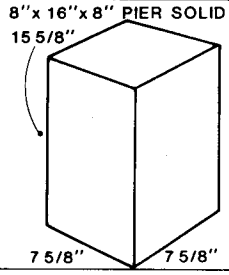
DOUBLE BRICK



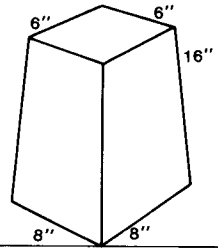
12"x 14"x 9" PIER BLOCK



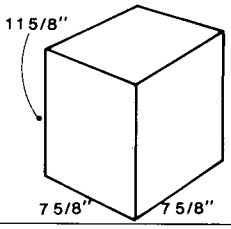
8"x 16"x 8" PIER SOLID



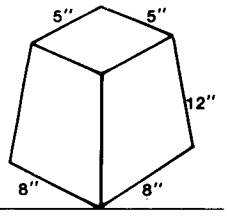
8"x 16"x 6" PIER SOLID



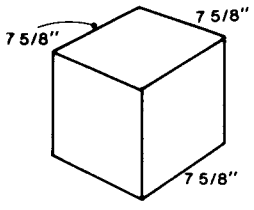
8"x 12"x 8" PIER SOLID



8"x 12"x 5" PIER BLOCK

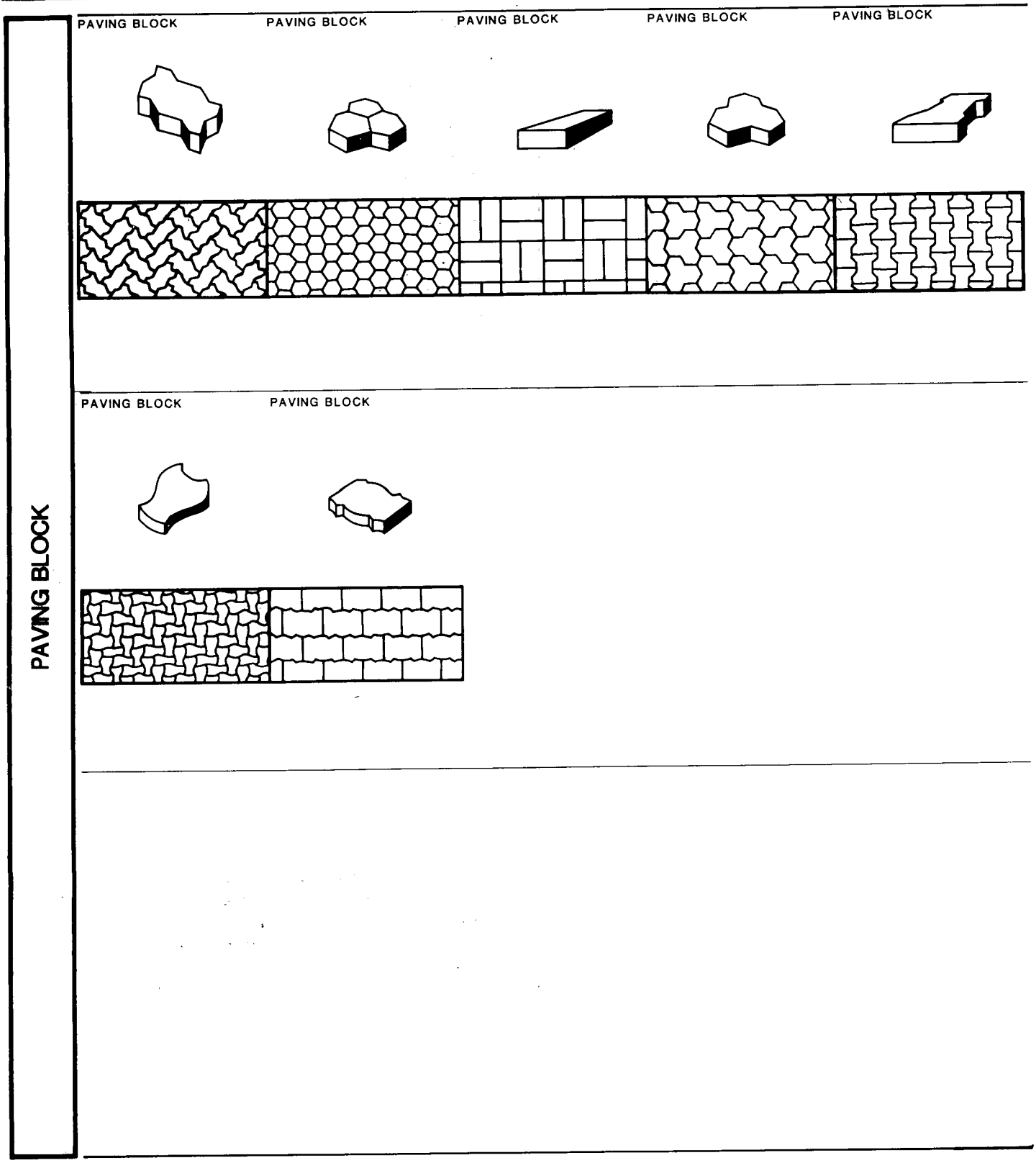


8"x 8"x 8" PIER SOLID



Concrete Masonry Units

Figure 4.11



exterior face of a solid CMU wall is not protected by the collector glazing. If this face is exposed directly to the environment, and not protected by some form of insulation and finish, stored heat will travel through the wall and be lost to the outside, severely reducing the thermal performance of the overall system.

There is a variety of methods for finishing the exterior of a concrete masonry wall being used for Direct Gain storage. Because it is recommended that insulation be placed on the outside of exterior walls being used for Direct Gain storage, such finishes will need to be applied over this insulation. In a standard masonry bearing wall configuration, stucco or siding can be applied over insulation which has been adhered or fastened to the CMU wall. In typical exterior CMU veneer wall construction, the configuration of the materials can be inverted, moving the masonry to the inside for heat storage and the insulated bearing frame wall to the outside. Siding is then applied in the conventional manner.

Such external finishes will affect the thermal performance of a Direct Gain storage component only insofar as they increase the effective insulation of that component. If a wall which is absorbing heat at its interior face is well insulated on its exterior, it will retain more of the heat energy imparted to it and will thus serve as a more effective solar energy storage medium.

It is recommended that interior finishes be kept to a minimum to preserve the inherent thermal performance capabilities of the CMUs. For example, if a finish such as wood paneling or gypsum board is applied to the interior face of a wall intended to absorb and store solar energy, it will reduce both the amount of heat reaching the wall and the amount which is reradiated from it to the space. This is especially true of covering a CMU paver floor with carpet, which is emphatically not recommended. Although the negative effects of such interior finishes have not yet been quantified, a good rule of thumb is to assume that, relative to other finish materials, the higher the insulating value of a given finish, the more it will inhibit the passive thermal performance of the component to which it is applied. (It should be noted that a variety of concrete masonry products have been designed specifically as finish materials and are suitable for residential construction.)

Carrying this concept one step further, it is obvious that putting insulation on the interior surface of a CMU component (e.g., a Direct Gain wall) used for energy storage is extremely counter-productive and will essentially nullify any passive benefits that might have been derived from the component. It is for this reason that it is recommended that no passive storage component (wall, floor, or roof/ceiling) be insulated on its interior face.

Color

Where concrete masonry is used to both absorb and store solar energy, the surface exposed to solar radiation should be as dark a color as possible to increase absorption of light and heat. Other surfaces in a space which are not being used for storage, such as standard wood frame walls, should be light in color in order to reflect more light to the darker storage material. For a listing of the solar absorptance characteristics of various colors/materials see Appendix A.

In the case of concrete masonry, natural color can vary from light to dark grey and also to tints of buff, red, or brown depending on the color of aggregate, cement, and other mix ingredients. Again, it is recommended that the darker tones be specified when the CMUs are being used unfinished for heat storage. In customized units specific dark colors can be requested from the manufacturer.

The concrete masonry can also be painted or stained. Care must be taken that

paints or stains which do not degrade when subjected to high temperatures be specified in applications where such temperatures are expected (e.g., Thermal Storage Walls).

Another possible finish is the so-called "selective surface," a coating which has a very high absorptivity of incoming solar radiation, but a very low emissivity of heat. Such coatings can be very effective at increasing the thermal efficiency of passive solar storage components and manufacturer's data should be referenced for specific performance characteristics.

Texture

One final note should be added concerning customized CMUs which have architecturally finished faces. Such units present a greater amount of exposed surface area for heat exchange to the surrounding air than do standard flat-surfaced CMUs. It might be assumed that such increased exposure might influence the performance of installations using these materials but this has not, as yet, been proven to be true. Until more accurate data is compiled in this regard, it is recommended that customized concrete masonry units be used interchangeably with standard units in passive solar storage applications.

Thermal Properties

From the point of view of thermal performance in a passive solar application, the most important material characteristics of any particular concrete masonry unit are its conductivity, density, specific heat, and thickness.

A material's conductivity (k) is a measure of how readily the material will transfer or "conduct" heat: the higher the conductivity, the faster heat will travel through a material. In general, thermal performance increases as the conductivity increases.

The remaining three basic material characteristics (density, specific heat, and thickness) can also be used as indicators of anticipated thermal performance. When multiplied together they yield the so-called "thermal storage capacity" of a specific unit of material. Essentially, this characteristic is a measure of the ability of a given unit of material to store heat. The higher the thermal storage capacity, the greater the amount of heat the unit can absorb and store.

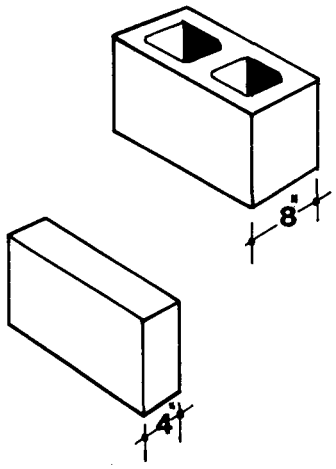
In the case of concrete masonry, the specific heat for the majority of available units remains basically constant. Thus the major variables which will determine the thermal storage capacity of a CMU are its density (measured in lb/ft^3) and its thickness.

In general, concrete masonry units can be divided into two broad categories of material density:

- "Dense or normal weight," employing sand, gravel, crushed stone, or air-cooled blast-furnace slag as aggregate.
- "Lightweight," using expanded shale, clay, and slate, expanded blast-furnace slag, sintered fly ash, coal cinders, or natural lightweight materials such as pumice or scoria.

By weight, concrete masonry is considered "lightweight" if its density is 105 pounds per cubic foot or less, "medium weight" if between 105 and 125 pcf, and "normal weight" if over 125 pcf. It is recommended that the heavier weight CMUs be used in passive solar storage applications.

The weight of any specific concrete masonry unit will be a function of the density of the concrete used and the volume of this concrete in the particular unit. In the case of hollow units the volume of concrete comprises the overall volume of the unit minus the volume of the cores. The concept of "equivalent solid thickness," used for rating a unit's fire resistance capability, comes to mind in this regard as a method for visualizing the "real" shape of a hollow core block:



In terms of thermal performance, however, such a model is misleading. In passive solar applications where concrete masonry is being used as a storage medium, an 8" hollow block with a 50% core area does not perform like a 4" solid unit. Heat transfer through the webs and across the air spaces formed by the cores is not uniform and the amount of heat reaching the far side of the block is considerably less in an 8" hollow unit than it is in a 4" solid one.

It is for this reason that filling all hollow concrete masonry cores when they are used as passive solar storage media is recommended (grout, small size normal weight aggregate, or other materials are suitable). For the purpose of analysis, when the grout or other material in the cores is of different density than the CMU itself, a weighted average of the densities involved should be used. The density of the joint mortar employed should be considered to be the same as that of the CMU itself.

Table 4.8 presents thermal performance data for a variety of CMUs with different thicknesses, densities, and grout types. The table can be used for general performance comparisons between the various material combinations presented, or specific information can be extracted for use with the Analysis Tools discussed in Appendix C. It should be noted that the conductivity (k) values presented are for the CMU material only.

In general, the higher the thermal storage capacity of a given unit, the better its performance from a passive solar point of view. This should be kept in mind when selecting a specific CMU for a specific installation. For example, given that a nominal 8" CMU wall is desired for a particular passive installation, the combination of unit density and grout type which results in the highest possible thermal storage capacity should generally be specified (subject to local cost considerations).

For grout types and block densities not covered in the tables, a good rule of thumb is to assume that, for a given unit thickness, the higher the density of the unit and/or of the grout, the greater the overall thermal storage capacity. It can also be assumed that the thermal storage capacities for thicknesses greater than 12" will roughly equal the sum of the capacities of smaller units which, when added together, will equal the total overall thickness desired. For example, the thermal storage capacity per square foot for a 20" thick wall of 80 lb. density block and 100 lb. grout will roughly equal the sum of the capacities of one 8" and one 12" block wall (12.4 + 19.2 = 31.6) or of two 10" walls (15.8 + 15.8 = 31.6).

It should be noted that some concrete masonry manufacturers in the United States produce CMUs with higher densities than those listed in Table 4.3. Should higher densities be required, local manufacturers of concrete masonry units should be consulted in advance.

Concrete Masonry Units: Physical Properties Table 4.8

Unit Thickness*	Unit Density∞	Specific Heat Θ	Thermal Storage Capacity Σ			R-Value Δ			Conductivity Ω
			A	B	C	A	B	C	
3"	80	.22		3.5			0.95		2.5
	95	.22		4.1			0.72		3.3
	105	.22		4.5			0.66		3.6
	125	.21		5.2			0.39		6.1
	135	.21		5.6			0.29		8.1
4"	80	.22	3.5	5.9	6.6	n/a	n/a	n/a	2.5
	95	.22	4.0	6.5	7.2	n/a	n/a	n/a	3.3
	105	.22	4.5	6.9	7.6	n/a	n/a	n/a	3.6
	125	.21	5.0	7.3	8.1	n/a	n/a	n/a	6.1
	135	.21	5.5	7.8	8.5	n/a	n/a	n/a	8.1
6"	80	.22	5.3	9.1	10.2	1.79	1.84	1.37	2.5
	95	.22	6.3	10.0	11.2	1.58	1.61	1.17	3.3
	105	.22	6.9	10.7	11.8	1.45	1.48	1.06	3.6
	125	.21	7.9	11.5	12.5	1.21	1.24	.85	6.1
	135	.21	8.5	12.1	13.1	1.08	1.11	.76	8.1
8"	80	.22	6.3	12.4	14.1	2.07	2.48	1.83	2.5
	95	.22	7.6	13.7	15.4	1.79	2.18	1.56	3.3
	105	.22	8.4	14.4	16.1	1.64	2.01	1.42	3.6
	125	.21	9.5	15.3	17.0	1.35	1.68	1.15	6.1
	135	.21	10.2	16.0	17.7	1.21	1.49	1.02	8.1
10"	80	.22	7.2	15.8	18.4	2.22	3.10	2.22	2.5
	95	.22	8.5	17.1	19.7	1.92	2.75	1.92	3.3
	105	.22	9.5	18.1	20.7	1.76	2.55	1.76	3.6
	125	.21	10.8	19.0	21.5	1.45	2.15	1.45	6.1
	135	.21	11.7	19.9	22.3	1.30	1.92	1.30	8.1
12"	80	.22	8.4	19.2	22.5	2.39	3.73	2.64	2.5
	95	.22	9.9	20.7	24.1	2.06	3.32	2.29	3.3
	105	.22	10.9	21.7	25.1	1.88	3.08	2.10	3.6
	125	.21	12.5	22.9	26.1	1.54	2.59	1.75	6.1
	135	.21	13.5	23.9	27.1	1.38	2.31	1.57	8.1

* 3" units solid CMU pavers.

A Cores hollow.
B Cores filled with 100 lb/ft^2 grout.
C Cores filled with 130 lb/ft^2 grout.
n/a data not available

∞ - Units of lb/ft^3
Θ - Units of btu/lb/°F
Σ - Units of btu/ft^2/°F
Δ - Units of hr °F/ft^2/btu
Ω - Units of btu in/hr/°F/ft^2

Concrete is essentially a mixture of two elements: aggregate and paste. The paste is made of Portland cement and water and it binds the aggregate (sand plus gravel or crushed stone) into a solid mass as it hardens due to a chemical reaction between the cement and water. The paste is usually between 25% and 40% of the total volume of the concrete, with aggregates comprising the remainder.

Concrete can be separated into the following four general categories based on density:

- Normal Weight Concrete (135-160 lb/ft^3) using sand, gravel, crushed stone, or air-cooled blast furnace slag as aggregate.
- Structural Lightweight Concrete (85-115 lb/ft^3).
- Insulating Lightweight Concrete (15-90 lb/ft^3) using pumice, scoria, perlite, vermiculite, or diatomite as aggregate.
- Heavyweight Concrete (160-400 lb/ft^3) using barite, limonite, magnetite, ilmenite, hematite, iron, or steel slugs as aggregate.

The most commonly used concrete is Normal Weight and this general type is recommended for most passive solar applications. Structural Lightweight is appropriate for use as floor fill over wood structural floors.

Concrete can be used in a wide variety of wall, floor and roof/ceiling applications which make use of either cast-in-place or precast elements. In the single-family, detached residential sector the use of precast concrete elements is quite uncommon. Cast-in-place concrete, on the the other hand, is commonly used for footings, foundation/basement walls, and slabs-on-grade. In such applications, although the possible thicknesses of cast-in-place elements are basically infinite, dimensions are generally as follows:

- Walls - 6, 8, 10, or 12 inches
- Structural floors - 4 to 8 inches
- Slabs-on-grade - 2 to 4 inches
- Floor fill - 1 1/2 to 2 1/2 inches
- Roofs/ceilings - not applicable

Precast elements also come in a wide variety of possible dimensions. The most common thicknesses are as follows:

- Solid slabs and tees - 2, 3, 4, 5, 6 and 8 inches (tee thickness is for slab portion only, exclusive of stem).
- Hollow core slabs - 6, 8, 10 and 12 inches.

Lengths can vary, as can widths, for solid slabs. Widths for tees and hollow core slabs are generally 2'-0", 4'-0" or 8'-0".

Construction

In most passive installations construction with concrete will follow standard practice. The only major departure from typical construction is placing insulation on the outside of concrete used for Direct Gain storage (e.g., in a solid concrete exterior wall). This change requires only minor modifications to the building process and is fully covered in the details in Section 3.0000.

Finishes

In Thermal Storage Wall and Attached Sunspace construction the exterior face of a concrete wall is used to absorb and

store heat and is protected from the environment by the collector glazing. Unfinished concrete of a dark color performs best in these conditions. In Direct Gain systems, however, the exterior face of a solid concrete wall is not protected by the collector glazing. If this face is exposed directly to the environment and not protected by some form of insulation and finish, stored heat will travel through the wall and be lost to the outside, severely reducing the thermal performance of the overall system.

There is a variety of methods for finishing the exterior of a concrete wall including paint, stain, stucco, and siding. Placing insulation on the outside of exterior walls being used for passive solar energy storage, requires that such finishes be applied over this insulation. Methods of applying these finishes are discussed in Section 3.0000.

Exterior finishes will affect the thermal performance of a Direct Gain storage component only insofar as they increase the effective insulation of that component. If a wall which is absorbing heat at its interior face is well insulated on its exterior it will retain more of the heat energy imparted to it and will thus serve as a more efficient solar energy storage medium.

It is recommended that interior finishes be kept to a minimum in order to preserve the inherent thermal performance capabilities of the concrete itself. For example, covering the interior face of a concrete storage component such as a Direct Gain wall, with gypsum board or wood paneling will reduce both the amount of solar energy reaching the wall and the amount which is reradiated from it to the space. This is especially true of covering a concrete slab floor with wall-to-wall carpet, which is emphatically not recommended. Although the exact negative effects of such coverings have not been quantified, a good rule of thumb is to assume that, relative to other finish materials, the higher the insulating value of a given finish, the more it will inhibit the passive thermal performance of the component to which it is applied.

Carrying this concept one step further, it is obvious that putting insulation on the interior surface of a concrete component (e.g., a Direct Gain wall) used for energy storage is extremely counter-productive and will essentially nullify any passive benefits that might have been derived from the installation. It is for this reason that it is recommended that no passive solar storage component (wall, floor, or roof/ceiling) be insulated on its interior face.

Special mention must be made concerning finishes for slab-on-grade floors which are used for thermal storage. As previously mentioned, such floors should never be covered with carpet. One alternative to carpet is to stamp the slab (while wet) with any one of a variety of surface textures. If done with proper care, this technique will result in a very handsome floor surface which can be waxed or polished and which will retain its inherent thermal performance capability. Imaginative layouts of the control joints can also help make standard wood float or steel trowel finished slabs more attractive. Alternate finished surfaces, such as exposed aggregate, tile, and brick or CMU pavers, can also be used effectively.

Color

When concrete is used to both absorb and store solar energy the surface exposed to solar radiation should be as dark a color as possible to increase absorption of light and heat. Other surfaces in a space, such as wood frame walls, which are not being used for storage should be light in color in order to reflect more light to the darker storage material (e.g., a concrete floor). For a listing of the solar absorptance characteristics of various colors/materials see Appendix A.

Colored concrete can be produced by utilizing colored aggregate, by adding

color pigments, or both. The concrete can also be stained or painted. It is recommended that paints or stains which do not degrade when subjected to high temperatures be specified in applications where such temperatures are expected (e.g., Thermal Storage Walls).

Another possible finish is the so-called "selective surface," a coating which has a very high absorptivity of incoming solar radiation, but a very low emissivity of heat. Such coatings can be very effective at increasing the thermal efficiency of passive solar storage components, and manufacturer's data should be referenced for specific performance characteristics.

Texture

Exposed concrete can also be textured in a number of different fashions. Patterns can be created by the particular mold employed, or aggregate can be exposed by a number of different methods, including washing, brushing, using retarders, scrubbing, abrasive blasting, tooling, or grinding. The net result of such techniques is to expose more surface area for heat exchange with surrounding air. It might be assumed that such increased exposure would influence the heat storage performance of components using these textured concretes, but this has not, as yet, been proven to be true. It is therefore recommended that textured and unfinished concrete be used interchangeably in passive solar storage applications.

Thermal Properties

From the point of view of thermal performance in a passive solar application, the most important material characteristics of a particular concrete mixture are its conductivity, density, specific heat, and thickness.

A material's conductivity (k) is a measure of how readily the material will transfer or "conduct" heat: the higher the conductivity, the faster heat will travel through a material. In general, thermal performance increases as the conductivity increases.

The remaining three basic material characteristics (density, specific heat, and thickness) can also be used as indicators of anticipated thermal performance. When multiplied together they yield the so-called "thermal storage capacity" of a specific unit of material. Essentially, this characteristic is a measure of the ability of a given unit of material to store heat. The higher the thermal storage capacity, the greater the amount of heat the unit can absorb and store.

In the case of concrete, the specific heat for the majority of mixtures and densities commonly used in residential construction varies only slightly. Thus the major variables which will determine the thermal storage capacity of a concrete component are its density (measured in lb/ft^3) and its thickness.

As discussed above, concrete can be divided into four broad density classifications:

- Normal weight: 135-160 lb/ft^3
- Structural lightweight: 85-115 lb/ft^3
- Insulating lightweight: 15- 90 lb/ft^3
- Heavyweight: 160-400 lb/ft^3

Tables 4.9 and 4.10 present thermal performance data, including thermal storage capacities, for a variety of concrete densities and thicknesses. The tables can be used for general performance comparisons between various thickness/density combinations or specific information can be extracted for use with the Analysis Tools discussed in detail in Appendix C.

The higher densities for heavyweight concrete are not shown, as this is not a very common building material and is principally used for radiation shielding.

Concrete: Physical Properties Table 4.9

Unit Thickness	Unit Density∞	Specific Heatθ	Thermal Storage CapacityΣ	R-ValueΔ	ConductivityΩ
2"	20	0.24	0.9	2.86	0.70
	50	0.23	1.9	1.34	1.50
	70	0.22	2.6	0.90	2.20
	90	0.22	3.3	0.60	3.30
	100	0.22	3.6	0.48	4.20
	110	0.21	3.9	0.38	5.30
	130	0.21	4.6	0.22	9.10
	145	0.21	5.0	0.15	13.30
3"	20	0.24	1.2	4.29	0.70
	50	0.23	2.9	2.01	1.50
	70	0.22	3.9	1.35	2.20
	90	0.22	4.9	0.90	3.30
	100	0.22	5.5	0.72	4.20
	110	0.21	5.8	0.57	5.30
	130	0.21	6.8	0.33	9.10
	145	0.21	7.6	0.23	13.30
4"	20	0.24	1.6	5.72	0.70
	50	0.23	3.9	2.68	1.50
	70	0.22	5.2	1.80	2.20
	90	0.22	6.6	1.20	3.30
	100	0.22	7.3	0.96	4.20
	110	0.21	7.6	0.76	5.30
	130	0.21	9.1	0.44	9.10
	145	0.21	10.2	0.30	13.30
5"	20	0.24	2.0	7.15	0.70
	50	0.23	4.8	3.35	1.50
	70	0.22	6.5	2.25	2.20
	90	0.22	8.2	1.50	3.30
	100	0.22	9.2	1.20	4.20
	110	0.21	9.7	0.95	5.30
	130	0.21	11.4	0.55	9.10
	145	0.21	12.7	0.38	13.30

∞ - Units of lb/ft^3
θ - Units of $btu/lb/°F$
Σ - Units of $btu/ft^2/°F$
Δ - Units of $hr\ °F/ft^2/btu$
Ω - Units of $btu\ in/hr/°F/ft^2$

Concrete: Physical Properties Table 4.10

Unit Thickness	Unit Density∞	Specific Heat θ	Thermal Storage Capacity Σ	R-Value Δ	Conductivity Ω
6"	20	0.24	2.5	8.58	0.70
	50	0.23	5.8	4.02	1.50
	70	0.22	7.6	2.70	2.20
	90	0.22	9.9	1.80	3.30
	100	0.22	10.9	1.44	4.20
	110	0 21	11.5	1.14	5.30
	130	0.21	13.7	0.66	9.10
	145	0.21	15.3	0.45	13.30
8"	20	0.24	3.2	11.44	0.70
	50	0.23	7.6	5.36	1.50
	70	0.22	10.2	3.60	2.20
	90	0.22	13.3	2.40	3.30
	100	0.22	14.7	1.92	4.20
	110	0.21	15.4	1.52	5.30
	130	0.21	18.1	0.88	9.10
	145	0.21	20.3	0.60	13.30
10"	20	0.24	4.0	14.30	0.70
	50	0.23	9.7	6.70	1.50
	70	0.22	13.4	4.50	2.20
	90	0.22	16.6	3.00	3.30
	100	0.22	18.3	2.40	4.20
	110	0.21	19.8	1.90	5.30
	130	0.21	22.8	1.10	9.10
	145	0.21	25.3	0.75	13.30
12"	20	0.24	4.8	17.16	0.70
	50	0.23	11.5	8.04	1.50
	70	0.22	15.4	5.40	2.20
	90	0.22	19.9	3.60	3.30
	100	0.22	22.0	2.88	4.20
	110	0.21	23.0	2.28	5.30
	130	0.21	27.4	1.32	9.10
	145	0.21	30.4	0.90	13.30

∞ - Units of lb/ft^3
θ - Units of $btu/lb/^\circ F$
Σ - Units of $btu/ft^2/^\circ F$
Δ - Units of $hr\ ^\circ F/ft^2/btu$
Ω - Units of $btu\ in/hr/^\circ F/ft^2$

Its heavier density will improve its thermal performance in a passive solar application but the exact extent of this improvement is not known. If use of heavyweight concrete is anticipated, manufacturer's specifications should be referenced, where possible, for specific thermal performance data.

In general, the higher the thermal storage capacity of a given component, the better its performance from a passive solar point of view. This should be kept in mind when selecting a specific concrete mixture for a specific installation. For example, given that an 8" concrete wall is desired for a particular passive installation, the density which results in the highest possible thermal storage capacity should generally be specified (subject to local cost considerations).

It can also be assumed that the thermal storage capacities for thicknesses greater than 12" will roughly equal the sum of the capacities of smaller thicknesses which, when added together, will equal the total overall dimension desired. For example, the thermal storage capacity per square foot of a 20" thick wall of 100 lb. density concrete will roughly equal the sum of the capacities of one 8" and one 12" wall (14.7 + 22.0 = 36.7) or of two 10" walls (18.3 + 18.3 = 36.6).

A brick is generally defined as a small building unit, solid or cored, formed from clay or shale into a rectangle and hardened by heat. Bricks are referred to as "solid" when the net cross-sectional area is 75% or more of its gross cross-sectional area. Most "cored" units are in this category. Bricks are referred as "hollow" when the net cross-sectional area is less than 75% but more than 60% of its gross cross-sectional area. It is recommended that all hollow bricks used for passive solar storage be fully grouted in addition to regular mortaring.

These general categorizations comprise a number of specific brick types which differ from each other in terms of texture, color, degree of water absorption, strength, and durability. These differences, however, do not significantly affect the thermal performance characteristics of the majority of brick types (see "Thermal Properties" subsection below).

Brick should be specified by the appropriate American Society for Testing and Materials (ASTM) Standards:

- ASTM C 216, Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale)
- ASTM C 62, Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale)
- ASTM C 652, Standard Specification for Hollow Brick (Hollow Masonry Units Made from Clay or Shale)
- ASTM C 902, Standard Specification for Pedestrian and Light Traffic Paving Brick
- ASTM C 126, Standard Specification for Ceramic Glazed Structural Clay Facing Tile, Facing Brick, and Solid Masonry Units

Brick construction is based on a modular system of dimensions for all standard products. Table 4.11 lists some of the typical industry sizes. The dimensions of the units listed in the table are "nominal." Actual dimensions are equal to the nominal dimension minus the thickness of the mortar joint with which the unit is designed to be laid. In general, such mortar joints are either 3/8" or 1/2" thick. Thus a brick which is nominally 4" by 2 3/4" by 8" can be 3 1/2" by 2 1/4" by 7 1/2" or 3 5/8" by 2 1/4" by 7 5/8", depending on the specifications for a particular application. Note that the vertical dimension does not always change and the difference in mortar joint size is made up in the coursing of the brick as it is constructed.

Although some solid brick units are manufactured without cores, most bricks are cored to some degree to reduce unit weight and improve firing, resulting in a denser and more durable product. The cores in solid brick units will not significantly affect the thermal performance of brick masonry used in passive solar storage applications. The process of laying brick usually results in the cores being filled with mortar and thus the thermal storage is not significantly different from comparable solid units. However, when using hollow brick units as thermal storage media, large cores should be grouted.

Illustrated in Figures 4.12 and 4.13 are some of the representative sizes and shapes of bricks on the market today.

Construction

In most passive installations, construction with brick will follow standard practice. The only major departure from

Brick: Typical Sizes Table 4.11

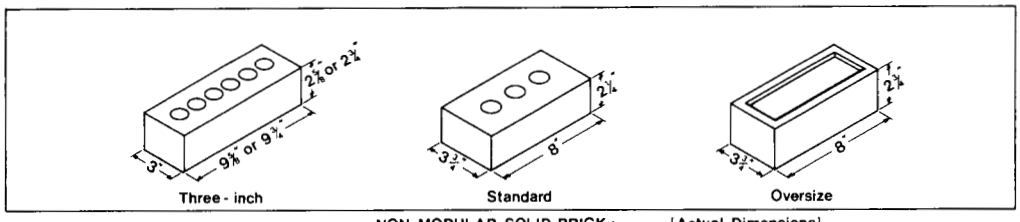
Nominal Dimensions			Joint Thickness	Manufactured Dimensions			Modular Coursing*
t	h	l		t	h	l	
4"	4"	12"	3/8"	3-5/8"	3-5/8"	11-5/8"	1C=4"
4"	4"	12"	1/2"	3-1/2"	3-1/2"	11-1/2"	1C=4"
6"	4"	12"	3/8"	5-5/8"	3-5/8"	11-5/8"	1C=4"
6"	4"	12"	1/2"	5-1/2"	3-1/2"	11-1/2"	1C=4"
8"	4"	12"	3/8"	7-5/8"	3-5/8"	11-5/8"	1C=4"
8"	4"	12"	1/2"	7-1/2"	3-1/2"	11-1/2"	1C=4"
12"	4"	12"	3/8"	11-5/8"	3-5/8"	11-5/8"	1C=4"
12"	4"	12"	1/2"	11-1/2"	3-1/2"	11-1/2"	1C=4"
6"	5-1/3"	12"	3/8"	5-5/8"	4-7/8"	11-5/8"	3C=16"
6"	5-1/3"	12"	1/2"	5-1/2"	4-3/4"	11-1/2"	3C=16"
8"	5-1/3"	12"	3/8"	7-5/8"	4-7/8"	11-5/8"	3C=16"
8"	5-1/3"	12"	1/2"	7-1/2"	4-3/4"	11-1/2"	3C=16"
4"	8"	8"	3/8"	3-5/8"	7-7/8"	7-7/8"	1C=8"
4"	8"	8"	1/2"	3-1/2"	7-1/2"	7-1/2"	1C=8"

t thickness
h height
l length

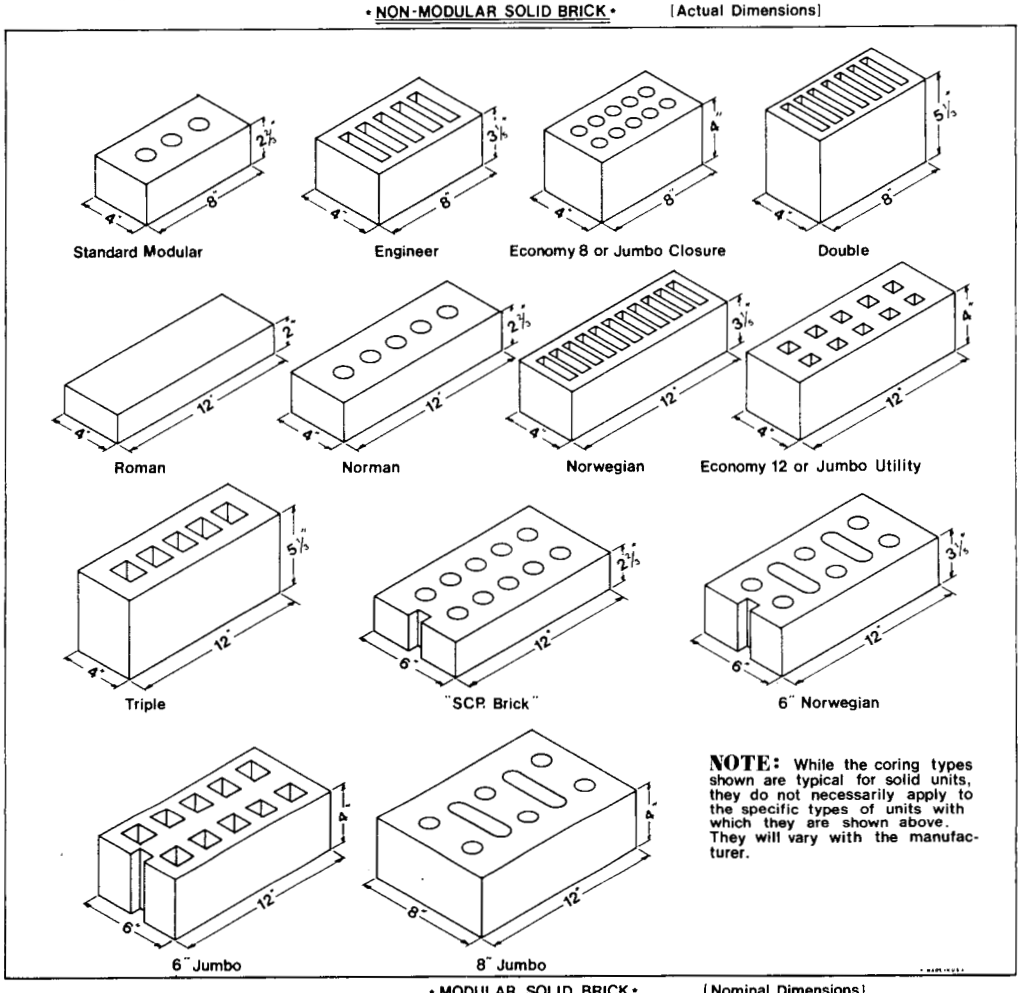
* Dimensions are for the number of courses indicted (e.g. 1C = 1 course).

Brick: Typical Shapes

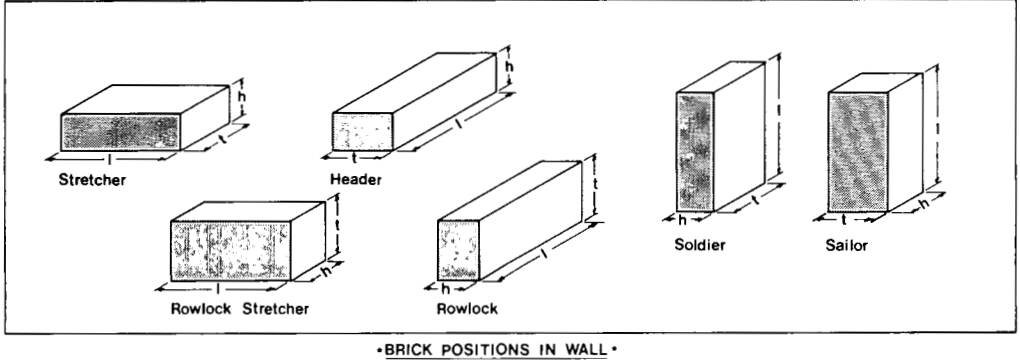
Figure 4.12



• NON-MODULAR SOLID BRICK • [Actual Dimensions]



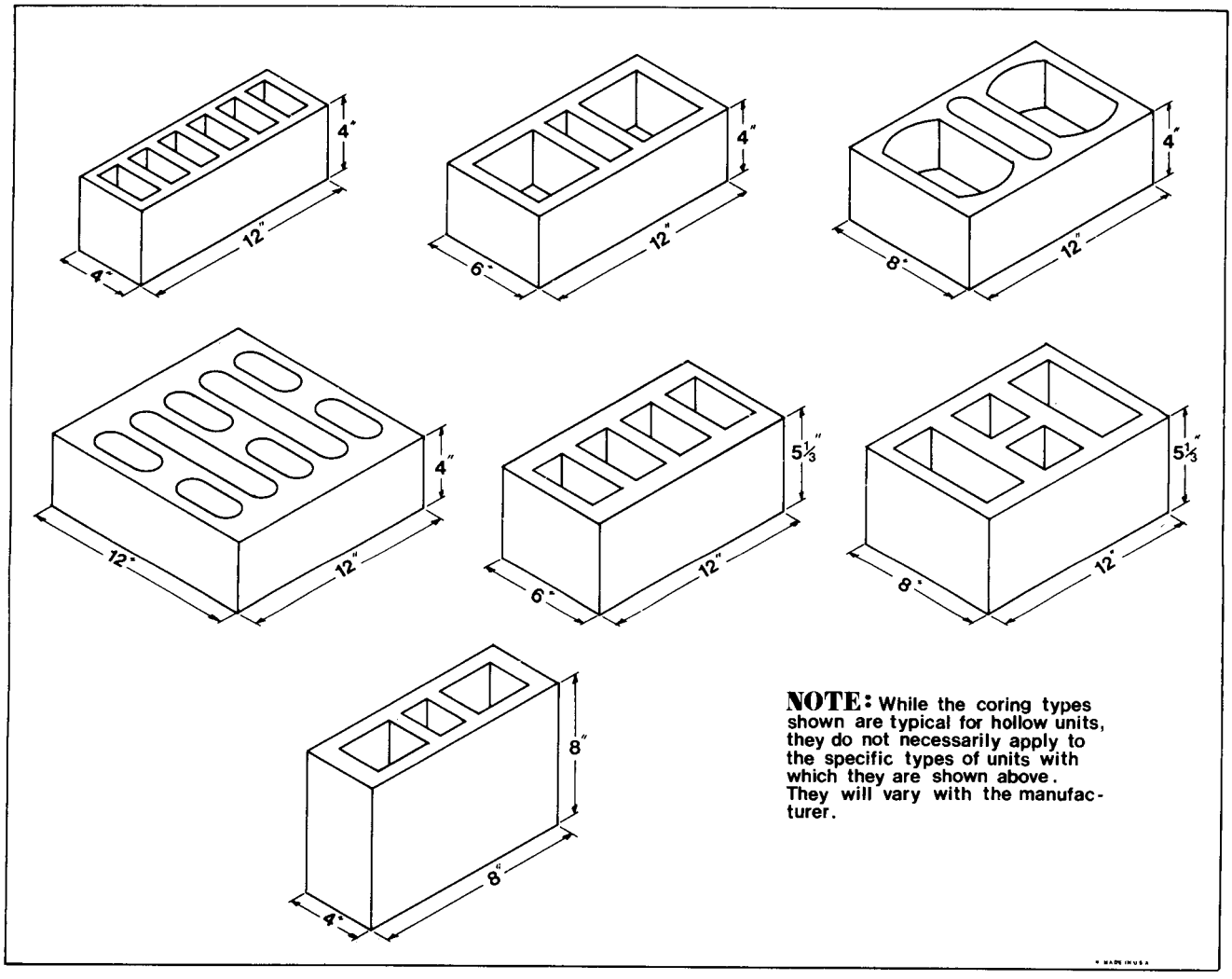
• MODULAR SOLID BRICK • [Nominal Dimensions]



• BRICK POSITIONS IN WALL •

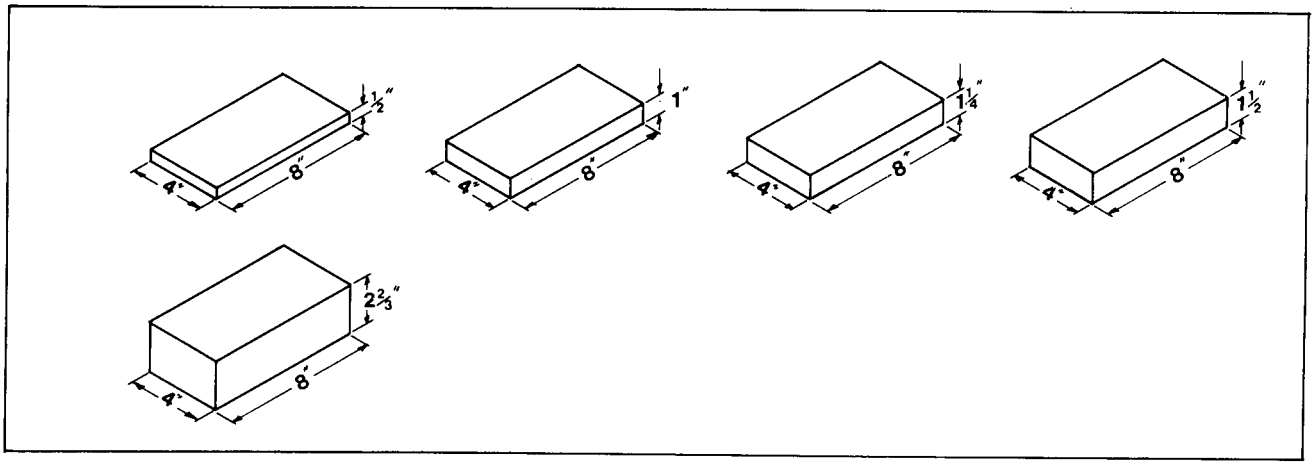
Brick: Typical Shapes

Figure 4.13



NOTE: While the coring types shown are typical for hollow units, they do not necessarily apply to the specific types of units with which they are shown above. They will vary with the manufacturer.

* MODULAR HOLLOW BRICK * (Nominal Dimensions)



* MODULAR PAVING BRICK * (Nominal Dimensions)

typical construction is placing insulation on the outside of a brick being used for Direct Gain storage (e.g., in a solid brick exterior wall). This and other changes require only minor modifications to the building process and are fully covered in the details in Section 3.0000.

Finishes

In Thermal Storage Wall and Attached Sunspace construction the exterior face of a brick wall is used to absorb and store heat and is protected from the environment by the collector glazing. Unfinished brick of a dark color performs best in these conditions. In Direct Gain systems, however, the exterior face of a solid brick wall is not protected by the collector glazing. If this exterior face is exposed directly to the environment and not protected by some form of insulation and finish, stored heat will travel through it and be lost to the outside, severely reducing the thermal performance of the overall system.

There is a variety of methods for finishing the exterior of a brick wall being used for Direct Gain storage. Because it is recommended that insulation be placed on the outside of exterior walls being used for Direct Gain storage, such finishes will need to be applied over this insulation. In a standard masonry bearing wall configuration, stucco or siding can be applied over insulation which has been adhered to the brick wall. In typical brick veneer wall construction, the configuration of the materials can be inverted, moving the masonry to the inside for heat storage and the insulated bearing frame wall to the outside. Siding can then be applied in the conventional manner. Neither of these configurations, however, provides a brick appearance on the outside of the house. In order to obtain this appearance while maintaining the passive solar performance characteristics of interior brick masonry, a cavity wall can be specified. If well-insulated, such a wall will provide both the aesthetic appeal of brick on the exterior (exterior wythe) and the heat storage capacity of brick on the interior (interior wythe). The cavity insulation will ensure that stored heat will not be lost while still providing a brick appearance on the exterior (see Section 3.1000 for details).

It is recommended that interior finishes be avoided in order to preserve the inherent thermal performance capabilities of the brick itself. For example, if a finish such as wood paneling or gypsum board is applied to the interior face of a brick wall intended to absorb and store solar energy, it will not only hide the brick, but will reduce both the amount of heat reaching the wall and the amount reradiated from the wall back to the space. This is especially true of covering a brick paver floor with wall to wall carpet, which is emphatically not recommended. Although the exact negative effects of such coverings have not been quantified, a good rule of thumb is to assume that, relative to other finish materials, the higher the insulating value of a given finish, the more it will inhibit the passive thermal performance of the installation to which it is applied.

Carrying this concept one step further, it is obvious that putting insulation on the interior surface of a brick component (e.g., Direct Gain wall) used for energy storage is extremely counter-productive and essentially nullifies any passive benefits that might have been derived from the component. It is for this reason that it is recommended that no passive solar storage component (wall, floor, or roof/ceiling) be insulated on its interior face.

Color

Where brick is used to both absorb and store solar energy, the surface exposed to solar radiation should be as dark a color as possible to increase absorption of light and heat. Other surfaces, such as standard frame walls, not being used for storage should be light in color in

order to reflect as much sunlight as possible on the darker storage material.

Although black is the most desirable storage material color from a thermal performance point of view, certain of the darker natural brick colors (browns, blues and reds) will perform almost as effectively. Using the exposed natural brick will avoid maintenance problems which might result from the use of paint. For a listing of the solar absorptance characteristics of various colors/ materials see Appendix A.

Brick with a glazed ceramic coating should be avoided as the finish will reflect a percentage of the solar radiation striking it. Many brick manufacturers, however, can supply brick with dull black ceramic glazed faces which perform as well as the dull finishes on natural colored brick.

Another possible finish is the so-called "selective-surface," a coating which has a very high absorptivity of incoming solar radiation, but a very low emissivity of heat. Such coatings can be very effective at increasing the thermal efficiency of passive solar components, and manufacturer's data should be referenced for specific performance characteristics.

Texture

Although it would seem at first glance that rough textured brick, by providing more surface area for the collection of energy, would be more effective than smooth brick as an energy storage medium, it has been determined that this is not the case. It appears that brick texture does not have a major impact on the performance of passive solar installations and that any desired texture can be used without significant loss or gain in effectiveness.

Thermal Properties

In terms of thermal performance, the most important material characteristics of a brick unit are its conductivity, density, specific heat, and thickness.

A material's conductivity (k) is a measure of how readily the material will transfer or "conduct" heat. The higher the conductivity, the faster heat will travel through a material. In general, thermal performance increases as the conductivity increases.

The remaining three basic material characteristics (density, specific heat, and thickness) can also be used as indicators of anticipated thermal performance. When multiplied together they yield the so-called "thermal storage capacity" of a specific unit of material. Essentially, this characteristic is a measure of the ability of a given unit of material to store heat. The higher the thermal storage capacity, the greater the amount of heat the unit can absorb and store.

In the case of brick, the specific heat, for the majority of units commonly used in residential construction, remains basically constant. Thus the major variables which will determine the thermal storage capacity of a brick unit are its density (measured in lb/ft^3), which varies only slightly, and its thickness.

Table 4.12 presents thermal performance data, including thermal storage capacities, for a variety of bricks with different thicknesses and two different densities. The table can be used for general performance comparisons between the various brick types presented, or specific information can be extracted for use with the Analysis Tools discussed in Appendix C.

In general, the higher the thermal storage capacity of a given unit, the better its performance in a passive solar application. This should be kept in mind when selecting a specific brick for use as a storage component. It is evident from Table 4.12 that thicker bricks will have higher thermal storage capaci-

Brick: Physical Properties Table 4.12

Brick Type[1]	Unit Thickness	Unit Density∞	Specific Heat[2] θ	Thermal Storage Capacity[3] Σ	R-Value Δ	Conductivity Ω
Paver	1-5/8"	120	0.24	3.90	0.36	5.00
Paver		130	0.24	4.23	0.20	9.00
Paver	2-1/4"	120	0.24	5.40	0.50	5.00
Paver		130	0.24	5.85	0.27	9.00
Common	4"	120	0.24	8.70	0.80	5.00
Facing		130	0.24	9.43	0.44	9.00
Common	6"	120	0.24	13.50	1.20	5.00
Facing		130	0.24	14.63	0.66	9.00
Common	8"	120	0.24	18.30	1.60	5.00
Facing		130	0.24	19.83	0.88	9.00
Common	10"	120	0.24	23.10	2.00	5.00
Facing		130	0.24	25.03	1.10	9.00
Common	12"	120	0.24	27.90	2.40	5.00
Facing		130	0.24	30.23	1.32	9.00
Common	16"	120	0.24	37.50	3.20	5.00
Facing		130	0.24	40.63	1.76	9.00

1 When using hollow units grouted, use values for Common Brick. When using paving units, use values for Facing Brick.
2 Specific heat may vary from 0.20 to 0.26; 0.24 is typical.
3 Thermal Storage Capacities are for actual dimensions of units listed.

∞ - Units of lb/ft^3
θ - Units of $btu/lb/^\circ F$
Σ - Units of $btu/ft^2/^\circ F$
Δ - Units of $hr\ ^\circ F\ ft^2/btu$
Ω - Units of $btu\ in/hr/^\circ F/ft^2$

ties and, within the Rules of Thumb guidelines set out in Section 3.0000, will generally perform better than thinner units.

It can also be assumed that the thermal storage capacities for thicknesses greater than 16" will roughly equal the sum of the capacities of smaller units which, when added together, will equal the overall thickness desired. For example, the thermal capacity per square foot for a 20" thick wall of facing brick will roughly equal the sum of the capacities of one 8" and one 12" wall (20.8 + 31.2 = 52.0) or of two 10" walls (26.0 + 26.0 = 52.0).

Mention should be made of the potential use of Magnesia brick as a passive storage medium. Magnesia brick exhibits much higher thermal conductivities than clay and shale brick. It is not, however, markedly superior in its capacity to store heat. Rather, it is capable of delivering more heat to the interior of a space and of holding it there. Such a capability can be useful in situations where relatively rapid heat transfer is desired, but can also have the drawback of causing a space to overheat during sunny days. Because Magnesia brick is also significantly more expensive than common brick, its advantages and disadvantages should be carefully weighed before it is substituted for common brick in passive solar applications.

It must also be noted that little documentation is available regarding the thermal performance of the various types of mortar which can be used in brick construction. Therefore, when conducting a thermal performance analysis it is recommended that a brick installation be considered solid brick without any mortar joints at all. This is equivalent to assuming that the mortar will exhibit the same thermal performance characteristics as the brick itself.

Introduction

This section of the Handbook presents basic information on passive solar CONTROL components. There are three basic types of control components, each of which is discussed in a separate subsection below: Shading, Reflecting, and Insulating.

Each subsection includes a general definition of the component being presented and a review of commonly available varieties and physical configurations.

(Author's Note: more specific material and construction information concerning actual products will be the subject of a future update of the Handbook.)

As its name implies, a control component is used to control the amount of heat gained and/or lost by a passive system during its day-to-day, as well as its seasonal, cycles. Heat gain can be controlled by any of a large number of shading, reflecting, and insulating devices, either alone or in various combinations with each other. These devices can be fixed or operable and can be manipulated to either inhibit or enhance the amount of heat generated by a given system, depending on seasonal or daily requirements.

Heat loss is primarily controlled by insulating devices, which can also be fixed or operable and which can be utilized to prevent heat loss during the heating season while controlling heat gain during the cooling season.

In most passive systems, some form of shading is required to avoid overheating during the cooling season. Shading devices can be placed on either the inside or the outside of the glazing. If placed on the exterior, the shade will intercept direct solar radiation before it strikes the collector. Such shades can be fixed or operable. Examples include: simple overhangs (fixed or adjustable), trellises, vegetation (trees, etc.), and shutters. None of these elements will cause serious construction problems and their addition to any passive system will improve performance considerably.

Shading devices placed inside the collector are not as thermally efficient as those placed on the exterior because they allow sunlight to penetrate into the space where it can cause heat gain. However, this heat build-up is usually restricted to the window surface and can be vented. Interior shades are typically light in color to reflect radiant energy back out the window before it can be converted to heat. Interior shades are easier to operate and maintain than most operable exterior elements. Some examples of components providing interior shading include: roller shades, blinds, drapes, and movable panels. These components are especially effective if they can also be designed to provide insulation during the day in the cooling periods and at night in the heating periods (see Section 4.4300, "Insulating").

In passive solar applications reflectors operate in a manner exactly opposite to that of shading devices. They enhance the collection of solar energy, and therefore heat, rather than reduce it. Reflectors are most useful, and result in the most significant performance increases, in areas where site obstructions prevent sufficient sunlight from reaching the collector. In certain situations, reflectors can increase collection of solar radiation 30 to 40%.

The most common type of reflector is a rigid panel, coated on one side with a material of high reflectance (e.g., aluminum) and placed adjacent to the collector. Typically these reflector panels are designed to close onto the collector and function as movable insulation during periods of heat loss.

If such panels are not feasible for a given application, solar collection can also be enhanced, although not as significantly, by reflections from adjacent light colored exterior surfaces. Examples include patios and terraces made of concrete or white gravel, as well as decks and balconies with light colored finishes.

Passive solar insulating components can be separated into two basic categories: fixed insulation which is permanently installed to reduce heat loss from a system's storage components; and, movable insulation which is usually located at the system collector and which is operated periodically to reduce nighttime and cloudy day heat loss (heating season) and/or daytime heat gain (cooling season).

Fixed Insulation

In order to be effective, fixed insulation must be placed on the exterior surface of storage components which would otherwise be directly exposed to the outside. This type of installation will prevent the heat absorbed and stored at the interior surface of, for example, a Direct Gain floor or wall, from being lost to the outside environment. If standard practice is followed and insulation is placed on the inside face of a storage component, the passive system is rendered ineffective.

Any of the materials commonly used for residential insulation can be employed as fixed exterior insulation for passive solar storage elements. The methods for attaching this insulation to the storage elements may differ slightly from standard practice (see Section 3.0000) but those differences require only minor modifications to standard construction practices.

Movable Insulation

Passive solar collectors, in addition to admitting and trapping large amounts of solar energy, can also lose large amounts of heat during the night. The provision of some form of movable insulation to prevent these losses will therefore have a significant impact on the overall thermal performance of any passive solar system. Such insulation, if in place during the daytime hours, can also be used to prevent unwanted heat gain during the cooling season.

Movable insulation can come in a variety of forms including: rigid panels, insulating shutters, insulating drapes and shades, and even double glazing with insulation integrated into the airspace. Depending on their physical characteristics these devices can be used on the exterior or the interior of the collector. Interior applications are generally easier to operate and maintain and they avoid degradation due to weathering. Exterior applications have the advantage, during the cooling season, of also acting as exterior shades.

The most distinctive characteristic of movable insulation is that it is operable and, in general, must be manipulated by the homeowner on a day-to-day basis. Although some varieties can be thermostatically controlled, the majority require homeowner participation and are hand-operated or motor driven and controlled by a switch. The choice of technique will depend on market factors and a careful assessment of a prospective homeowner's willingness to become involved in the day-to-day management of the home. Manufacturer's data should be consulted for recommended installation procedures and operational techniques.

Introduction

The following is a selected BIBLIOGRAPHY of books, articles and papers which will provide additional information on topics covered in the Handbook. Included at the end of the BIBLIOGRAPHY are several trade periodicals which provide up-to-date information on new technologies, products and ideas related to passive and active solar energy. Entries are listed alphabetically by title.

The number(s) following each entry classify the overall subject matter into the following groups:

< 1 > Design Primer
< 2 > Case Studies
< 3 > Conference Proceedings
< 4 > Economics
< 5 > Energy Analysis
< 6 > Technical Literature
< 7 > Construction Guide
< 8 > Bibliography
< 9 > Product Guide
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ABSORBER - A solid surface, usually dark colored, which is exposed to, and struck by, sunlight and which transforms radiant solar energy to heat energy.

ABSORPTANCE - The ratio of the radiation absorbed by a surface to the total energy falling on that surface measured as a percentage.

ABSORPTIVITY - See "Absorptance."

ACTIVE SOLAR SYSTEM - A system that uses mechanical devices and an external energy source, in addition to solar energy, to collect, store, and distribute thermal (heat) energy.

AIR CHANGE - The replacement of a quantity of air in a volume within a given period of time. This is expressed in number of changes per hour. If a house has one air change per hour, all the air in the house will be replaced in a one-hour period.

AIRLOCK ENTRY - A vestibule enclosed with two air-tight doors for permitting entrance while limiting air or heat exchange.

AMBIENT TEMPERATURE - The prevailing temperature outside a building.

ANGLE OF INCIDENCE - The angle that the sun's rays make with a line perpendicular to a surface.

ANNUAL FUEL REQUIREMENT - Annual heating load divided by the product of the Mechanical Plant Efficiency (MPE) and a fuel conversion factor.

APERTURE - That part of the south facing glazing that contributes to solar heating; literally, an opening.

ASHRAE - Abbreviation for the American Society of Heating, Air-Conditioning, and Refrigerating Engineers.

AUXILIARY ENERGY SYSTEM - Equipment utilizing energy other than solar both to supplement the output provided by the solar energy system, as required by the design conditions, and to provide full energy backup requirements during periods when the solar heating or domestic hot water systems are inoperable.

AUXILIARY HEATING FRACTION (AHF) - That part of the total building heating requirements supplied by the auxiliary heating system.

AZIMUTH - The angular distance between true south and the point on the horizon directly below the sun.

BACK-UP SYSTEM - See "Auxiliary Energy System."

BERM - A man-made mound or small hill of earth.

BLACK BODY - A theoretically perfect absorber.

BTU (BRITISH THERMAL UNIT) - Basic heat measurement, equivalent to the amount of heat needed to raise 1 pound of water 1° Fahrenheit.

BTU/DD/FT^2 (HEATED AREA) - A unit commonly used to express the inherent ability of the building shell to resist heat loss.

BUILDING ENVELOPE - The elements of a building which enclose conditioned spaces through which thermal energy may be transferred to or from the exterior.

BUILDING LOAD COEFFICIENT (BLC) - BLC is

a rough measure of the insulating quality of the home, exclusive of the south facade, used in estimating the Solar Savings Fraction (SSF).

BUILDING SKIN CONDUCTANCE - Weighted average conductance of all the components of the building skin.

CALORIE (cal) - The quantity of heat needed to raise the temperature of one gram of water 1°C. One calorie is approximately .004 BTU.

CLERESTORY - Vertical window placed high in a wall near the eaves or between a lower roof and a higher roof, used for light, heat gain, and ventilation.

COLLECTOR - An area of transparent or translucent glazing commonly located on the south facing side of the home.

COLLECTOR EFFICIENCY - The amount of energy gathered by a collector compared to the amount striking it.

COMFORT RANGE - The range of climatic conditions within which people feel comfortable.

COMPONENT - An individually distinguishable product that forms part of a more complex product (i.e., subsystem of a system).

CONDUCTANCE (C) - The quantity of heat (Btu's) that will flow through one square foot of material in one hour, when there is a 1°F temperature difference between both surfaces. Conductance values are given for a specific thickness of materials, not per inch of thickness.

CONDUCTION - The transmission of heat through materials.

CONDUCTIVITY (k) - The quantity of heat (Btu's) that will flow through one square foot of a material, one inch thick, in one hour, when there is a temperature difference of 1°F between both surfaces.

CONTROL - A device or devices that regulate heat flow between the building and the exterior.

CONVECTION - The transfer of heat by movement of a fluid (liquid or gas).

CONVECTION, FORCED - Heat transfer through a medium such as air or water by currents caused by a device powered by an external energy source.

CONVECTION, NATURAL - Heat transfer of a fluid such as air or water that results from the natural rising of the lighter, warm fluid and the sinking of the heavier, cool fluid.

CONVECTIVE LOOP - The flow of air in a closed path induced by rising hot air and falling cold air.

"COOLTH" - A term used to describe the quality of a material at a lower than ambient temperature. "Coolth" is to cooling as warmth is to heating.

DECLINATION - The angular distance of the sun north or south of the celestial equator. The declination varies between +23½° (summer) to -23½° (winter).

DEGREE DAY (DD), COOLING - See degree day for heating, except that the base temperature is established at 65°F, and cooling degree days are measured above the base.

DEGREE DAY (DD), HEATING - A unit of heat measurement equal to one degree variation from a standard temperature (usually 65°F) in the average temperature of one day. If the standard is 65°F and the average outside temperature for one day is 50°F, then the number of degree days recorded for that day would be 15.

DELTA T (ΔT) - A difference in temperature.

DENSITY (p) - The mass of a substance

which is expressed in pounds per cubic foot.

DESIGN LIFE - The period of time during which a heating, cooling, or domestic hot water system is expected to perform its intended function without requiring major maintenance or replacement.

DESIGN TEMPERATURE - A designated temperature close to the most severe winter or summer temperature extremes of an area, used in estimating heating and/or cooling demand.

DIFFUSE RADIATION - Sunlight that is scattered by air molecules, dust, water vapor and translucent materials.

DIRECT GAIN (DG) - A passive system in which solar radiation is admitted directly into the conditioned (or living) space, where it is converted to heat and stored.

DIRECT RADIATION - Light that has traveled a straight path from the sun, as opposed to diffuse radiation.

DISTRIBUTION - Method by which heat is delivered to the living areas.

DRY BULB TEMPERATURE - A measure of the temperature of the air.

DWH - Domestic hot water.

ECONOMIC EFFICIENCY - Maximizing net benefits or minimizing costs for a given level of benefits.

EFFICIENCY - In solar applications, the amount of useful solar energy collected divided by the amount of solar energy available to the collector.

EMISSIVITY - The ability to radiate heat in the form of long wave radiation.

EMITTANCE - The ratio of the amount of heat radiated by a surface to the amount which would be radiated by a black body at the same temperature. Emittance values range from 0.05 for brightly polished metals to 0.96 for flat black paint.

ENERGY - The capacity for doing work. It takes a number of forms which may be transformed from one into another, such as thermal (heat), mechanical (work), electrical, and chemical; customarily measured in kilowatt-hours (kwh) or British thermal units (Btu).

ENERGY TRANSPORT SYSTEM - The portion of the heating and domestic hot water systems which contains heat transfer fluids and transports energy throughout the system.

EQUINOX - Either of the two times during the year when the sun crosses the celestial equator and when the length of day and night are approximately equal. These are the autumnal equinox on or about September 22 and the vernal equinox which is on or about March 22.

FIRST COST - A measure of the initial cost of a component or system.

FLAT PLATE COLLECTOR - A panel of metal or other suitable material that converts sunlight into heat. The solar radiative absorbing surface is essentially flat and the aperture and absorber are similar in area and geometry.

FORCED VENTILATION - See "Ventilation, Forced."

GLAZING - A covering of transparent or translucent material (glass or plastic) used for admitting light. Glazing reduces heat losses from reradiation and convection. Examples: windows, skylights, greenhouses and clerestories.

GREENHOUSE EFFECT - Ability of a glazing material to both transmit short wave solar radiation into a space and trap long wave heat generated by the conversion of the short wave radiation into heat.

GROSS FLOOR AREA - The sum of the areas of all floors of a building, including basements, cellars, mezzanine

and intermediate floored tiers, and penthouses of headroom height, measured from the exterior faces of exterior walls or from the centerline of the walls separating buildings.

GROSS WALL AREA - The gross area of exterior walls consists of all opaque wall areas (including foundation walls, areas between floor spandrels, peripheral edges of floors, window areas including sash, and door areas) where such surfaces are exposed to outdoor air and enclose a heated or mechanically cooled space, including interstitial areas between two such spaces.

HEAT - The form of energy that is transferred by virtue of a temperature difference.

HEAT CAPACITY - The property of a material defined as the quantity of heat needed to raise one cubic foot of the material 1°F. Numerically, the density multiplied by the specific heat.

HEAT EXCHANGER - A device specifically designed to transfer heat between two fluids.

HEAT GAIN - An increase in the amount of heat contained in a space, resulting from solar radiation and the flow of heat through the building envelope plus internal heat gain.

HEAT LOSS - A decrease in the amount of heat contained in a space, resulting from heat flow through walls, windows, roof and other building envelope components.

HEAT LOSS COEFFICIENT (UA) - The rate of energy transfer through the walls, roof, and floor of a house, calculated in BTU/Hr/°F.

HEAT SINK - A substance which is capable of accepting and storing heat, a heat reservoir.

HEAT TRANSFER MEDIUM - A medium -- liquid, air or solid -- which is used to transport thermal energy.

HEATED SPACE - Space within a building which is provided with a positive heat supply to maintain the air temperature at 50°F or higher.

HVAC - Heating, ventilating and air-conditioning.

HVAC SYSTEM - A system that provides either collectively or individually the processes of comfort control including heating, ventilating, and/or air-conditioning within or associated with a building.

HYBRID SYSTEM - Solar heating system that combines active and passive techniques.

INCIDENT ANGLE - The angle between the incident ray from the sun and a line drawn perpendicular to the solar collector surface.

INDIRECT GAIN PASSIVE SYSTEM - A solar heating system in which sunlight first strikes a thermal mass located between the sun and a space. The sunlight absorbed by the mass is converted to heat and then transferred into the living space.

INDUCED VENTILATION - See "Ventilation, Induced."

INFILTRATION - The uncontrolled inward air leakage through cracks and interstices in any building element and around windows and doors of a building, caused by the pressure effects of wind and/or the effect of differences in the indoor and outdoor air density.

INFRARED RADIATION - See "Radiation, Infrared."

INSOLATION - Total amount of solar radiation incident upon an exposed surface measured in Btu/hr/ft^2 or in Langleys.

INSULATION - A material having a relatively high resistance to heat flow and

used principally to reduce heat flow.

INTERNAL HEAT GAIN - Heat generated by equipment, appliances, lights, and people.

ISOLATED GAIN PASSIVE SYSTEM - A system where solar collection and heat storage are isolated from the living spaces.

LIFE CYCLE COST - A measure of total system cost including initial, maintenance, and operating costs over its lifespan. The accumulation generally includes a discounting of future costs to reflect the relative value of money over time.

LOAD COLLECTOR RATIO (LCR) - The Building Load Coefficient (BLC) divided by the total passive solar collector area. The LCR is used to determine the Solar Savings Fraction.

MAGNETIC SOUTH - South as indicated by a compass; changes markedly with geographic location.

MECHANICAL PLANT EFFICIENCY (MPE) - The efficiency of the mechanical system, usually obtainable from the equipment manufacturer.

MICROCLIMATE - The climate of a defined local area, such as a house or building site, formed by a unique combination of factors such as wind, topography, solar exposure, soil and vegetation.

MMBTU - Million (10^6) BTU's. The predominant unit of measure for energy in the United States.

MOVABLE INSULATION - Insulation placed over windows when needed to prevent heat loss or gain, and removed for light, view, venting, or heat.

NATURAL VENTILATION - See "Ventilation, Natural."

NIGHT INSULATION (NI) - See "Movable Insulation."

NOCTURNAL COOLING - Cooling by nighttime radiation, convection, and evaporation.

NON-DEPLETABLE ENERGY SOURCES - Sources of energy (excluding minerals) derived from incoming solar radiation, including photosynthetic processes; from phenomena resulting therefrom, including wind, waves, and tides, lake or pond thermal differences; and energy derived from the earth, or gravity.

OPAQUE - Impenetrable by light.

OUTSIDE AIR - Air taken from the outdoors and, therefore, not previously circulated through the system.

PASSIVE SOLAR SYSTEM - An assembly of natural and architectural components, including collectors, thermal storage device(s), and transfer fluid, which converts solar energy into thermal energy in a controlled manner and in which no fans or pumps are used to accomplish the transfer of thermal energy. The prime elements in a passive solar system are usually some form of thermal capacitance and solar energy control.

PAYBACK - A traditional measure of economic viability of investment projects. A payback period is defined in several ways, one of which is the number of years required to accumulate fuel savings which exactly equal the initial capital cost of the system. Payback often does not give an accurate representation of the total life cycle value of the investment.

PEAK LOAD - The design heating and cooling load used in mechanical system sizing. Usually set to meet human comfort requirements 93%-97% of the time.

PERCENT SOLAR - A crude measure of the amount of heating or cooling provided by a solar system compared to the total demand.

PHASE CHANGE MATERIAL - A material such as salt or wax which stores thermal energy when it melts and

releases heat when it solidifies.

POWER - In connection with machines, power is the time rate of doing work. In connection with the transmission of energy of all types, power refers to the rate at which energy is transmitted. In customary units, it is measured in watts (W) or British thermal units per hour (Btu/hr).

RADIATION - The direct transport of energy through a space by means of electromagnetic waves.

RADIATION, SOLAR - See "Solar Radiation."

RECOVERED ENERGY - Energy utilized which would otherwise be wasted from an energy utilization system.

REFLECTANCE - The ratio of the light reflected by a surface to the light falling upon it.

REFLECTED RADIATION - Solar radiation reflected by light colored or polished surfaces. Can be used to increase solar gain.

REFRACTION - The change in direction of light rays as they enter a transparent medium such as water, air or glass.

REHEAT - The application of sensible heat to supply air that has been previously cooled below the temperature of the conditioned space by either mechanical refrigeration or the introduction of outdoor air to provide cooling.

RESISTANCE (R) - The tendency of a material to reduce the flow of heat (see R-Value).

ROCK STORAGE SYSTEM - A solar energy system in which the collected heat is stored in a rock bin for later use. This type of storage can be used in an active, hybrid or passive system. However, rock storage is primarily used with a system which circulates air as the transfer medium between the collector and storage, and from the storage to the heated space.

R-VALUE - A unit of thermal resistance used for comparing insulating values of different materials. The reciprocal of the conductivity. The higher the R-value of a material, the greater its insulating capabilities.

SELECTIVE SURFACE - A coating with high solar radiation absorptance and low thermal emittance, used on the surface of an absorber to increase system efficiency.

SENSIBLE HEAT - Heat that results in a temperature change.

SHADING COEFFICIENT (SC) - The ratio of the solar heat gain through a specific glazing system under a given set of conditions, to the total solar heat gain through a single layer of clear, double-strength glass under the same conditions.

SOLAR ALTITUDE - The angle of the sun above the horizon measured in a vertical plane.

SOLAR CONSTANT - The amount of solar radiation that reaches the outside of the earth's atmosphere.

SOLAR HEATING FRACTION (SHF) - The percentage of heating needs supplied by the passive solar system.

SOLAR RADIATION - Electromagnetic radiation emitted by the sun.

SOLAR RETROFIT - The application of a solar heating or cooling system to an existing building.

SOLAR SAVING FRACTION (SSF) - The difference in auxiliary heat required with and without the solar collection aperture (solar wall). The reference building is simply the same building without a solar wall.

$$SSF = \frac{\text{solar savings}}{\text{reference net thermal load}}, \text{ or,}$$

SSF = 1 - $\frac{\text{aux. heat required by solar building}}{\text{aux. heat required by reference bldg.}}$

SOLAR TIME - The hours of the day reckoned by the apparent position of the sun. Solar noon is that instant on any day at which time the sun reaches its maximum altitude for that day. Solar time is very rarely the same as local standard time in any locality.

SOLAR WINDOW - An opening that is designed or placed primarily to admit solar energy into a space.

SPECIFIC HEAT - The number of Btu's required to raise the temperature of one pound of a material 1°F.

SPECULAR - An imaging reflection. A mirror is a specular reflector.

STORAGE - The assembly used for storing thermal energy so that it can be used when required.

STRATIFICATION - In the context of solar heating, the formation of layers in a substance where the top layer is warmer than the bottom.

SUNTEMPERED - A structure which is designed or oriented to take into account climatic conditions but which does not possess strict passive features such as thermal mass.

THERMAL BREAK - An element of low thermal conductivity placed in such a way as to reduce the flow of heat.

THERMAL CAPACITY - See "Heat Capacity."

THERMAL CONDUCTANCE - See "Conductance."

THERMAL ENERGY - Heat possessed by a material resulting from the motion of molecules.

THERMAL MASS - A thermally absorptive component used to store heat energy. In a passive solar system, the mass absorbs the sun's heat during the day and radiates it at night as the temperatures drop. Thermal Mass can also refer to the overall amount of heat storage capacity available in a given system or assembly.

THERMAL STORAGE CAPACITY - The ability of a material, per square foot of exposed surface area, to absorb and store heat. Numerically, the density times the specific heat times the thickness.

THERMAL STORAGE ROOF - A passive system in which the storage mass is located on the roof. Mass can be water or masonry and usually has movable insulation.

THERMAL STORAGE WALL - A passive system in which the storage mass is a wall located between the collector and the living space(s) to be heated. The mass can be a variety of materials including water or masonry.

THERMAL TRANSMITTANCE (U) - Overall coefficient of heat transmission (air-to-air) expressed in units of BTU per hour per square foot per degree F. The U-value applies to combinations of different materials used in a series along the heat flow path, single materials that comprise a building section, cavity air spaces, and surface air films on both sides of a building element.

THERMOCIRCULATION - The convective circulation of fluid which occurs when warm fluid rises and is displaced by denser, cooler fluid in the same system.

THERMOSIPHON - See "Thermocirculation."

TILT ANGLE - The angle of a collector relative to the ground. A rule of thumb collector angle for winter heating is the latitude +10°.

TIME LAG - The period of time between the absorption of solar radiation by a material and its release into a space. Time lag is an important consideration in sizing a thermal storage wall.

TRANSLUCENT - Transmitting light but causing sufficient diffusion to eliminate perception of distinct images.

TRANSMITTANCE - The ratio of radiant energy transmitted through a transparent or translucent substance to the total radiant energy incident on its surface.

TRANSPARENT - Transmitting light so that objects or images can be seen as if there were no intervening material.

TROMBE WALL - Another name for a "Thermal Storage Wall," named after its inventor, Dr. Felix Trombe.

U-VALUE - The number of Btu's that flow through one square foot of roof, wall or floor, in one hour, when there is a 1°F difference in temperature between the inside and outside air, under steady state conditions. The U-value is the reciprocal of the resistance or R-value (see Thermal Transmittance).

VAPOR BARRIER - A layer of material, resistant to the flow of water in the gaseous state, used to prevent condensation of water within insulation or dead air spaces.

VENTILATION, FORCED - Mechanically assisted movement of fresh air through a building using some sort of fan or blower.

VENTILATION, INDUCED - The thermally assisted movement of fresh air through a building, such as by thermocirculation.

VENTILATION, NATURAL - The unassisted movement of fresh air through a building.

WATER WALL - A passive technique for collecting solar energy. Water walls are usually black, water-filled containers exposed to the sun. These collect and store heat, which is used to warm a living space.

WET BULB TEMPERATURE - The lowest temperature attainable by evaporating water into the air.

WYTHE - Each continuous vertical section of a wall one masonry unit in thickness and tied to an adjacent vertical section or sections.

ZONE - A space or group of spaces within a building with heating and/or cooling requirements sufficiently similar so that comfort conditions can be maintained throughout by a single controlling device.

SOLAR ABSORPTANCE OF VARIOUS MATERIALS*

Optical flat black paint	.98
Flat black paint	.95
Black lacquer	.92
Dark gray paint	.91
Black concrete	.91
Dark blue lacquer	.91
Black oil paint	.90
Stafford blue bricks	.89
Dark olive drab paint	.89
Dark brown paint	.88
Dark blue-gray paint	.88
Azure blue or dark green lacquer	.88
Brown concrete	.85
Medium brown paint	.84
Medium light brown paint	.80
Brown or Green lacquer	.79
Medium rust paint	.78
Light gray oil paint	.75
Red oil paint	.74
Red bricks	.70
Uncolored concrete	.65
Moderately light buff bricks	.60
Medium dull green paint	.59
Medium orange paint	.58
Medium yellow paint	.57
Medium blue paint	.51
Medium Kelly green paint	.51
Light green paint	.47
White semi-gloss paint	.30
White gloss paint	.25
Silver paint	.25
White lacquer	.21
Polished aluminum reflector sheet	.12
Aluminized mylar film	.10
Laboratory vapor deposited coatings	.02

This table is meant to serve as a guide only. Variations in texture, tone, overcoats, pigments, binders, etc. can vary these values.

*Data obtained from: Passive Solar Design Handbook, Volume Two: Passive Solar Design Analysis by J.D.Balcomb et al. (see BIBLIOGRAPHY reference no. 39)

MINIMUM REQUIREMENTS FOR NON-STRUCTURAL GROUT*

Where concrete masonry walls are grouted for the purpose of increasing thermal storage capacity, i.e., non-structural purposes, the grout may consist of a mixture of Portland Cement, aggregate and water.

Portland Cement shall conform to the requirements of ASTM C-150, Standard Specification for Portland Cement, or ASTM C-595, Specification for Blended Hydraulic Cements.

Aggregate shall conform to the requirements for fine aggregate of ASTM C-33, Standard Specification for Concrete Aggregates (except that the grading Requirements need not apply), or ASTM C-404, Standard Specification for Aggregates for Masonry Grout.

Grout shall consist of a mixture of Portland Cement and aggregate proportioned such that the aggregate to cement ratio does not exceed 12:1; and sufficient water to permit the mixture to flow readily, without segregation, into the cores of the masonry.

*Courtesy of the National Concrete Masonry Association
2302 Horse Pen Road
P.O.Box 781
Herndon, Va. 22070

Throughout the design/development stages it is useful to periodically estimate the projected energy consumption of the home and the energy savings attributable to the selected passive system. Basic design guidelines and rules of thumb offer some guidance but typically do not provide estimates of the projected energy savings attributable to solar. A variety of methods is available which aid in the selection and sizing of the appropriate passive system(s). However, most of these methods tend to be cumbersome, requiring a costly piece of hardware (e.g., a microcomputer) or too much time to be practical as a design tool.

Described below is a simple and fast technique for estimating the performance of a passive design. The technique, referred to as the Load Collector Ratio or "LCR" method, is particularly useful during the schematic design stages when only the general characteristics of the home have been established and relatively major modifications can be considered.

Of course, the simplicity of the LCR method also imposes certain limitations. For example, certain design situations, such as underground structures, cannot be accurately evaluated. Furthermore, the method is based on conservative assumptions as to how the passive system is constructed (e.g., the thickness of the Thermal Storage Wall storage material is assumed to be 18"). It should be emphasized, however, that the LCR method is simply intended to provide "quick and dirty" estimates of energy savings as a tool for making design decisions. At later stages in the design process it may be appropriate to use a more sophisticated and flexible analysis method to fine-tune the estimates of energy savings derived from the LCR method (see Appendix C).

The Procedure

Although the LCR method is appropriate for the early stages of design, a few characteristics of the home need to be established prior to performing the analysis. These include: the gross floor area and length of the perimeter, the number of stories, the foundation type (slab, crawl space or basement), and the R-Values of the walls and roof.

The method consists of four steps. In Step 1 the Building Load Coefficient (BLC), a rough measure reflecting the insulating quality of the home, is estimated In Step 2 the solar collector area anticipated for the passive system, is determined. In Step 3 the BLC is divided by the collector area to yield the Load Collector Ratio (LCR). Finally, the LCR is used, in conjunction with a series of data tables, to determine the amount of auxiliary heat saved by utilizing the passive system. This savings is expressed as a fraction conventionally referred to as the Solar Savings Fraction (SSF).

Step 1: Determining the Building Load Coefficient (BLC)

This step consists of estimating and totaling the individual heat losses of each of the major components of the home.

a) Calculate Areas

Calculate the gross floor area (sq.ft.), the length of perimeter (ft.), and the area of the non-south (east, west, and north) glazing (sq.ft.). If the projected amount of glazing is not known use the following formula to derive a rough estimate:

- Non-south glazing area = [2/3] x [gross east, west and north wall area] x [non-south window fraction (see note)]

Note: The non-south window fraction is a factor specifically derived for use with this formula. It will vary between 0.05, for a home with a minimum amount of non-south window area, and 0.10 for a home with a substantial amount of non-south glazing.

b) Compute R-Values

For each of the components including walls, floor(s), and roof determine the overall R-Value. Also derive the R-Value for the perimeter insulation. These values can be derived from the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Handbook of Fundamentals (see BIBLIOGRAPHY reference No. 6).

c) Compute Component Heat Loss Factors

For each component (e.g., wall, roof) a factor is computed which represents the insulating quality for that component.

WALL FACTOR

- $L_w = 24 \times \frac{\text{wall area (sq.ft.)}}{\text{R-Value of walls}}$

Note: Wall area = [perimeter (ft.)] x [ceiling height (ft.)] - [area of non-south glazing (sq.ft.)] - [south window area (sq.ft.)]

NON-SOUTH GLAZING FACTOR

- $L_g = 26 \times \frac{\text{non-south glazing area}}{\text{number of glazings}}$

Note: For number of glazings use 1 for single glazed, 2 for double glazed, etc.

FLOOR FACTOR

Slab-on-Grade:

- $L_f = 100 \times \frac{\text{[length of foundation perimeter (ft.)]}}{\text{[R-Value of perimeter insulation + 5]}}$

Crawl Space (vented):

- $L_f = 24 \times \frac{\text{[area of ground floor (sq.ft.)]}}{\text{[R-Value of floor]}}$

Note: If unheated basement is specified, use crawl space calculation.

Basement (heated):

o $L_b = 256 \times \frac{\text{[perimeter length of basement wall (ft)]}}{\text{[R-Value of wall insulation + 8]}}$

Note: If more than one floor/foundation type is used, individual values for each type should be combined.

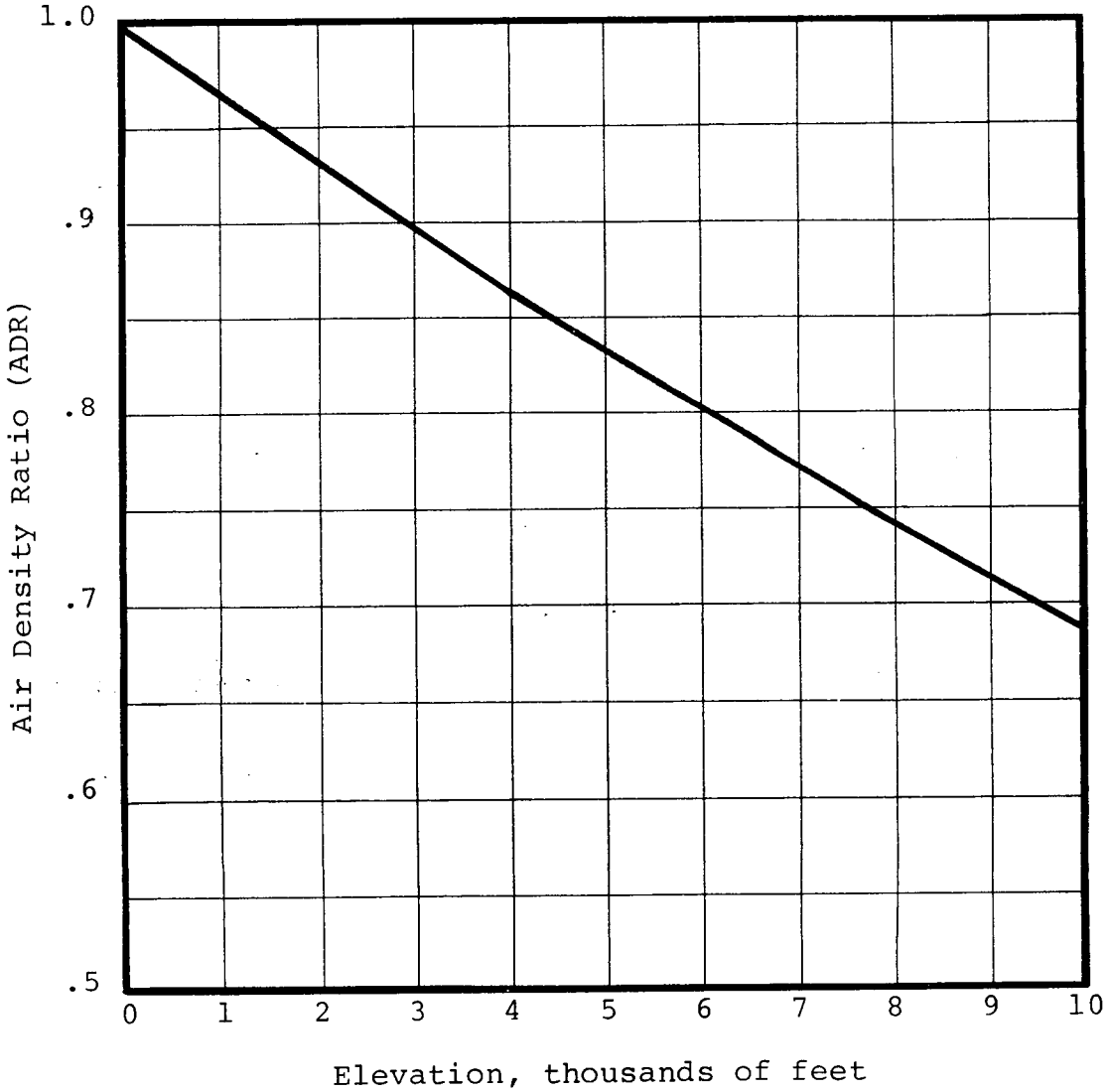
ROOF FACTOR

o $L_r = 24 \times \frac{\text{[area of insulated roof (sq.ft.)]}}{\text{[R-Value of roof]}}$

INFILTRATION FACTOR

o L_i = [0.432] x [ADR (see note)] x [ceiling height (ft.)] x [combined area of all floors (sq.ft.)] x [air change rate]

Note: The value of Air Density Ratio (ADR) can be determined from the graph below:



d) Determine the Building Load Coefficient (BLC)

The BLC is simply the sum of the component heat loss factors

$$BLC = L_w + L_g + L_r + L_p \text{ (and/or } L_f\text{; and/or } L_b) + L_i$$

Step 2: Determine the South Facing Glazed Area

Determine the area of south facing glazing (A_G). This area is the net glazed area of the collector excluding framing.

Step 3: Determine the Load Collector Ratio (LCR)

The LCR is a simple ratio of the BLC and the south facing glazed area (A_G):

$$LCR = BLC/A_G$$

Step 4: Identify the Solar Savings Fraction (SSF)

Armed with the LCR, identify on the tables on pages B.7 through B.35 the location closest to the anticipated site for the passive home and the type of passive system selected. The values calculated are for water wall, Trombe Wall (Thermal Storage Wall), and Direct Gain systems. Attached Sunspaces should be modeled as Trombe Walls. Simply locate the system type by the following code:

WW - Water Wall
WWNI - Water Wall with Night Insulation
TW - Trombe Wall
TWNI - Trombe Wall with Night Insulation
DG - Direct Gain
DGNI - Direct Gain with Night Insulation

Read across the table to the closest LCR, and read up the table to determine the SSF. To find the SSF if more than one passive system is employed:

a) Determine the SSF for each system using the BLC and total south facing glazing area in each case;
b) Average the SSF in proportion to the fraction of the total collector area represented by each system.

The SSF will is a rough estimate of the amount of auxiliary heat that will be saved by using the passive system.

Example

The following example illustrates the use of the LCR method:

A 1,800 sq. ft. two story home (25' x 36' plan) is constructed on a slab with an R-19 wall, R-30 roof and R-10 perimeter insulation. Seven and one-half percent of the east, west and north wall area is glazed (double glazing is used throughout). The air change rate is 1.0 air changes per hour. The home is to be built in Dodge City, Kansas (elev. 2580 ft.). The ceiling height is 8 ft. The south glazing is 220 sq. ft. of Direct Gain with night insulation and 280 sq. ft. of Thermal Storage Wall (Trombe Wall) without night insulation.

Step 1: BLC Calculations

a) Areas:

Plan Area = 900 sq. ft.
Gross Floor Area = 1800 sq. ft.
Perimeter Length = 122 ft.
Wall Height (2 story) = 16 ft.
Gross (non-south facing) Wall Area: (25 ft. + 25 ft. + 36 ft.) x (16 ft.)
= 1376 sq.ft.
Non-South Glazing Area: (2/3) x (1376 sq.ft.) x (0.075)
= 69 sq.ft.
Note: Assumes average amount of glazing.

b) R-Values:

Wall	R-19
Roof	R-30
Perimeter	R-10

c) Heat Loss Factors:

Wall Area = (122 ft. x 16 ft.) - (69 sq.ft.) - (500 sq.ft.)
= 1383 sq.ft.

$$L_w = 24 \times \frac{1383}{19} = 1746$$

$$L_g = 26 \times \frac{69}{2} = 897$$

$$L_f = 100 \times \frac{122}{10 + 5} = 813$$

$$L_r = 24 \times \frac{900}{30} = 720$$

$$L_i = (0.432) \times (1) \times (0.92) \times (8 \text{ ft.}) \times (1800 \text{ sq.ft.})$$
$$= 5723$$

d) BLC = 1746 + 897 + 813 + 720 + 5723
= 9899

Step 2: South Facing Glazed Area

A_G = [20 sq.ft. (Direct Gain)] + [280 sq.ft. (Thermal Storage Wall)]
= 500 sq.ft.

Step 3: Load Collector Ratio (LCR)

$$LCR = \frac{9899}{500} = 19.8$$

Step 4: Solar Savings Fraction (SSF)

Find the LCR values for Dodge City, Kansas on the tables on pages B.7 through B.35. For the first system, Direct Gain with night insulation (DGNI), read across the table to the value closest to a LCR of 19.8 (20 in this case). Reading up the table we see that a LCR of 20 corresponds to a SSF of 0.70 or 70%. Repeating the procedure for the Thermal Storage Wall without night insulation (interpolating between an LCR of 17 and 25) yields a SSF of approximately 0.47. Proportioning the SSF by the area of each system yields:

- Direct Gain:

$$\frac{220 \text{ sq.ft.}}{500 \text{ sq.ft. (total)}} = 0.44 \times 0.7 \text{ (SSF)} = 0.31$$

- Thermal Storage:

$$\frac{280 \text{ sq.ft.}}{500 \text{ sq.ft. (total)}} = 0.65 \times 0.47 \text{ (SSF)} = 0.26$$

- SSF (total) = (0.31) + (0.26) = 0.57.

Approximate energy consumption for heating is then:

- AUX = (1-SSF)(DD)(BLC) = (1-.57)(5046)(9899) = 21.47 MMBTU/YR

NANAIMO
BRITISH COLUMBIA

49.2 N
5515 DD
T(JAN)=37

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	140	61	35	21	13	7	-	-	-
L	WWNI	229	105	65	44	32	23	17	12	8
C	TW	135	58	32	20	12	7	-	-	-
R	TWNI	214	98	60	40	29	21	15	10	6
	DG	126	43	-	-	-	-	-	-	-
	DGNI	233	106	63	42	29	20	14	9	4
	WW	12.2	9.5	6.9	4.4	2.6	1.1	-	-	-
	WWNI	21.5	18.2	15.4	12.9	9.9	7.4	5.4	3.4	1.3
D	TW	12.0	8.8	6.1	4.1	2.3	1.0	-	-	-
	TWNI	19.8	16.7	14.1	11.2	8.7	6.5	4.5	2.5	.9
	DG	9.7	4.1	-	-	-	-	-	-	-
	DGNI	21.3	17.4	13.9	10.7	8.0	5.5	3.3	1.6	.3

VANCOUVER
BRITISH COLUMBIA

49.3 N
5515 DD
T(JAN)=37

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	111	47	26	15	9	4	-	-	-
L	WWNI	193	89	54	37	27	20	15	11	7
C	TW	109	46	25	15	8	4	-	-	-
R	TWNI	181	83	50	34	24	18	13	9	6
	DG	86	-	-	-	-	-	-	-	-
	DGNI	195	88	52	34	24	17	11	7	3
	WW	9.5	6.9	4.7	2.8	1.4	.1	-	-	-
	WWNI	18.3	15.2	12.7	10.8	8.4	6.6	4.9	3.2	1.2
D	TW	9.5	6.7	4.5	2.8	1.4	.4	-	-	-
	TWNI	16.9	14.1	11.7	9.5	7.6	5.7	4.0	2.3	.8
	DG	5.9	-	-	-	-	-	-	-	-
	DGNI	17.8	14.3	11.4	8.8	6.6	4.6	2.7	1.3	.2

WINNIPEG
MANITOBA

49.9 N
10679 DD
T(JAN)= -

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	53	21	9	-	-	-	-	-	-
L	WWNI	125	58	36	25	18	13	10	7	5
C	TW	59	23	11	4	-	-	-	-	-
R	TWNI	119	55	34	23	17	12	9	6	4
	DG	-	-	-	-	-	-	-	-	-
	DGNI	121	54	32	21	15	10	6	3	-
	WW	4.3	2.7	1.0	-	-	-	-	-	-
	WWNI	11.4	10.1	8.8	7.4	5.9	4.7	3.4	2.2	.8
D	TW	4.8	3.1	1.6	.2	-	-	-	-	-
	TWNI	10.7	9.4	8.1	6.6	5.3	4.1	2.8	1.6	.5
	DG	-	-	-	-	-	-	-	-	-
	DGNI	10.8	9.0	7.1	5.4	3.9	2.5	1.3	.4	-

DARTMOUTH
NOVA SCOTIA

44.6 N
7361 DD
T(JAN)=26

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	73	31	18	11	7	4	-	-	-
L	WWNI	148	68	43	30	23	18	14	11	7
C	TW	76	33	18	11	6	3	-	-	-
R	TWNI	140	64	40	28	21	16	12	9	6
	DG	34	-	-	-	-	-	-	-	-
	DGNI	146	66	41	28	20	15	11	7	3
	WW	6.0	4.8	3.7	2.7	1.5	.3	-	-	-
	WWNI	13.5	11.9	11.1	9.8	8.8	7.5	5.7	3.7	1.4
D	TW	6.6	5.0	3.5	2.2	1.1	.3	-	-	-
	TWNI	12.9	11.4	10.2	9.1	7.7	6.1	4.3	2.5	1.0
	DG	1.5	-	-	-	-	-	-	-	-
	DGNI	13.1	11.3	9.8	8.3	6.5	4.6	2.9	1.4	.3

MOOSONEE
ONTARIO

51.3 N
11572 DD
T(JAN)=-1

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	34	11	-	-	-	-	-	-	-
L	WWNI	102	48	30	21	15	11	8	6	4
C	TW	42	15	-	-	-	-	-	-	-
R	TWNI	98	45	28	19	14	10	7	5	3
	DG	-	-	-	-	-	-	-	-	-
	DGNI	96	43	26	17	11	7	4	-	-
	WW	2.5	.9	-	-	-	-	-	-	-
	WWNI	9.7	8.3	7.3	6.4	4.9	3.6	2.5	1.6	.5
D	TW	3.4	1.7	-	-	-	-	-	-	-
	TWNI	9.2	7.8	6.9	5.6	4.3	3.2	2.2	1.2	.4
	DG	-	-	-	-	-	-	-	-	-
	DGNI	8.7	7.1	5.6	4.0	2.7	1.6	.6	-	-

OTTAWA
ONTARIO

45.5 N
8735 DD
T(JAN)=13

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	65	26	14	8	-	-	-	-	-
L	WWNI	140	63	39	27	20	16	12	9	6
C	TW	69	28	15	8	3	-	-	-	-
R	TWNI	133	60	37	26	19	14	11	8	5
	DG	-	-	-	-	-	-	-	-	-
	DGNI	137	60	36	25	17	12	9	5	2
	WW	5.1	3.6	2.4	1.2	-	-	-	-	-
	WWNI	12.6	10.7	9.7	8.6	7.4	6.0	4.6	3.0	1.1
D	TW	5.7	4.0	2.5	1.3	.2	-	-	-	-
	TWNI	12.0	10.2	9.0	7.8	6.5	5.1	3.5	2.1	.8
	DG	-	-	-	-	-	-	-	-	-
	DGNI	12.0	10.0	8.4	6.8	5.2	3.6	2.1	.9	.1

TORONTO
ONTARIO

43.7 N
6827 DD
T(JAN)=25

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	73	31	17	11	7	-	-	-	-
L	WWNI	148	68	43	30	22	17	14	10	7
C	TW	76	32	18	11	6	2	-	-	-
R	TWNI	140	65	40	28	21	16	12	9	6
	DG	32	-	-	-	-	-	-	-	-
	DGNI	146	66	40	28	20	14	10	7	3
	WW	6.0	4.6	3.4	2.4	1.2	-	-	-	-
	WWNI	13.7	11.9	10.9	9.5	8.3	7.1	5.5	3.6	1.4
D	TW	6.5	4.9	3.3	2.0	1.0	.1	-	-	-
	TWNI	12.8	11.3	10.0	8.8	7.5	5.9	4.1	2.4	.9
	DG	1.2	-	-	-	-	-	-	-	-
	DGNI	13.0	11.2	9.5	8.0	6.3	4.4	2.7	1.3	.3

NORMANDIN
QUEBEC

48.8 N
10528 DD
T(JAN)= 4

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	49	19	9	-	-	-	-	-	-
L	WWNI	118	56	35	24	18	13	10	7	5
C	TW	54	22	11	4	-	-	-	-	-
R	TWNI	112	52	33	23	16	12	9	6	4
	DG	-	-	-	-	-	-	-	-	-
	DGNI	113	52	31	21	14	10	6	4	-
	WW	4.1	2.5	1.0	-	-	-	-	-	-
	WWNI	11.4	9.9	8.6	7.7	6.2	4.8	3.4	2.2	.8
D	TW	4.6	2.9	1.5	.2	-	-	-	-	-
	TWNI	10.6	9.2	8.1	6.7	5.4	4.1	2.8	1.6	.5
	DG	-	-	-	-	-	-	-	-	-
	DGNI	10.6	8.7	7.1	5.5	3.9	2.6	1.4	.4	-

BIRMINGHAM ALABAMA
33.6 N, 2844 DD, T(JAN)=44

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 186	87	53	37	27	21	15	10	5
	L	WWNI 281	134	85	60	45	36	29	23	16
	C	TW 179	82	50	33	23	16	11	7	4
	R	TWNI 265	126	79	56	42	32	25	18	12
		DG 192	83	47	28	15	-	-	-	-
		DGNI 296	139	86	61	45	34	25	18	11
		WW 17.1	14.8	12.6	11.4	9.5	7.4	4.6	2.2	.4
		WWNI 26.1	25.0	21.2	19.4	18.3	15.6	12.9	8.3	3.4
	D	TW 16.3	13.9	11.6	8.9	6.6	4.5	2.9	1.6	.6
		TWNI 24.9	22.5	20.0	18.2	15.8	12.7	9.0	5.5	2.2
		DG 16.6	12.9	8.9	5.1	2.0	-	-	-	-
		DGNI 27.7	24.3	21.8	19.0	15.9	11.9	8.2	4.8	1.8

MOBILE ALABAMA
30.7 N, 1684 DD, T(JAN)=51

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 318	144	89	64	48	37	29	21	13
	L	WWNI 441	205	127	92	71	56	45	36	25
	C	TW 293	135	83	57	40	30	22	15	10
	R	TWNI 412	191	120	86	65	51	39	29	19
		DG 354	159	96	63	43	29	18	10	-
		DGNI 469	216	135	96	72	55	42	30	20
		WW 29.8	24.2	23.0	21.1	18.3	15.1	10.5	5.9	2.0
		WWNI 42.6	34.9	32.9	32.4	29.0	25.3	20.8	13.4	5.6
	D	TW 27.0	23.4	19.7	16.1	12.6	9.5	6.7	4.2	1.8
		TWNI 39.1	33.2	31.4	28.4	25.2	20.3	14.5	8.9	3.7
		DG 31.7	26.4	21.5	15.9	11.0	7.0	3.6	1.2	-
		DGNI 43.8	37.6	34.9	31.0	26.5	20.2	14.3	8.6	3.5

MONTGOMERY ALABAMA
32.3 N, 2269 DD, T(JAN)=48

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 236	111	68	48	36	27	21	15	8
	L	WWNI 339	165	103	73	56	44	35	28	20
	C	TW 224	103	63	43	30	22	15	11	7
	R	TWNI 320	153	96	68	51	40	30	23	15
		DG 257	115	67	42	27	16	7	-	-
		DGNI 362	171	107	75	56	42	32	23	15
		WW 22.7	18.9	16.6	15.2	12.8	10.3	6.8	3.6	1.0
		WWNI 32.7	29.9	25.6	24.2	22.5	19.3	15.9	10.2	4.3
	D	TW 20.6	17.9	15.0	11.8	8.9	6.4	4.4	2.6	1.0
		TWNI 31.0	27.2	24.5	22.2	19.3	15.6	11.1	6.8	2.8
		DG 22.9	18.6	14.1	9.4	5.7	2.7	.5	-	-
		DGNI 34.9	30.0	27.2	23.7	20.0	15.1	10.5	6.3	2.4

PHOENIX ARIZONA
33.4 N, 1552 DD, T(JAN)=51

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 467	219	139	100	75	58	45	34	22
	L	WWNI 620	293	188	136	104	82	65	51	36
	C	TW 436	202	126	87	63	46	34	25	16
	R	TWNI 583	275	176	126	95	73	56	42	28
		DG 555	256	157	107	75	53	37	24	12
		DGNI 673	316	201	143	107	82	62	45	29
		WW 42.5	39.7	37.2	32.9	28.2	23.2	17.0	9.9	3.7
		WWNI 56.5	54.3	50.3	48.3	40.8	35.1	28.6	18.8	7.9
	D	TW 40.1	35.6	31.1	25.6	20.3	15.2	10.9	7.0	3.1
		TWNI 53.8	50.0	47.3	41.3	35.6	29.0	20.6	12.6	5.1
		DG 50.4	44.2	37.5	29.5	21.9	15.1	9.4	4.8	1.4
		DGNI 62.2	57.3	52.7	46.2	39.2	30.0	21.1	12.8	5.3

PRESCOTT ARIZONA
34.6 N, 4456 DD, T(JAN)=37

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 189	89	56	40	30	23	17	12	7
	L	WWNI 286	135	88	63	48	39	31	25	18
	C	TW 183	85	53	36	25	18	13	9	5
	R	TWNI 269	128	82	59	45	35	27	20	14
		DG 198	89	52	32	20	10	-	-	-
		DGNI 300	142	90	64	49	37	28	20	13
		WW 17.1	16.5	14.3	13.1	11.3	8.9	5.7	2.9	.7
		WWNI 26.2	25.4	23.7	21.5	20.3	18.0	14.6	9.3	3.9
	D	TW 16.9	14.9	12.7	10.0	7.6	5.5	3.5	2.0	.9
		TWNI 24.9	23.8	21.7	20.2	17.7	14.1	10.0	6.2	2.5
		DG 17.6	14.6	10.6	6.8	3.6	1.0	-	-	-
		DGNI 27.7	25.8	23.7	21.4	17.8	13.4	9.3	5.5	2.1

TUCSON ARIZONA
32.1 N, 1752 DD, T(JAN)=51

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 425	199	127	92	70	55	43	32	21
	L	WWNI 571	268	172	125	97	77	62	49	36
	C	TW 394	185	116	81	59	43	32	23	16
	R	TWNI 533	252	161	116	89	69	54	40	27
		DG 498	231	143	98	69	49	34	22	12
		DGNI 613	289	185	132	100	77	59	43	29
		WW 39.0	36.4	33.8	31.6	27.6	23.3	16.7	9.8	3.7
		WWNI 53.0	49.5	46.6	44.5	41.0	35.4	29.5	18.8	8.0
	D	TW 36.9	33.2	29.0	23.9	19.1	14.7	10.4	6.7	3.3
		TWNI 49.8	46.1	43.6	39.9	35.1	28.2	20.2	12.5	5.2
		DG 46.0	40.7	34.7	27.2	20.3	14.2	8.8	4.5	1.4
		DGNI 57.3	52.6	49.4	44.2	37.9	29.0	20.6	12.7	5.3

WINSLOW ARIZONA
35.0 N, 4733 DD, T(JAN)=33

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 165	78	49	34	25	19	14	9	4
	L	WWNI 255	123	79	57	43	34	27	21	15
	C	TW 162	75	46	31	22	15	10	7	4
	R	TWNI 242	116	74	53	40	31	24	18	12
		DG 168	74	42	24	12	-	-	-	-
		DGNI 268	127	81	57	43	32	24	17	11
		WW 15.3	14.0	12.2	10.8	8.9	6.8	4.1	1.9	.2
		WWNI 23.8	23.4	20.8	19.2	17.6	15.3	11.9	7.8	3.2
	D	TW 14.6	13.1	10.8	8.4	6.2	4.3	2.7	1.5	.6
		TWNI 22.6	21.4	19.5	17.8	15.1	12.2	8.6	5.3	2.1
		DG 14.7	11.6	7.7	4.2	1.2	-	-	-	-
		DGNI 25.1	23.1	20.9	18.4	15.2	11.3	7.7	4.5	1.6

YUMA ARIZONA
32.7 N, 1010 DD, T(JAN)=55

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 728	342	219	155	116	89	70	52	35
	L	WWNI 932	442	283	204	154	119	94	74	53
	C	TW 670	313	194	135	97	72	53	38	25
	R	TWNI 877	413	264	187	140	108	82	61	40
		DG 887	412	254	174	124	89	64	44	26
		DGNI 1021	481	305	215	160	122	92	67	44
		WW 68.9	61.9	58.9	49.2	42.7	35.4	26.9	16.1	6.6
		WWNI 88.7	80.0	77.5	67.6	57.4	49.4	41.5	27.2	11.6
	D	TW 61.7	55.0	47.8	39.2	31.4	24.0	17.3	10.3	5.4
		TWNI 81.9	75.7	68.5	59.7	51.2	41.9	29.6	18.1	7.5
		DG 81.2	71.5	61.0	49.4	37.6	27.3	18.2	10.4	4.0
		DGNI 94.8	88.2	77.6	67.9	57.7	44.5	31.3	19.2	8.2

FORT SMITH ARKANSAS		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	158	74	45	31	23	17	13	8	-
35.3 N	L	WWNI	246	119	75	53	40	32	26	20	14
3336 DD	C	TW	153	70	43	29	20	14	9	6	3
T(JAN)=39	R	TWNI	233	111	70	50	37	29	22	17	11
		DG	156	67	36	20	-	-	-	-	-
		DGNI	258	121	76	53	40	30	22	16	10
		WW	15.0	12.4	10.8	9.7	8.0	6.1	3.6	1.6	-
		WWNI	23.5	21.8	18.8	17.6	16.5	14.2	11.7	7.4	3.1
	D	TW	14.0	12.0	9.9	7.5	5.4	3.7	2.3	1.2	.4
		TWNI	22.3	19.9	17.9	16.4	14.2	11.4	8.1	5.0	2.0
		DG	13.4	10.1	6.2	2.8	-	-	-	-	-
		DGNI	24.6	21.3	19.3	16.9	14.0	10.4	7.1	4.1	1.5

LITTLE ROCK ARKANSAS		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	157	72	44	31	22	17	12	8	-
34.7 N	L	WWNI	246	117	74	52	40	31	25	20	14
3354 DD	C	TW	153	69	42	28	19	13	9	6	3
T(JAN)=39	R	TWNI	232	110	69	49	37	29	22	16	11
		DG	154	65	35	18	-	-	-	-	-
		DGNI	257	120	75	53	39	29	22	15	10
		WW	14.6	12.1	10.5	9.4	7.7	5.8	3.4	1.5	-
		WWNI	23.0	21.4	18.5	17.2	16.1	13.9	11.4	7.3	3.0
	D	TW	13.8	11.7	9.6	7.3	5.2	3.5	2.2	1.2	.3
		TWNI	21.9	19.6	17.6	16.0	13.9	11.2	7.9	4.9	2.0
		DG	13.0	9.6	5.8	2.4	-	-	-	-	-
		DGNI	24.2	21.0	18.9	16.5	13.7	10.2	7.0	4.0	1.5

BAKERSFIELD CALIFORNIA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	323	143	89	63	46	35	26	18	10
35.4 N	L	WWNI	449	203	127	91	69	54	42	32	22
2185 DD	C	TW	297	135	81	55	39	28	20	14	8
T(JAN)=48	R	TWNI	418	191	119	85	63	48	36	27	17
		DG	359	158	93	60	40	26	15	-	-
		DGNI	475	216	135	94	69	52	39	27	17
		WW	28.6	24.4	22.6	19.7	15.7	11.9	8.5	4.5	1.3
		WWNI	41.9	34.7	33.5	31.1	26.5	21.1	16.2	11.1	4.6
	D	TW	26.9	22.7	18.8	15.1	11.6	8.5	5.7	3.3	1.2
		TWNI	38.0	33.2	30.7	26.9	22.3	18.1	12.7	7.6	3.0
		DG	31.5	25.4	19.8	14.3	9.5	5.4	2.3	-	-
		DGNI	42.9	37.5	34.0	28.8	23.6	18.2	12.4	7.2	2.8

DAGGETT CALIFORNIA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	360	165	103	73	55	42	32	24	15
34.9 N	L	WWNI	491	228	144	103	79	62	49	39	27
2203 DD	C	TW	334	153	94	65	46	34	25	17	11
T(JAN)=47	R	TWNI	461	214	135	96	72	56	43	32	21
		DG	411	185	112	74	51	35	23	13	-
		DGNI	526	244	153	108	81	61	46	33	22
		WW	33.0	28.9	26.3	24.2	20.3	16.2	11.6	6.5	2.2
		WWNI	46.6	40.2	37.7	35.4	32.0	26.8	21.3	14.2	5.9
	D	TW	30.6	26.6	22.6	18.3	14.4	10.8	7.4	4.6	1.9
		TWNI	42.6	38.2	35.1	31.6	27.0	22.0	15.6	9.5	3.9
		DG	36.9	31.1	25.3	19.0	13.5	8.7	4.8	1.9	-
		DGNI	48.3	43.0	39.6	34.5	29.0	22.3	15.5	9.3	3.8

FRESNO CALIFORNIA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	272	122	74	51	37	27	20	13	7
36.8 N	L	WWNI	383	179	110	77	58	45	34	26	18
2650 DD	C	TW	252	114	68	45	31	22	15	10	5
T(JAN)=45	R	TWNI	361	166	102	72	53	40	30	22	14
		DG	295	128	72	44	27	15	-	-	-
		DGNI	408	186	114	79	57	42	31	22	13
		WW	25.8	19.8	17.4	15.1	11.7	8.5	5.8	2.8	.6
		WWNI	37.0	29.9	27.4	24.9	21.6	17.1	12.7	8.8	3.6
	D	TW	22.6	18.8	15.1	11.6	8.7	6.2	3.9	2.2	.7
		TWNI	34.1	28.4	25.3	22.0	18.0	14.4	10.2	6.0	2.3
		DG	25.6	19.6	14.1	9.3	5.4	2.2	-	-	-
		DGNI	37.7	31.8	27.9	23.2	18.6	14.3	9.6	5.5	2.0

LONG BEACH CALIFORNIA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	527	249	156	112	85	67	53	40	27
33.8 N	L	WWNI	689	331	208	150	115	91	74	59	42
1606 DD	C	TW	488	228	142	99	72	53	39	29	19
T(JAN)=54	R	TWNI	650	307	195	139	106	83	64	48	32
		DG	630	291	180	123	87	63	44	30	17
		DGNI	753	354	224	159	120	92	70	52	34
		WW	50.5	43.9	40.6	37.1	33.3	28.8	20.7	12.4	4.9
		WWNI	66.1	59.1	54.6	51.7	47.0	42.1	34.8	22.4	9.6
	D	TW	45.3	40.4	35.5	29.2	23.0	17.8	13.0	8.3	4.2
		TWNI	62.3	55.2	51.2	46.5	41.5	33.3	23.9	14.8	6.2
		DG	57.9	50.8	43.8	34.6	26.2	18.8	12.3	6.8	2.4
		DGNI	71.4	63.6	58.1	52.3	45.0	34.6	24.7	15.3	6.5

LOS ANGELES CALIFORNIA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	563	259	161	115	87	68	54	41	27
33.9 N	L	WWNI	737	342	215	153	117	93	75	60	43
1819 DD	C	TW	513	238	147	101	73	54	40	29	20
T(JAN)=54	R	TWNI	687	320	200	143	108	84	65	49	33
		DG	665	304	187	127	90	65	46	31	18
		DGNI	793	369	231	163	123	94	72	53	35
		WW	52.5	45.3	41.1	37.7	33.7	29.6	21.2	12.8	5.1
		WWNI	71.1	60.1	55.3	52.1	47.4	42.5	35.7	22.9	9.8
	D	TW	47.7	41.4	36.1	29.5	23.7	18.3	13.1	8.7	4.3
		TWNI	64.3	56.3	51.7	47.0	42.6	33.9	24.3	15.1	6.3
		DG	61.0	52.0	44.7	35.3	27.0	19.4	12.7	7.1	2.7
		DGNI	74.0	64.7	58.9	53.0	45.9	35.3	25.2	15.7	6.7

MOUNT SHASTA CALIFORNIA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	142	62	37	25	18	13	9	5	-
41.3 N	L	WWNI	230	106	66	46	35	27	21	16	11
5890 DD	C	TW	137	61	36	23	15	10	7	4	-
T(JAN)=34	R	TWNI	216	99	62	43	32	25	19	14	9
		DG	130	50	23	-	-	-	-	-	-
		DGNI	237	107	66	46	33	25	18	12	7
		WW	12.4	10.1	8.5	7.0	5.4	3.6	1.9	.5	-
		WWNI	21.0	18.3	16.6	15.0	13.2	11.4	8.5	5.7	2.3
	D	TW	12.1	9.7	7.6	5.6	3.9	2.4	1.3	.5	-
		TWNI	20.0	17.2	15.4	13.6	11.6	9.2	6.5	3.9	1.5
		DG	10.4	6.5	2.7	-	-	-	-	-	-
		DGNI	21.4	18.3	15.9	13.7	11.0	8.1	5.4	2.9	.9

NEEDLES CALIFORNIA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	508	239	152	108	81	62	47	35	23
34.8 N	L	WWNI	668	317	202	147	111	86	68	53	37
1428 DD	C	TW	474	220	136	94	67	49	36	26	17
T(JAN)=52	R	TWNI	630	297	189	134	100	77	59	44	29
		DG	608	280	171	116	81	57	40	26	13
		DGNI	729	342	217	153	114	86	65	47	30
		WW	47.4	42.8	40.9	34.3	29.0	23.6	17.5	10.2	3.9
		WWNI	62.3	57.4	54.6	49.8	41.8	34.9	28.8	19.1	8.1
	D	TW	43.3	38.5	33.1	27.3	21.3	16.1	11.4	6.9	3.3
		TWNI	59.0	53.9	49.8	43.2	36.5	29.9	21.1	12.8	5.2
		DG	55.1	48.1	40.2	31.7	23.3	16.2	10.1	5.2	1.5
		DGNI	67.6	62.2	55.5	48.0	40.6	31.2	21.7	13.1	5.4

OAKLAND CALIFORNIA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	348	170	107	75	56	42	32	23	14
37.7 N	L	WWNI	472	234	150	106	80	62	49	38	27
2909 DD	C	TW	327	155	96	66	47	34	24	17	11
T(JAN)=49	R	TWNI	446	219	139	98	73	56	43	31	20
		DG	405	189	115	76	51	35	22	12	-
		DGNI	512	249	157	110	82	61	46	33	21
		WW	34.8	31.7	26.6	23.1	20.0	15.3	11.0	6.1	2.0
		WWNI	47.2	44.8	39.1	33.8	30.6	26.4	19.8	13.5	5.6
	D	TW	31.7	27.6	23.2	18.7	14.3	10.4	7.0	4.2	2.0
		TWNI	44.5	40.8	35.4	31.5	26.6	21.0	15.0	9.1	3.6
		DG	38.8	32.5	25.8	19.2	13.3	8.3	4.4	1.6	-
		DGNI	50.6	45.6	39.7	34.7	28.1	21.6	15.0	8.9	3.5

RED BLUFF CALIFORNIA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	258	115	69	48	35	26	19	13	6
40.1 N	L	WWNI	365	170	104	74	56	43	33	26	18
2688 DD	C	TW	239	108	64	43	30	21	15	10	5
T(JAN)=45	R	TWNI	345	158	98	69	51	39	29	21	14
		DG	276	119	68	41	25	14	-	-	-
		DGNI	389	177	109	76	55	41	30	21	13
		WW	24.4	18.5	16.7	14.8	11.4	8.3	5.7	2.7	.6
		WWNI	35.5	28.4	26.0	24.1	21.6	17.1	12.6	8.7	3.5
	D	TW	21.4	18.0	14.4	11.1	8.4	6.0	3.9	2.1	.7
		TWNI	32.6	27.0	24.3	21.6	17.7	14.2	10.1	6.0	2.3
		DG	23.9	18.4	13.2	8.6	4.9	1.8	-	-	-
		DGNI	35.9	30.1	26.7	22.6	18.2	14.0	9.4	5.4	1.9

SACRAMENTO CALIFORNIA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	258	119	73	50	36	26	19	13	6
38.5 N	L	WWNI	368	174	108	76	57	44	34	26	18
2843 DD	C	TW	244	110	66	44	31	22	15	10	5
T(JAN)=45	R	TWNI	347	162	101	71	52	39	30	21	14
		DG	283	124	71	44	27	15	-	-	-
		DGNI	393	182	112	78	57	42	31	22	13
		WW	23.9	20.2	17.4	15.0	11.6	8.3	5.7	2.7	.5
		WWNI	34.2	30.7	27.1	24.4	21.7	17.1	12.4	8.7	3.5
	D	TW	22.0	18.5	15.0	11.8	8.6	6.0	3.9	2.0	.6
		TWNI	32.6	28.4	25.2	22.1	17.9	14.1	10.1	6.0	2.3
		DG	24.7	19.4	13.9	9.2	5.1	2.0	-	-	-
		DGNI	36.3	31.4	27.6	23.2	18.4	14.1	9.4	5.4	1.9

SAN DIEGO CALIFORNIA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	612	284	179	129	98	77	61	46	31
32.7 N	L	WWNI	796	373	235	170	131	104	84	67	48
1507 DD	C	TW	562	261	163	113	82	61	46	33	23
T(JAN)=55	R	TWNI	744	348	220	158	120	94	73	54	37
		DG	734	338	210	144	103	75	53	37	22
		DGNI	864	403	255	181	137	105	80	59	40
		WW	56.7	49.9	47.0	43.3	39.0	33.5	24.4	14.7	6.0
		WWNI	74.2	66.1	62.3	59.7	53.5	48.3	39.3	25.5	10.9
	D	TW	51.9	46.0	40.5	33.6	26.8	20.9	15.3	9.9	4.9
		TWNI	69.7	62.0	58.3	52.9	47.6	38.0	27.3	16.9	7.1
		DG	67.0	58.8	51.2	41.1	31.7	23.1	15.5	8.9	3.5
		DGNI	80.7	71.9	66.4	60.1	51.4	39.9	28.5	17.7	7.6

SAN FRANCISCO CALIFORNIA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	332	163	103	72	53	40	31	22	13
37.6 N	L	WWNI	453	225	145	103	77	60	47	37	26
3042 DD	C	TW	313	149	92	63	45	33	23	16	10
T(JAN)=48	R	TWNI	428	210	134	94	71	54	41	30	20
		DG	385	180	109	72	49	32	20	11	-
		DGNI	491	239	151	106	79	59	44	32	20
		WW	33.2	30.6	25.5	22.0	19.0	14.7	10.5	5.8	1.9
		WWNI	45.3	43.2	37.9	32.5	29.4	25.5	19.3	13.1	5.4
	D	TW	30.4	26.5	22.3	17.9	13.6	9.9	6.7	4.0	1.9
		TWNI	42.8	39.6	34.2	30.4	25.7	20.4	14.6	8.8	3.6
		DG	37.0	30.9	24.5	18.1	12.4	7.7	3.9	1.3	-
		DGNI	48.7	44.0	38.2	33.4	27.1	20.8	14.4	8.6	3.4

SANTA MARIA CALIFORNIA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	327	164	107	77	58	46	35	26	17
34.9 N	L	WWNI	448	224	148	108	83	66	53	42	30
3053 DD	C	TW	311	152	97	67	49	36	27	19	12
T(JAN)=50	R	TWNI	423	211	138	100	76	59	46	34	23
		DG	383	185	116	79	55	38	26	16	7
		DGNI	485	241	156	112	85	65	50	36	24
		WW	32.7	32.3	29.1	25.7	22.4	19.1	13.2	7.6	2.8
		WWNI	44.8	44.8	42.6	37.4	33.8	29.6	24.9	15.9	6.8
	D	TW	30.9	28.2	24.8	20.2	15.9	12.0	8.4	5.1	2.6
		TWNI	42.3	41.6	37.8	34.0	30.3	23.9	17.1	10.5	4.4
		DG	37.7	33.6	28.3	21.5	15.5	10.3	6.0	2.7	.6
		DGNI	48.5	46.9	42.3	37.7	32.0	24.3	17.1	10.4	4.3

COLORADO SPRINGS COLORADO		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	130	60	38	26	19	15	11	7	-
38.8 N	L	WWNI	211	102	65	47	36	29	23	18	13
6473 DD	C	TW	128	59	36	24	17	11	8	5	2
T(JAN)=29	R	TWNI	201	96	61	44	33	26	20	15	10
		DG	120	51	26	10	-	-	-	-	-
		DGNI	220	104	66	47	35	26	20	14	9
		WW	12.5	10.5	9.2	8.1	6.9	4.9	2.8	1.1	-
		WWNI	20.4	18.7	17.4	16.0	14.6	13.2	10.8	6.8	2.8
	D	TW	11.8	10.2	8.3	6.3	4.5	3.0	1.8	.8	.3
		TWNI	19.4	17.6	16.2	14.7	13.1	10.4	7.4	4.5	1.8
		DG	10.4	7.5	3.8	.4	-	-	-	-	-
		DGNI	20.9	19.0	16.9	15.2	12.5	9.2	6.3	3.6	1.3

DENVER COLORADO		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	136	63	39	27	20	15	11	7	-
39.7 N	L	WWNI	218	105	67	48	37	29	24	19	13
6016 DD	C	TW	132	61	38	25	17	12	8	5	3
T(JAN)=30	R	TWNI	207	99	63	45	34	27	21	15	10
		DG	127	54	28	13	-	-	-	-	-
		DGNI	227	108	68	48	36	27	20	14	9
		WW	12.9	11.1	9.6	8.4	7.1	5.1	3.0	1.2	-
		WWNI	21.8	19.1	18.2	16.2	15.0	13.6	10.8	6.9	2.9
	D	TW	12.5	10.6	8.7	6.5	4.7	3.2	1.9	.9	.3
		TWNI	20.2	18.2	16.5	15.1	13.3	10.6	7.5	4.6	1.9
		DG	11.2	8.0	4.3	1.1	-	-	-	-	-
		DGNI	21.8	19.6	17.4	15.6	12.8	9.5	6.5	3.7	1.3

EAGLE COLORADO		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	95	43	26	17	12	8	5	-	-
39.6 N	L	WWNI	172	81	52	37	28	22	17	13	9
8426 DD	C	TW	96	43	25	16	10	7	4	-	-
T(JAN)=18	R	TWNI	163	77	49	34	26	20	15	11	7
		DG	72	22	-	-	-	-	-	-	-
		DGNI	174	81	51	35	26	19	14	9	5
		WW	8.5	7.1	5.8	4.7	3.3	1.9	.6	-	-
		WWNI	16.0	15.2	13.4	12.2	10.8	9.3	7.1	4.7	1.9
	D	TW	8.7	7.0	5.4	3.7	2.3	1.3	.5	-	-
		TWNI	15.3	13.8	12.5	11.1	9.5	7.6	5.3	3.2	1.2
		DG	5.4	1.5	-	-	-	-	-	-	-
		DGNI	16.2	14.3	12.6	10.8	8.6	6.2	4.0	2.1	.6

GRAND JUNCTION COLORADO		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	135	61	37	25	18	13	9	5	-
39.1 N	L	WWNI	222	104	66	46	35	28	22	17	12
5605 DD	C	TW	133	60	36	23	16	11	7	4	1
T(JAN)=27	R	TWNI	210	98	61	43	33	25	19	14	9
		DG	125	50	24	-	-	-	-	-	-
		DGNI	229	106	66	46	34	25	18	13	8
		WW	12.0	10.3	8.7	7.5	5.7	4.1	2.2	.7	-
		WWNI	20.1	18.7	16.8	15.2	13.9	11.8	9.1	6.0	2.4
	D	TW	11.8	9.8	7.9	5.9	4.1	2.6	1.5	.6	.1
		TWNI	19.2	17.4	15.6	14.1	11.9	9.6	6.8	4.1	1.6
		DG	10.2	6.7	3.0	-	-	-	-	-	-
		DGNI	20.9	18.4	16.3	14.1	11.5	8.5	5.7	3.2	1.1

PUEBLO COLORADO		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	145	67	41	29	21	16	12	8	-
38.3 N	L	WWNI	234	109	70	50	38	30	24	19	14
5394 DD	C	TW	143	65	39	26	18	13	9	5	3
T(JAN)=30	R	TWNI	220	103	66	47	36	28	21	16	11
		DG	140	59	32	16	-	-	-	-	-
		DGNI	242	113	71	50	38	28	21	15	9
		WW	12.8	11.8	10.2	9.0	7.5	5.5	3.2	1.4	-
		WWNI	21.2	20.3	18.6	16.9	15.4	13.9	11.2	7.1	3.0
	D	TW	12.9	11.0	9.1	7.0	5.1	3.4	2.1	1.1	.4
		TWNI	20.2	18.9	17.2	15.7	13.7	11.0	7.8	4.8	1.9
		DG	11.8	8.8	5.1	1.9	-	-	-	-	-
		DGNI	22.1	20.1	18.1	16.2	13.4	9.9	6.8	3.9	1.4

HARTFORD CONNECTICUT		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	62	26	14	9	5	-	-	-	-
41.9 N	L	WWNI	134	62	39	28	21	16	13	10	7
6350 DD	C	TW	66	28	16	9	5	-	-	-	-
T(JAN)=25	R	TWNI	127	59	37	26	19	15	11	8	5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	131	60	37	25	18	13	9	6	3
		WW	5.2	3.8	2.8	1.7	.6	-	-	-	-
		WWNI	12.4	11.3	10.0	8.9	7.9	6.6	5.1	3.3	1.3
	D	TW	5.6	4.2	2.8	1.6	.5	-	-	-	-
		TWNI	11.6	10.6	9.3	8.2	6.9	5.5	3.8	2.3	.8
		DG	-	-	-	-	-	-	-	-	-
		DGNI	11.8	10.2	8.8	7.3	5.7	3.9	2.4	1.1	.2

WILMINGTON DELAWARE		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	95	44	26	18	12	9	5	-	-
39.7 N	L	WWNI	171	83	52	37	28	22	18	14	9
4940 DD	C	TW	97	44	26	17	11	7	4	-	-
T(JAN)=32	R	TWNI	163	78	49	35	26	20	15	11	7
		DG	74	24	-	-	-	-	-	-	-
		DGNI	174	82	51	36	26	19	14	10	5
		WW	8.9	7.2	6.0	4.8	3.5	2.1	.7	-	-
		WWNI	16.1	15.5	13.4	12.3	11.1	9.3	7.4	4.8	1.9
	D	TW	8.7	7.2	5.5	3.9	2.5	1.4	.6	-	-
		TWNI	15.4	14.1	12.7	11.3	9.6	7.7	5.4	3.3	1.3
		DG	5.7	1.9	-	-	-	-	-	-	-
		DGNI	16.5	14.5	12.8	10.9	8.8	6.4	4.1	2.2	.7

WASHINGTON DC		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	92	42	25	17	11	8	4	-	-
38.9 N	L	WWNI	169	80	51	36	27	21	17	13	9
5010 DD	C	TW	94	42	25	16	10	6	3	-	-
T(JAN)=32	R	TWNI	160	76	48	34	25	19	15	11	7
		DG	69	19	-	-	-	-	-	-	-
		DGNI	171	80	50	35	25	19	13	9	5
		WW	8.4	6.9	5.5	4.4	3.1	1.8	.5	-	-
		WWNI	15.6	14.9	13.1	11.7	10.7	8.9	7.1	4.6	1.8
	D	TW	8.4	6.8	5.2	3.6	2.2	1.2	.4	-	-
		TWNI	14.9	13.7	12.2	10.9	9.3	7.4	5.2	3.1	1.2
		DG	5.0	.9	-	-	-	-	-	-	-
		DGNI	15.9	14.0	12.3	10.4	8.4	6.0	3.9	2.1	.6

APALACHICOLA FLORIDA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	405	182	114	81	61	48	37	27	18
29.7 N	L	WWNI	547	249	156	113	87	68	55	44	31
1361 DD	C	TW	371	170	104	72	51	38	28	20	13
T(JAN)=54	R	TWNI	511	233	147	105	79	62	48	36	24
		DG	464	208	126	84	59	41	28	17	8
		DGNI	585	267	168	119	89	68	52	38	25
		WW	36.6	31.0	29.9	26.7	23.1	19.7	13.9	8.0	2.9
		WWNI	50.2	42.8	41.4	39.2	34.7	30.4	25.3	16.3	6.9
	D	TW	33.7	29.1	25.2	20.5	16.3	12.4	8.8	5.6	2.5
		TWNI	46.7	40.7	38.4	34.5	31.0	24.7	17.6	10.9	4.5
		DG	41.1	34.7	29.2	22.5	16.4	11.1	6.6	3.1	.6
		DGNI	53.0	46.7	43.0	38.3	32.9	25.2	17.8	10.8	4.5

DAYTONA BEACH FLORIDA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	603	281	180	130	100	79	62	48	32
29.2 N	L	WWNI	784	367	235	172	133	106	86	69	49
902 DD	C	TW	556	260	164	114	83	62	47	34	23
T(JAN)=58	R	TWNI	735	344	221	159	122	96	74	56	38
		DG	725	337	211	146	105	76	55	38	23
		DGNI	852	399	256	183	139	107	82	61	41
		WW	55.5	50.8	49.4	45.2	39.8	35.4	25.3	15.3	6.3
		WWNI	73.8	66.4	65.2	61.3	55.2	49.0	41.9	26.4	11.4
	D	TW	50.7	46.6	41.7	34.3	27.9	21.7	15.9	10.5	5.4
		TWNI	67.6	63.0	59.8	54.4	49.3	39.1	28.1	17.5	7.3
		DG	65.9	59.8	52.8	42.3	32.8	24.1	16.2	9.4	3.7
		DGNI	78.1	73.2	68.4	61.6	53.3	41.1	29.4	18.3	7.9

JACKSONVILLE FLORIDA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	425	191	120	87	66	52	41	31	20
30.5 N	L	WWNI	573	260	164	119	92	74	60	47	34
1327 DD	C	TW	390	179	111	77	55	41	30	22	15
T(JAN)=55	R	TWNI	533	244	154	111	85	66	52	39	26
		DG	489	221	136	92	65	46	32	21	11
		DGNI	611	279	177	126	96	73	56	41	27
		WW	37.8	32.9	32.3	29.8	26.0	22.6	15.8	9.3	3.5
		WWNI	52.8	44.9	44.0	43.2	38.5	33.9	28.8	18.1	7.7
	D	TW	35.4	31.2	27.3	22.4	18.0	13.9	10.0	6.4	3.1
		TWNI	48.4	42.9	41.4	37.7	33.9	27.1	19.4	12.0	5.0
		DG	43.5	37.7	32.3	25.2	18.8	13.1	8.1	4.1	1.2
		DGNI	55.2	49.2	46.6	41.9	36.1	27.8	19.7	12.1	5.1

MIAMI FLORIDA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	2285	1138	731	516	389	307	242	186	130
25.8 N	L	WWNI	2804	1401	906	641	483	382	307	242	174
206 DD	C	TW	2102	1013	641	449	329	245	184	135	94
T(JAN)=67	R	TWNI	2638	1304	832	589	446	344	265	198	133
		DG	2912	1403	886	620	452	336	249	181	121
		DGNI	3119	1534	975	692	520	398	303	224	151
		WW	229.	218.	189.	166.	153.	131.	101.	64.	28.
		WWNI	280.	274.	240.	205.	188.	178.	136.	92.	39.
	D	TW	206.	185.	163.	137.	110.	84.	63.	42.	23.
		TWNI	264.	247.	214.	192.	169.	136.	97.	61.	25.
		DG	286.	255.	226.	188.	149.	114.	81.	52.	25.
		DGNI	312.	287.	251.	228.	190.	149.	107.	68.	30.

ORLANDO FLORIDA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	723	346	224	163	124	98	78	60	41
28.5 N	L	WWNI	927	446	289	211	163	130	105	84	60
733 DD	C	TW	663	319	202	142	104	78	58	43	30
T(JAN)=60	R	TWNI	867	418	270	195	149	117	91	68	46
		DG	879	421	265	185	134	99	72	51	32
		DGNI	1010	487	314	226	171	132	101	75	50
		WW	69.8	64.7	61.8	56.4	49.8	43.6	31.9	19.6	8.2
		WWNI	90.9	83.1	81.9	75.0	67.1	60.0	50.3	32.1	13.8
	D	TW	64.0	58.4	52.1	43.2	35.1	27.4	20.1	12.8	7.0
		TWNI	83.7	78.8	73.7	66.7	59.7	47.7	34.2	21.2	8.9
		DG	84.3	76.5	67.6	54.9	43.0	32.0	22.0	13.1	5.6
		DGNI	97.3	92.0	84.6	76.2	65.8	50.7	36.3	22.6	9.8

TALLAHASSEE FLORIDA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	359	162	101	72	55	43	33	24	16
30.4 N	L	WWNI	491	226	141	102	79	62	50	40	28
1563 DD	C	TW	330	152	93	64	46	34	25	18	12
T(JAN)=53	R	TWNI	458	211	133	95	72	56	43	32	22
		DG	405	183	110	74	51	35	23	14	5
		DGNI	523	240	151	107	80	62	47	34	22
		WW	33.2	27.3	26.3	24.0	20.8	17.8	12.3	7.0	2.5
		WWNI	46.5	38.5	36.9	36.6	32.0	28.0	23.7	15.0	6.4
	D	TW	30.2	26.2	22.5	18.2	14.5	11.0	7.8	4.9	2.1
		TWNI	42.7	36.7	35.1	31.5	28.2	22.6	16.2	10.0	4.1
		DG	36.2	30.5	25.3	19.2	13.8	9.1	5.2	2.2	.3
		DGNI	48.2	41.9	39.0	34.7	29.9	22.9	16.1	9.8	4.0

TAMPA FLORIDA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	720	343	223	162	124	98	78	59	41
28.0 N	L	WWNI	926	441	288	211	162	129	105	83	60
718 DD	C	TW	663	317	201	141	104	78	58	43	30
T(JAN)=60	R	TWNI	866	415	269	195	149	117	90	68	46
		DG	878	418	264	184	134	98	72	50	32
		DGNI	1008	484	312	225	171	132	101	75	50
		WW	67.7	64.8	61.7	56.0	49.6	43.5	31.8	19.5	8.2
		WWNI	87.2	83.2	82.5	74.9	66.5	59.8	50.9	32.0	13.8
	D	TW	63.4	57.8	51.8	43.2	35.1	27.3	20.1	12.8	6.5
		TWNI	82.1	78.7	73.7	66.5	59.6	47.6	34.1	21.2	8.9
		DG	83.5	75.8	67.2	54.9	42.9	31.9	21.9	13.1	5.6
		DGNI	95.7	91.5	84.2	76.1	65.6	50.6	36.2	22.5	9.8

WEST PALM BEACH FLORIDA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	1523	761	494	350	264	208	164	126	88
26.7 N	L	WWNI	1886	943	619	441	331	261	211	167	120
299 DD	C	TW	1407	682	433	304	223	167	125	91	63
T(JAN)=65	R	TWNI	1775	884	568	403	305	237	183	136	92
		DG	1930	935	592	415	302	224	165	119	79
		DGNI	2093	1038	663	471	355	272	207	153	103
		WW	152.	151.	130.	112.	103.	90.	68.	43.	19.
		WWNI	189.	189.	168.	141.	128.	121.	96.	64.	28.
	D	TW	139.	125.	111.	93.	75.	58.	42.	28.	15.
		TWNI	178.	171.	150.	132.	118.	94.	67.	42.	18.
		DG	192.	171.	152.	125.	99.	75.	53.	34.	16.
		DGNI	209.	197.	172.	155.	132.	102.	73.	46.	21.

ATLANTA GEORGIA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	172	79	48	33	25	19	14	9	4
33.6 N	L	WWNI	264	126	79	56	42	33	27	21	15
3095 DD	C	TW	166	75	46	31	21	15	10	7	4
T(JAN)=42	R	TWNI	249	118	74	52	39	30	23	17	11
		DG	173	74	41	23	10	-	-	-	-
		DGNI	276	129	80	56	42	32	23	17	10
		WW	15.8	13.5	11.5	10.2	8.5	6.6	4.0	1.8	.2
		WWNI	24.6	22.9	20.0	18.3	16.9	14.6	12.1	7.7	3.2
	D	TW	15.0	12.8	10.5	8.1	5.8	4.1	2.5	1.4	.5
		TWNI	23.3	21.0	18.8	17.0	14.8	11.9	8.4	5.2	2.1
		DG	14.8	11.2	7.3	3.7	.8	-	-	-	-
		DGNI	25.9	22.6	20.3	17.6	14.8	11.0	7.5	4.4	1.6

AUGUSTA GEORGIA
33.4 N 2547 DD T(JAN)=46

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
	L	WW	213	101	62	43	32	25	19	13	7
	C	WWNI	312	152	95	67	51	41	33	26	18
	R	TW	204	94	58	39	27	20	14	9	6
		TWNI	295	141	89	63	48	37	28	21	14
		DG	228	101	59	37	22	12	-	-	-
		DGNI	332	157	98	69	52	39	29	21	13
		WW	20.5	17.2	15.0	13.8	11.6	9.4	6.0	3.1	.8
		WWNI	30.0	27.9	23.8	22.4	21.0	18.0	15.0	9.6	4.0
	D	TW	18.7	16.3	13.7	10.7	8.0	5.7	3.8	2.2	.9
		TWNI	28.5	25.2	22.7	20.7	18.0	14.5	10.4	6.4	2.6
		DG	20.3	16.3	12.0	7.8	4.3	1.6	-	-	-
		DGNI	32.0	27.7	25.1	21.9	18.5	13.9	9.7	5.7	2.2

MACON GEORGIA
32.7 N 2240 DD T(JAN)=48

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
	L	WW	244	114	70	49	37	28	21	15	9
	C	WWNI	349	169	105	74	57	45	36	28	20
	R	TW	230	106	65	44	31	22	16	11	7
		TWNI	330	156	98	69	52	41	31	23	16
		DG	266	119	70	44	28	17	9	-	-
		DGNI	373	175	109	77	57	43	33	24	15
		WW	23.8	19.1	17.1	15.7	13.4	11.0	7.2	3.8	1.1
		WWNI	34.0	29.7	26.0	25.0	23.1	19.9	16.7	10.6	4.4
	D	TW	21.2	18.4	15.5	12.2	9.1	6.7	4.6	2.8	1.1
		TWNI	32.1	27.5	25.0	22.7	19.9	16.1	11.5	7.1	2.9
		DG	23.7	19.2	14.7	10.0	6.1	3.1	.9	-	-
		DGNI	35.9	30.5	27.8	24.3	20.7	15.6	10.9	6.5	2.6

SAVANNAH GEORGIA
32.1 N 1952 DD T(JAN)=50

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
	L	WW	278	131	81	57	43	33	26	19	11
	C	WWNI	389	189	118	84	65	51	41	32	23
	R	TW	260	122	75	51	37	26	19	13	9
		TWNI	367	175	110	79	59	46	36	27	18
		DG	309	141	84	55	37	24	14	6	-
		DGNI	417	197	124	88	66	50	38	27	18
		WW	27.5	22.5	20.4	18.7	15.9	13.3	9.0	4.9	1.6
		WWNI	38.9	33.7	30.0	28.9	26.2	22.6	19.1	12.1	5.1
	D	TW	24.5	21.4	18.2	14.3	11.1	8.2	5.7	3.5	1.5
		TWNI	36.1	31.2	28.7	25.8	22.8	18.4	13.1	8.1	3.3
		DG	28.4	23.5	18.7	13.4	8.9	5.2	2.4	.4	-
		DGNI	40.5	35.0	32.0	28.0	23.9	18.1	12.7	7.7	3.1

BOISE IDAHO
43.6 N 5833 DD T(JAN)=29

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
	L	WW	132	58	34	22	15	10	5	-	-
	C	WWNI	215	101	63	44	32	25	19	14	9
	R	TW	127	56	32	20	13	8	4	-	-
		TWNI	203	95	59	41	30	22	16	12	7
		DG	117	42	-	-	-	-	-	-	-
		DGNI	221	102	62	42	30	22	15	10	5
		WW	11.8	9.5	7.2	5.4	3.6	2.1	.7	-	-
		WWNI	21.1	17.5	15.8	13.4	11.3	9.2	6.5	4.4	1.7
	D	TW	11.4	8.9	6.5	4.6	3.0	1.6	.6	-	-
		TWNI	19.2	16.7	14.3	12.1	9.8	7.5	5.3	3.1	1.1
		DG	9.3	4.6	-	-	-	-	-	-	-
		DGNI	20.5	17.4	14.5	11.9	9.0	6.6	4.1	2.1	.6

LEWISTON IDAHO
46.4 N 5464 DD T(JAN)=31

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
	L	WW	110	46	26	15	9	4	-	-	-
	C	WWNI	192	88	54	37	27	20	15	11	7
	R	TW	108	46	25	15	9	4	-	-	-
		TWNI	181	82	50	34	25	18	13	9	6
		DG	85	-	-	-	-	-	-	-	-
		DGNI	194	87	52	34	24	17	11	7	3
		WW	9.2	7.1	4.9	3.0	1.5	.3	-	-	-
		WWNI	18.5	14.8	13.3	10.9	8.7	6.8	4.8	3.3	1.3
	D	TW	9.3	6.7	4.6	2.9	1.5	.4	-	-	-
		TWNI	16.5	14.0	11.9	9.7	7.7	5.8	4.1	2.3	.8
		DG	5.8	-	-	-	-	-	-	-	-
		DGNI	17.4	14.4	11.6	9.0	6.7	4.7	2.8	1.3	.2

POCATELLO IDAHO
42.9 N 7063 DD T(JAN)=23

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
	L	WW	105	47	28	18	12	8	3	-	-
	C	WWNI	182	88	55	39	29	22	17	13	9
	R	TW	104	47	27	17	11	6	3	-	-
		TWNI	173	82	51	36	26	20	15	11	7
		DG	84	27	-	-	-	-	-	-	-
		DGNI	186	87	54	37	26	19	14	9	5
		WW	9.9	7.8	5.9	4.4	2.8	1.5	.2	-	-
		WWNI	17.7	15.6	14.2	12.1	10.4	8.5	6.1	4.1	1.6
	D	TW	9.5	7.5	5.5	3.7	2.3	1.1	.3	-	-
		TWNI	16.8	14.7	12.8	11.0	9.1	7.0	4.9	2.9	1.1
		DG	6.5	2.1	-	-	-	-	-	-	-
		DGNI	17.6	15.3	12.8	10.5	8.1	5.8	3.7	1.8	.5

CHICAGO ILLINOIS
41.8 N 6127 DD T(JAN)=24

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
	L	WW	73	31	17	11	6	-	-	-	-
	C	WWNI	149	69	43	30	22	17	14	10	7
	R	TW	78	33	18	11	6	-	-	-	-
		TWNI	141	65	40	28	21	16	12	9	5
		DG	34	-	-	-	-	-	-	-	-
		DGNI	148	67	41	28	20	14	10	7	3
		WW	6.3	4.6	3.4	2.2	1.1	-	-	-	-
		WWNI	13.1	12.7	10.6	9.3	8.4	6.9	5.3	3.5	1.3
	D	TW	6.5	4.9	3.4	2.0	.9	-	-	-	-
		TWNI	12.6	11.4	10.0	8.8	7.3	5.8	4.0	2.4	.9
		DG	1.3	-	-	-	-	-	-	-	-
		DGNI	13.1	11.3	9.6	7.9	6.2	4.3	2.6	1.3	.2

MOLINE ILLINOIS
41.4 N 6395 DD T(JAN)=21

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
	L	WW	72	30	17	10	6	-	-	-	-
	C	WWNI	147	68	42	30	22	17	13	10	7
	R	TW	76	32	18	10	6	-	-	-	-
		TWNI	139	64	40	28	21	16	12	9	5
		DG	29	-	-	-	-	-	-	-	-
		DGNI	145	66	40	27	19	14	10	6	3
		WW	6.2	4.4	3.2	2.1	1.0	-	-	-	-
		WWNI	13.1	12.3	10.4	9.1	8.3	6.9	5.3	3.4	1.3
	D	TW	6.4	4.7	3.3	1.9	.8	-	-	-	-
		TWNI	12.6	11.2	9.7	8.7	7.2	5.7	4.0	2.4	.9
		DG	.8	-	-	-	-	-	-	-	-
		DGNI	13.0	11.0	9.4	7.8	6.1	4.2	2.6	1.2	.2

SPRINGFIELD ILLINOIS		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	90	39	22	14	10	6	-	-	-
39.8 N	L	WWNI	168	78	49	34	25	20	16	12	8
5558 DD	C	TW	92	39	23	14	9	5	2	-	-
T(JAN)=27	R	TWNI	159	74	46	32	24	18	14	10	6
		DG	61	-	-	-	-	-	-	-	-
		DGNI	169	77	47	32	23	17	12	8	4
		WW	7.9	5.9	4.7	3.6	2.4	1.1	-	-	-
		WWNI	15.0	14.1	12.0	10.6	9.8	8.2	6.4	4.2	1.7
	D	TW	7.8	6.1	4.5	2.9	1.7	.8	.1	-	-
		TWNI	14.4	12.8	11.2	10.0	8.5	6.8	4.8	2.9	1.1
		DG	4.0	-	-	-	-	-	-	-	-
		DGNI	15.2	13.0	11.2	9.4	7.6	5.4	3.4	1.8	.5

EVANSVILLE INDIANA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	104	46	26	17	12	8	5	-	-
38.0 N	L	WWNI	182	86	54	37	28	22	17	13	9
4629 DD	C	TW	104	45	26	17	11	7	4	-	-
T(JAN)=33	R	TWNI	173	81	50	35	26	20	15	11	7
		DG	81	25	-	-	-	-	-	-	-
		DGNI	186	85	52	36	26	19	14	9	5
		WW	9.3	7.2	5.6	4.5	3.3	1.9	.6	-	-
		WWNI	16.9	15.6	13.3	11.6	10.9	9.1	7.2	4.7	1.9
	D	TW	9.1	7.2	5.5	3.7	2.3	1.3	.5	-	-
		TWNI	16.1	14.2	12.3	11.1	9.4	7.5	5.3	3.2	1.2
		DG	5.9	1.9	-	-	-	-	-	-	-
		DGNI	17.1	14.5	12.5	10.6	8.6	6.2	4.0	2.1	.6

FORT WAYNE INDIANA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	62	25	13	8	-	-	-	-	-
41.0 N	L	WWNI	136	62	39	27	20	16	12	9	6
6209 DD	C	TW	67	28	15	8	4	-	-	-	-
T(JAN)=25	R	TWNI	128	59	37	25	19	14	11	8	5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	132	60	36	24	17	12	9	5	2
		WW	5.1	3.6	2.4	1.3	-	-	-	-	-
		WWNI	12.1	11.3	9.6	8.3	7.4	6.2	4.7	3.1	1.2
	D	TW	5.5	4.0	2.6	1.3	.2	-	-	-	-
		TWNI	11.5	10.3	8.9	7.9	6.5	5.2	3.6	2.1	.8
		DG	-	-	-	-	-	-	-	-	-
		DGNI	11.7	9.9	8.4	6.9	5.3	3.6	2.2	1.0	.1

INDIANAPOLIS INDIANA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	74	31	17	11	7	-	-	-	-
39.7 N	L	WWNI	148	69	43	30	23	17	14	11	7
5577 DD	C	TW	77	33	18	11	6	2	-	-	-
T(JAN)=28	R	TWNI	141	65	41	28	21	16	12	9	6
		DG	35	-	-	-	-	-	-	-	-
		DGNI	147	67	41	28	20	14	10	7	3
		WW	6.5	4.6	3.4	2.3	1.3	-	-	-	-
		WWNI	13.4	12.6	10.6	9.3	8.5	7.1	5.5	3.6	1.4
	D	TW	6.6	4.9	3.4	2.1	.9	.1	-	-	-
		TWNI	12.9	11.4	9.9	8.9	7.4	5.9	4.1	2.4	.9
		DG	1.4	-	-	-	-	-	-	-	-
		DGNI	13.4	11.3	9.6	8.0	6.3	4.4	2.7	1.3	.3

SOUTH BEND INDIANA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	60	24	12	6	-	-	-	-	-
41.7 N	L	WWNI	137	61	38	26	19	15	11	9	6
6462 DD	C	TW	66	26	14	7	-	-	-	-	-
T(JAN)=24	R	TWNI	129	58	36	25	18	13	10	7	5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	132	58	35	23	16	12	8	5	-
		WW	4.8	3.2	1.9	.7	-	-	-	-	-
		WWNI	11.8	10.8	9.1	7.8	6.9	5.6	4.2	2.8	1.0
	D	TW	5.3	3.6	2.2	1.0	-	-	-	-	-
		TWNI	11.2	9.9	8.5	7.4	6.1	4.8	3.3	1.9	.7
		DG	-	-	-	-	-	-	-	-	-
		DGNI	11.3	9.4	7.8	6.3	4.8	3.2	1.9	.8	-

BURLINGTON IOWA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	83	36	20	13	8	5	-	-	-
40.8 N	L	WWNI	159	74	46	32	24	19	15	11	8
6149 DD	C	TW	85	36	21	13	7	4	-	-	-
T(JAN)=23	R	TWNI	151	70	43	30	22	17	13	9	6
		DG	50	-	-	-	-	-	-	-	-
		DGNI	159	72	44	30	22	16	11	7	4
		WW	7.2	5.4	4.1	3.0	1.9	.6	-	-	-
		WWNI	14.3	13.4	11.4	10.0	9.2	7.6	5.9	3.9	1.5
	D	TW	7.3	5.6	4.0	2.6	1.3	.5	-	-	-
		TWNI	13.7	12.2	10.6	9.5	7.9	6.4	4.4	2.6	1.0
		DG	3.0	-	-	-	-	-	-	-	-
		DGNI	14.4	12.2	10.5	8.8	6.9	4.9	3.1	1.5	.4

DES MOINES IOWA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	78	33	18	11	7	3	-	-	-
41.5 N	L	WWNI	155	71	44	31	23	18	14	11	7
6710 DD	C	TW	81	34	19	11	6	3	-	-	-
T(JAN)=19	R	TWNI	146	67	41	29	21	16	12	9	6
		DG	41	-	-	-	-	-	-	-	-
		DGNI	153	69	42	29	20	15	11	7	3
		WW	6.6	4.8	3.6	2.5	1.5	.2	-	-	-
		WWNI	13.9	12.7	10.8	9.5	8.6	7.3	5.6	3.7	1.4
	D	TW	6.8	5.1	3.6	2.2	1.0	.2	-	-	-
		TWNI	13.2	11.6	10.1	9.0	7.5	6.1	4.2	2.5	1.0
		DG	2.0	-	-	-	-	-	-	-	-
		DGNI	13.7	11.5	9.8	8.2	6.5	4.5	2.8	1.4	.3

MASON CITY IOWA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	68	27	14	8	4	-	-	-	-
43.1 N	L	WWNI	143	65	40	28	21	16	12	9	6
7901 DD	C	TW	72	29	16	9	4	-	-	-	-
T(JAN)=14	R	TWNI	136	62	38	26	19	15	11	8	5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	141	63	37	25	18	13	9	6	2
		WW	5.5	3.7	2.6	1.5	.3	-	-	-	-
		WWNI	13.0	11.3	9.7	8.5	7.5	6.3	4.8	3.2	1.2
	D	TW	5.9	4.2	2.7	1.4	.4	-	-	-	-
		TWNI	12.2	10.6	9.1	8.0	6.7	5.3	3.7	2.2	.8
		DG	-	-	-	-	-	-	-	-	-
		DGNI	12.3	10.2	8.5	7.1	5.4	3.7	2.3	1.0	.1

SIOUX CITY IOWA

42.4 N, 6953 DD, T(JAN)=18

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 77	32	17	11	7	-	-	-	-
	L	WWNI 153	70	44	30	22	17	14	10	7
	C	TW 80	33	18	11	6	-	-	-	-
	R	TWNI 144	66	41	28	21	16	12	9	6
		DG 37	-	-	-	-	-	-	-	-
		DGNI 151	68	41	28	20	14	10	7	3
		WW 6.5	4.6	3.3	2.3	1.2	-	-	-	-
		WWNI 14.0	12.4	10.6	9.2	8.4	7.0	5.4	3.5	1.4
	D	TW 6.7	5.0	3.4	2.0	.9	-	-	-	-
		TWNI 13.2	11.4	9.9	8.8	7.3	5.9	4.1	2.4	.9
		DG 1.6	-	-	-	-	-	-	-	-
		DGNI 13.6	11.3	9.5	7.9	6.2	4.3	2.7	1.3	.3

DODGE CITY KANSAS

37.8 N, 5046 DD, T(JAN)=31

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 140	64	39	27	19	15	10	6	-
	L	WWNI 228	107	67	48	36	29	23	18	13
	C	TW 138	62	37	25	17	11	8	5	2
	R	TWNI 215	100	63	45	34	26	20	15	10
		DG 132	54	27	10	-	-	-	-	-
		DGNI 236	109	68	47	35	26	20	14	8
		WW 12.5	10.6	9.1	8.1	6.6	4.7	2.7	1.0	-
		WWNI 20.6	19.6	17.1	15.6	14.4	12.8	10.3	6.6	2.7
	D	TW 12.2	10.3	8.4	6.3	4.5	2.9	1.7	.8	.2
		TWNI 19.7	17.8	16.0	14.6	12.7	10.2	7.2	4.4	1.8
		DG 10.8	7.5	3.9	.3	-	-	-	-	-
		DGNI 21.6	18.9	16.8	14.9	12.3	9.1	6.2	3.5	1.2

GOODLAND KANSAS

39.4 N, 6119 DD, T(JAN)=28

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 120	55	33	23	17	12	8	5	-
	L	WWNI 202	95	61	43	33	26	21	16	12
	C	TW 118	54	32	21	14	10	6	4	1
	R	TWNI 190	90	57	40	31	24	18	13	9
		DG 105	42	18	-	-	-	-	-	-
		DGNI 206	97	60	42	31	24	17	12	7
		WW 10.8	9.4	7.8	6.7	5.4	3.7	1.9	.6	-
		WWNI 19.7	17.2	16.0	14.2	12.9	11.7	9.3	5.9	2.5
	D	TW 10.9	9.0	7.2	5.3	3.7	2.4	1.3	.5	.1
		TWNI 18.1	16.4	14.6	13.2	11.6	9.2	6.5	4.0	1.6
		DG 8.7	5.4	1.7	-	-	-	-	-	-
		DGNI 19.3	17.1	15.2	13.4	10.9	8.0	5.4	3.0	1.0

TOPEKA KANSAS

39.1 N, 5243 DD, T(JAN)=28

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 112	50	29	20	14	10	6	-	-
	L	WWNI 194	91	57	40	30	23	19	14	10
	C	TW 112	49	29	18	12	8	5	2	-
	R	TWNI 183	85	53	37	28	21	16	12	8
		DG 93	33	-	-	-	-	-	-	-
		DGNI 198	91	56	39	28	21	15	10	6
		WW 10.0	7.9	6.4	5.4	4.0	2.6	1.1	-	-
		WWNI 17.7	16.5	14.2	12.6	11.6	9.9	7.9	5.1	2.1
	D	TW 9.8	7.9	6.1	4.3	2.8	1.7	.8	.2	-
		TWNI 16.9	14.9	13.2	11.9	10.1	8.1	5.7	3.5	1.4
		DG 7.1	3.4	-	-	-	-	-	-	-
		DGNI 18.2	15.6	13.5	11.6	9.4	6.8	4.5	2.4	.8

WICHITA KANSAS

37.6 N, 4687 DD, T(JAN)=31

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 138	63	38	26	19	14	10	6	-
	L	WWNI 224	106	66	47	35	28	22	17	12
	C	TW 135	61	36	24	16	11	7	4	2
	R	TWNI 212	99	62	44	33	25	19	14	9
		DG 128	52	25	-	-	-	-	-	-
		DGNI 232	107	66	46	34	26	19	13	8
		WW 12.6	10.3	8.7	7.6	6.1	4.4	2.4	.8	-
		WWNI 20.7	19.1	16.8	15.1	14.1	12.2	9.8	6.3	2.6
	D	TW 12.0	10.1	8.1	5.9	4.1	2.7	1.5	.7	.1
		TWNI 19.8	17.5	15.6	14.2	12.2	9.8	7.0	4.3	1.7
		DG 10.5	7.1	3.3	-	-	-	-	-	-
		DGNI 21.4	18.7	16.4	14.3	11.8	8.7	5.9	3.3	1.1

LEXINGTON KENTUCKY

38.0 N, 4729 DD, T(JAN)=33

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 96	42	24	16	11	7	4	-	-
	L	WWNI 174	82	51	36	27	21	17	13	9
	C	TW 98	42	25	15	10	6	3	-	-
	R	TWNI 165	77	48	34	25	19	15	11	7
		DG 71	17	-	-	-	-	-	-	-
		DGNI 177	81	50	34	25	18	13	9	5
		WW 8.6	6.6	5.2	4.1	2.9	1.6	.4	-	-
		WWNI 16.0	14.9	12.7	11.2	10.4	8.7	7.0	4.5	1.8
	D	TW 8.5	6.7	5.0	3.4	2.0	1.1	.3	-	-
		TWNI 15.3	13.5	11.8	10.6	9.0	7.2	5.1	3.1	1.2
		DG 4.9	.4	-	-	-	-	-	-	-
		DGNI 16.2	13.8	11.9	10.1	8.2	5.8	3.8	2.0	.6

LOUISVILLE KENTUCKY

38.2 N, 4645 DD, T(JAN)=33

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 98	44	25	17	12	8	4	-	-
	L	WWNI 176	84	52	37	27	21	17	13	9
	C	TW 99	44	25	16	10	6	3	-	-
	R	TWNI 167	78	49	34	25	19	15	11	7
		DG 74	21	-	-	-	-	-	-	-
		DGNI 179	83	51	35	25	19	14	9	5
		WW 8.9	6.9	5.4	4.3	3.1	1.8	.5	-	-
		WWNI 16.3	15.3	13.1	11.4	10.6	8.9	7.1	4.6	1.8
	D	TW 8.7	6.9	5.2	3.5	2.2	1.2	.4	-	-
		TWNI 15.6	13.8	12.1	10.8	9.2	7.4	5.2	3.1	1.2
		DG 5.3	1.2	-	-	-	-	-	-	-
		DGNI 16.5	14.2	12.2	10.3	8.4	6.0	3.9	2.1	.6

BATON ROUGE LOUISIANA

30.5 N, 1670 DD, T(JAN)=51

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 312	142	87	62	46	36	28	20	12
	L	WWNI 430	203	125	90	69	54	43	34	24
	C	TW 287	133	81	55	39	28	21	15	9
	R	TWNI 405	188	118	84	63	49	38	28	19
		DG 346	156	93	61	41	27	17	8	-
		DGNI 460	213	133	94	70	53	40	29	19
		WW 30.3	23.6	22.1	20.0	17.2	14.1	9.7	5.4	1.7
		WWNI 43.0	34.4	31.8	31.4	27.5	23.9	19.6	12.7	5.3
	D	TW 26.6	22.8	19.3	15.2	12.0	9.0	6.2	3.9	1.6
		TWNI 39.0	32.7	30.5	27.2	24.1	19.4	13.8	8.5	3.5
		DG 31.2	25.5	20.4	14.8	10.2	6.3	3.1	.9	-
		DGNI 43.5	37.0	33.8	29.7	25.2	19.3	13.5	8.1	3.3

LAKE CHARLES LOUISIANA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	330	144	89	63	48	37	28	21	13
30.1 N	L	WWNI	457	205	127	92	70	55	44	35	25
1498 DD	C	TW	301	136	83	56	40	29	21	15	10
T(JAN)=52	R	TWNI	425	192	120	85	64	50	39	29	19
		DG	364	160	95	62	42	28	18	9	-
		DGNI	482	218	136	96	71	54	41	30	19
		WW	29.3	23.9	23.1	20.6	17.8	14.4	10.0	5.6	1.8
		WWNI	43.2	34.2	33.1	31.7	28.2	24.7	19.7	12.9	5.4
	D	TW	27.1	23.0	19.4	15.8	12.4	9.3	6.5	4.0	1.7
		TWNI	38.8	32.9	30.9	27.9	24.8	19.9	14.1	8.7	3.5
		DG	31.8	25.9	20.9	15.5	10.7	6.7	3.4	1.0	-
		DGNI	43.6	37.3	34.3	30.6	25.8	19.8	13.9	8.3	3.3

NEW ORLEANS LOUISIANA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	374	169	104	74	56	44	34	25	16
30.0 N	L	WWNI	506	235	146	105	80	64	51	40	29
1465 DD	C	TW	342	158	97	66	47	35	25	18	12
T(JAN)=53	R	TWNI	474	219	137	98	74	57	44	33	22
		DG	423	191	115	76	52	36	24	14	6
		DGNI	542	249	156	110	83	63	48	35	23
		WW	35.5	28.2	26.8	24.6	21.3	17.7	12.5	7.1	2.5
		WWNI	50.6	39.6	37.4	36.6	32.7	28.6	23.2	15.1	6.4
	D	TW	31.5	27.2	23.2	18.6	14.8	11.2	8.0	5.0	2.2
		TWNI	45.0	37.9	35.6	32.1	28.6	22.9	16.4	10.1	4.1
		DG	38.1	31.8	26.1	19.7	14.2	9.5	5.4	2.3	.3
		DGNI	50.6	43.2	39.8	35.4	30.2	23.2	16.4	10.0	4.1

SHREVEPORT LOUISIANA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	250	115	70	50	37	29	22	15	9
32.5 N	L	WWNI	356	170	105	75	57	45	36	29	20
2167 DD	C	TW	234	108	66	45	32	23	16	11	7
T(JAN)=47	R	TWNI	336	158	99	70	53	41	32	23	16
		DG	271	120	71	45	29	18	9	-	-
		DGNI	380	177	110	78	58	44	33	24	15
		WW	23.9	19.2	17.5	15.9	13.6	10.9	7.3	3.9	1.1
		WWNI	34.8	29.7	26.5	25.6	23.3	20.1	16.5	10.6	4.5
	D	TW	21.5	18.6	15.6	12.2	9.3	6.9	4.7	2.8	1.2
		TWNI	32.2	27.6	25.4	22.9	20.1	16.2	11.6	7.1	2.9
		DG	24.0	19.5	14.9	10.2	6.4	3.3	.9	-	-
		DGNI	35.9	30.8	27.9	24.6	20.8	15.8	11.0	6.6	2.6

CARIBOU MAINE		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	48	18	8	-	-	-	-	-	-
46.9 N	L	WWNI	119	55	34	24	18	13	10	7	5
9632 DD	C	TW	54	21	10	3	-	-	-	-	-
T(JAN)=11	R	TWNI	113	52	32	22	16	12	9	6	4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	114	51	31	20	14	10	6	4	-
		WW	3.8	2.3	.9	-	-	-	-	-	-
		WWNI	11.1	9.5	8.4	7.4	6.2	4.9	3.5	2.2	.8
	D	TW	4.5	2.8	1.4	.1	-	-	-	-	-
		TWNI	10.5	8.9	7.9	6.7	5.4	4.1	2.9	1.6	.6
		DG	-	-	-	-	-	-	-	-	-
		DGNI	10.3	8.5	7.0	5.4	3.9	2.6	1.4	.4	-

PORTLAND MAINE		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	60	24	13	7	-	-	-	-	-
43.6 N	L	WWNI	133	61	38	27	20	15	12	9	6
7498 DD	C	TW	65	27	14	8	3	-	-	-	-
T(JAN)=21	R	TWNI	126	58	36	25	19	14	11	8	5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	130	58	35	24	17	12	8	5	2
		WW	4.8	3.4	2.3	1.2	-	-	-	-	-
		WWNI	12.2	10.5	9.7	8.4	7.3	6.1	4.7	3.0	1.2
	D	TW	5.4	3.8	2.4	1.2	.2	-	-	-	-
		TWNI	11.6	10.0	8.8	7.7	6.5	5.1	3.6	2.1	.8
		DG	-	-	-	-	-	-	-	-	-
		DGNI	11.5	9.8	8.2	6.8	5.2	3.6	2.1	.9	.1

BALTIMORE MARYLAND		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	101	46	28	19	13	9	6	-	-
39.2 N	L	WWNI	178	86	55	39	29	23	18	14	10
4729 DD	C	TW	102	46	27	18	12	7	4	2	-
T(JAN)=33	R	TWNI	169	81	51	36	27	21	16	12	8
		DG	81	29	-	-	-	-	-	-	-
		DGNI	182	86	54	37	27	20	15	10	6
		WW	9.5	7.7	6.4	5.2	3.9	2.4	1.0	-	-
		WWNI	16.8	16.1	14.0	12.7	11.6	9.7	7.8	5.0	2.0
	D	TW	9.1	7.6	5.9	4.2	2.7	1.6	.7	.1	-
		TWNI	16.1	14.7	13.1	11.8	10.0	8.0	5.6	3.4	1.3
		DG	6.4	2.8	-	-	-	-	-	-	-
		DGNI	17.1	15.2	13.4	11.4	9.3	6.7	4.4	2.4	.7

BOSTON MASSACHUSETTS		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	81	35	20	13	9	5	-	-	-
42.4 N	L	WWNI	159	73	46	32	24	19	15	11	8
5621 DD	C	TW	85	36	21	13	8	4	-	-	-
T(JAN)=29	R	TWNI	150	69	43	30	23	17	13	10	6
		DG	49	-	-	-	-	-	-	-	-
		DGNI	158	72	44	30	22	16	11	8	4
		WW	6.8	5.3	4.2	3.1	2.0	.8	-	-	-
		WWNI	14.1	13.2	11.5	10.3	9.3	7.7	6.1	4.0	1.6
	D	TW	7.2	5.5	4.1	2.6	1.4	.5	-	-	-
		TWNI	13.5	12.1	10.8	9.6	8.1	6.5	4.5	2.7	1.0
		DG	2.9	-	-	-	-	-	-	-	-
		DGNI	14.0	12.1	10.6	8.9	7.1	5.0	3.2	1.6	.4

ALPENA MICHIGAN		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	53	19	8	-	-	-	-	-	-
45.1 N	L	WWNI	126	57	35	24	17	13	10	7	5
8518 DD	C	TW	58	22	10	-	-	-	-	-	-
T(JAN)=18	R	TWNI	119	54	33	22	16	12	9	6	4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	121	53	31	20	14	10	6	3	-
		WW	4.0	2.2	.7	-	-	-	-	-	-
		WWNI	11.6	9.5	8.5	7.1	5.8	4.6	3.3	2.2	.8
	D	TW	4.7	2.8	1.4	-	-	-	-	-	-
		TWNI	11.0	9.0	7.7	6.4	5.2	4.0	2.7	1.6	.5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	10.8	8.5	6.7	5.2	3.7	2.4	1.3	.4	-

DETROIT MICHIGAN		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	62	26	14	8	-	-	-	-	-
42.4 N	L	WWNI	137	63	39	27	20	16	12	9	6
6228 DD	C	TW	68	28	15	8	3	-	-	-	-
T(JAN)=25	R	TWNI	130	60	37	26	19	14	11	8	5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	134	60	36	25	17	12	9	5	2
		WW	5.2	3.6	2.5	1.2	-	-	-	-	-
		WWNI	12.0	11.4	9.6	8.4	7.4	6.1	4.6	3.0	1.1
	D	TW	5.6	4.0	2.6	1.3	.2	-	-	-	-
		TWNI	11.5	10.3	9.0	7.9	6.5	5.1	3.6	2.1	.8
		DG	-	-	-	-	-	-	-	-	-
		DGNI	11.8	10.0	8.4	6.8	5.2	3.6	2.1	.9	.1

FLINT MICHIGAN		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	54	21	10	-	-	-	-	-	-
43.0 N	L	WWNI	129	58	36	25	18	14	11	8	5
7041 DD	C	TW	60	24	12	5	-	-	-	-	-
T(JAN)=22	R	TWNI	122	55	34	23	17	13	9	7	4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	124	54	32	21	15	10	7	4	-
		WW	4.1	2.6	1.3	-	-	-	-	-	-
		WWNI	11.6	9.8	8.7	7.3	6.3	5.2	3.8	2.5	.9
	D	TW	4.8	3.1	1.7	.5	-	-	-	-	-
		TWNI	10.8	9.4	8.0	6.9	5.6	4.4	3.0	1.8	.6
		DG	-	-	-	-	-	-	-	-	-
		DGNI	10.6	8.8	7.1	5.7	4.2	2.8	1.6	.6	-

GRAND RAPIDS MICHIGAN		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	57	22	10	-	-	-	-	-	-
42.9 N	L	WWNI	133	59	37	25	19	14	11	8	5
6801 DD	C	TW	63	25	12	6	-	-	-	-	-
T(JAN)=23	R	TWNI	125	56	34	24	17	13	10	7	4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	128	56	33	22	15	11	7	4	-
		WW	4.4	2.8	1.5	-	-	-	-	-	-
		WWNI	11.5	10.3	8.8	7.5	6.5	5.2	3.8	2.5	.9
	D	TW	5.0	3.2	1.9	.6	-	-	-	-	-
		TWNI	10.9	9.6	8.2	7.0	5.7	4.4	3.1	1.8	.6
		DG	-	-	-	-	-	-	-	-	-
		DGNI	10.9	9.0	7.4	5.9	4.3	2.9	1.6	.6	-

SAULT STE. MARIE MICHIGAN		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	45	15	-	-	-	-	-	-	-
46.5 N	L	WWNI	116	53	33	22	16	12	9	6	4
9193 DD	C	TW	51	19	8	-	-	-	-	-	-
T(JAN)=14	R	TWNI	110	50	31	21	15	11	8	6	3
		DG	-	-	-	-	-	-	-	-	-
		DGNI	110	49	29	19	12	8	5	2	-
		WW	3.4	1.5	-	-	-	-	-	-	-
		WWNI	10.8	9.0	7.9	6.6	5.3	4.0	2.8	1.8	.7
	D	TW	4.1	2.2	.8	-	-	-	-	-	-
		TWNI	10.2	8.5	7.2	5.9	4.7	3.5	2.4	1.3	.4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	10.0	7.9	6.1	4.5	3.1	1.9	.9	.2	-

TRAVERSE CITY MICHIGAN		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	51	18	-	-	-	-	-	-	-
44.7 N	L	WWNI	127	56	34	23	17	13	9	7	4
7698 DD	C	TW	58	21	9	-	-	-	-	-	-
T(JAN)=21	R	TWNI	120	53	32	22	16	11	8	6	4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	121	52	30	20	13	9	6	3	-
		WW	3.6	1.9	-	-	-	-	-	-	-
		WWNI	11.3	9.1	8.1	6.7	5.5	4.3	3.1	2.0	.7
	D	TW	4.4	2.6	1.1	-	-	-	-	-	-
		TWNI	10.6	8.9	7.4	6.2	4.9	3.7	2.6	1.4	.5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	10.2	8.1	6.4	4.9	3.4	2.2	1.1	.3	-

DULUTH MINNESOTA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	42	15	-	-	-	-	-	-	-
46.8 N	L	WWNI	113	52	32	22	16	12	9	7	4
9756 DD	C	TW	49	18	8	-	-	-	-	-	-
T(JAN)= 9	R	TWNI	107	49	30	21	15	11	8	6	3
		DG	-	-	-	-	-	-	-	-	-
		DGNI	107	48	28	18	12	8	5	3	-
		WW	3.2	1.5	-	-	-	-	-	-	-
		WWNI	10.2	9.0	7.9	6.6	5.4	4.2	3.0	2.0	.7
	D	TW	3.9	2.2	.8	-	-	-	-	-	-
		TWNI	9.8	8.4	7.2	6.0	4.8	3.6	2.5	1.4	.5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	9.6	7.8	6.1	4.6	3.3	2.0	1.0	.2	-

INTER. FALLS MINNESOTA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	38	10	-	-	-	-	-	-	-
48.6 N	L	WWNI	109	49	30	21	15	11	8	6	4
10547 DD	C	TW	45	16	-	-	-	-	-	-	-
T(JAN)= 2	R	TWNI	104	47	28	19	14	10	7	5	3
		DG	-	-	-	-	-	-	-	-	-
		DGNI	103	45	26	16	11	7	4	-	-
		WW	2.7	.4	-	-	-	-	-	-	-
		WWNI	9.8	8.4	7.2	5.7	4.5	3.5	2.5	1.6	.5
	D	TW	3.5	1.6	-	-	-	-	-	-	-
		TWNI	9.3	7.9	6.6	5.3	4.1	3.1	2.1	1.2	.4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	9.0	7.1	5.3	3.8	2.5	1.4	.6	-	-

MINNEAPOLIS MINNESOTA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	54	21	10	-	-	-	-	-	-
44.9 N	L	WWNI	126	58	36	25	18	14	11	8	5
8159 DD	C	TW	59	24	12	5	-	-	-	-	-
T(JAN)=12	R	TWNI	120	55	34	23	17	13	9	7	4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	122	54	32	22	15	10	7	4	-
		WW	4.3	2.5	1.3	-	-	-	-	-	-
		WWNI	11.6	10.1	8.6	7.3	6.4	5.3	3.8	2.5	.9
	D	TW	4.8	3.2	1.7	.5	-	-	-	-	-
		TWNI	10.9	9.4	8.0	6.9	5.7	4.4	3.1	1.8	.6
		DG	-	-	-	-	-	-	-	-	-
		DGNI	10.8	8.8	7.2	5.7	4.3	2.8	1.6	.6	-

ROCHESTER MINNESOTA

43.9 N, 8227 DD, T(JAN)=13

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	53	20	9	-	-	-	-	-	-
	L	WWNI	126	57	35	24	18	14	11	8	5
	C	TW	59	23	12	5	-	-	-	-	-
	R	TWNI	120	54	33	23	17	13	9	7	4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	121	54	32	21	15	10	7	4	-
		WW	4.1	2.5	1.3	-	-	-	-	-	-
		WWNI	11.3	9.8	8.5	7.3	6.4	5.4	4.0	2.6	1.0
	D	TW	4.7	3.1	1.7	.5	-	-	-	-	-
		TWNI	10.7	9.3	7.9	6.9	5.7	4.5	3.1	1.8	.7
		DG	-	-	-	-	-	-	-	-	-
		DGNI	10.6	8.7	7.1	5.8	4.3	2.9	1.6	.6	-

JACKSON MISSISSIPPI

32.3 N, 2300 DD, T(JAN)=47

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	230	108	66	46	34	26	20	14	8
	L	WWNI	331	161	100	71	54	43	34	27	19
	C	TW	218	101	62	42	29	21	15	10	6
	R	TWNI	313	149	94	66	50	39	30	22	15
		DG	248	111	65	41	26	15	5	-	-
		DGNI	354	167	104	73	55	41	31	22	14
		WW	22.4	18.2	16.1	14.7	12.5	10.0	6.6	3.4	.9
		WWNI	32.3	29.0	25.0	23.8	22.0	18.9	15.6	10.0	4.2
	D	TW	20.1	17.5	14.6	11.5	8.6	6.2	4.2	2.5	1.0
		TWNI	30.5	26.5	24.0	21.7	19.0	15.3	10.9	6.7	2.7
		DG	22.2	17.9	13.4	8.9	5.2	2.4	.2	-	-
		DGNI	34.1	29.3	26.5	23.1	19.5	14.8	10.3	6.1	2.4

MERIDIAN MISSISSIPPI

32.3 N, 2388 DD, T(JAN)=47

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	216	103	63	44	33	25	19	13	7
	L	WWNI	315	154	97	69	53	41	33	26	19
	C	TW	206	96	59	40	28	20	14	10	6
	R	TWNI	298	144	90	64	48	38	29	21	14
		DG	233	104	61	38	24	13	-	-	-
		DGNI	335	160	100	71	53	40	30	21	14
		WW	21.0	17.8	15.4	14.2	11.9	9.5	6.2	3.2	.8
		WWNI	30.6	28.8	24.4	22.8	21.4	18.3	15.1	9.7	4.1
	D	TW	19.2	16.8	14.1	11.0	8.2	5.9	4.0	2.3	.9
		TWNI	28.9	25.9	23.3	21.1	18.3	14.8	10.5	6.5	2.6
		DG	20.9	17.0	12.6	8.2	4.6	1.9	-	-	-
		DGNI	32.6	28.4	25.7	22.4	18.8	14.2	9.8	5.8	2.3

COLUMBIA MISSOURI

38.8 N, 5083 DD, T(JAN)=29

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	102	45	26	17	12	8	5	-	-
	L	WWNI	182	85	53	37	28	22	17	13	9
	C	TW	103	45	26	16	10	6	3	-	-
	R	TWNI	173	80	50	35	26	20	15	11	7
		DG	79	23	-	-	-	-	-	-	-
		DGNI	185	84	51	36	26	19	14	9	5
		WW	9.1	7.0	5.5	4.5	3.2	1.9	.6	-	-
		WWNI	16.5	15.2	13.1	11.6	10.7	9.1	7.1	4.6	1.9
	D	TW	8.9	7.1	5.3	3.6	2.2	1.2	.4	-	-
		TWNI	15.8	13.9	12.2	10.9	9.3	7.5	5.2	3.2	1.2
		DG	5.6	1.6	-	-	-	-	-	-	-
		DGNI	16.8	14.3	12.4	10.5	8.5	6.1	4.0	2.1	.6

KANSAS CITY MISSOURI

39.3 N, 5357 DD, T(JAN)=27

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	102	45	26	17	12	8	5	-	-
	L	WWNI	182	85	53	37	28	22	17	14	9
	C	TW	103	45	26	17	11	7	4	-	-
	R	TWNI	172	80	50	35	26	20	15	11	7
		DG	79	25	-	-	-	-	-	-	-
		DGNI	184	84	52	36	26	19	14	10	5
		WW	9.1	7.1	5.7	4.6	3.4	2.0	.7	-	-
		WWNI	16.5	15.5	13.3	11.8	10.9	9.2	7.4	4.8	1.9
	D	TW	8.9	7.2	5.5	3.8	2.3	1.3	.5	-	-
		TWNI	15.8	14.0	12.4	11.1	9.5	7.6	5.3	3.2	1.3
		DG	5.7	1.9	-	-	-	-	-	-	-
		DGNI	16.9	14.5	12.5	10.7	8.7	6.2	4.1	2.2	.6

SAINT LOUIS MISSOURI

38.7 N, 4750 DD, T(JAN)=31

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	113	50	29	19	14	10	6	-	-
	L	WWNI	194	91	57	40	30	23	18	14	10
	C	TW	113	49	29	18	12	8	4	2	-
	R	TWNI	184	86	53	37	28	21	16	12	8
		DG	94	32	-	-	-	-	-	-	-
		DGNI	199	91	56	38	28	21	15	10	6
		WW	10.2	8.0	6.3	5.2	3.9	2.5	1.0	-	-
		WWNI	17.8	16.4	14.1	12.4	11.5	9.7	7.8	5.0	2.0
	D	TW	9.8	7.9	6.1	4.2	2.7	1.6	.7	.2	-
		TWNI	17.0	15.0	13.1	11.7	10.0	8.0	5.7	3.4	1.3
		DG	7.0	3.3	-	-	-	-	-	-	-
		DGNI	18.2	15.5	13.4	11.4	9.3	6.7	4.4	2.4	.7

SPRINGFIELD MISSOURI

37.2 N, 4570 DD, T(JAN)=33

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	123	55	33	22	16	11	8	4	-
	L	WWNI	207	97	61	43	32	25	20	16	11
	C	TW	122	54	32	21	14	9	6	3	-
	R	TWNI	196	91	57	40	30	23	18	13	8
		DG	108	41	16	-	-	-	-	-	-
		DGNI	213	97	60	42	31	23	17	12	7
		WW	11.0	8.9	7.3	6.3	4.9	3.3	1.7	.4	-
		WWNI	18.7	17.6	15.2	13.6	12.6	10.9	8.8	5.7	2.3
	D	TW	10.6	8.8	6.9	5.0	3.4	2.1	1.1	.4	-
		TWNI	17.9	15.9	14.1	12.8	11.0	8.9	6.3	3.8	1.5
		DG	8.4	5.0	1.0	-	-	-	-	-	-
		DGNI	19.2	16.8	14.7	12.7	10.4	7.6	5.1	2.8	.9

BILLINGS MONTANA

45.8 N, 7265 DD, T(JAN)=22

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	91	41	23	15	9	6	-	-	-
	L	WWNI	165	80	50	35	26	20	15	12	8
	C	TW	92	40	23	14	9	5	-	-	-
	R	TWNI	158	75	47	32	24	18	14	10	6
		DG	64	-	-	-	-	-	-	-	-
		DGNI	168	78	48	33	23	17	12	8	4
		WW	8.5	6.5	4.7	3.4	2.0	.8	-	-	-
		WWNI	16.0	14.2	12.8	10.8	9.3	7.8	5.8	3.9	1.5
	D	TW	8.2	6.4	4.6	2.9	1.7	.6	-	-	-
		TWNI	15.2	13.4	11.5	9.9	8.3	6.4	4.5	2.7	1.0
		DG	4.4	-	-	-	-	-	-	-	-
		DGNI	15.8	13.6	11.3	9.4	7.2	5.1	3.2	1.6	.4

CUT BANK MONTANA

48.6 N, 9033 DD, T(JAN)=16

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	77	33	18	10	5	-	-	-	-
	L	WWNI	153	71	44	31	23	17	13	9	6
	C	TW	80	34	18	11	5	-	-	-	-
	R	TWNI	144	67	42	29	21	15	11	8	5
		DG	40	-	-	-	-	-	-	-	-
		DGNI	151	69	42	28	20	14	9	6	-
		WW	6.5	5.0	3.2	1.8	.4	-	-	-	-
		WWNI	14.1	12.7	11.1	9.4	7.7	6.1	4.3	2.9	1.1
	D	TW	7.0	5.0	3.3	1.8	.6	-	-	-	-
		TWNI	13.3	11.7	10.1	8.5	6.9	5.1	3.6	2.0	.7
		DG	1.7	-	-	-	-	-	-	-	-
		DGNI	13.8	11.7	9.5	7.5	5.6	3.8	2.2	.9	-

DILLON MONTANA

45.2 N, 8354 DD, T(JAN)=20

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	90	40	24	15	10	6	-	-	-
	L	WWNI	168	78	50	35	26	20	16	12	8
	C	TW	92	40	23	15	9	5	-	-	-
	R	TWNI	158	74	47	33	24	18	14	10	6
		DG	64	-	-	-	-	-	-	-	-
		DGNI	168	78	48	33	24	17	12	8	4
		WW	7.8	6.6	5.1	3.7	2.3	1.0	-	-	-
		WWNI	15.2	14.4	12.9	11.4	9.7	8.1	5.9	4.0	1.5
	D	TW	8.1	6.3	4.7	3.1	1.8	.8	-	-	-
		TWNI	14.6	13.3	11.9	10.3	8.6	6.6	4.7	2.7	1.0
		DG	4.5	-	-	-	-	-	-	-	-
		DGNI	15.3	13.6	11.7	9.7	7.5	5.4	3.4	1.7	.4

GLASGOW MONTANA

48.2 N, 8969 DD, T(JAN)= 9

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	60	23	10	-	-	-	-	-	-
	L	WWNI	130	61	38	26	19	14	10	8	5
	C	TW	64	25	13	5	-	-	-	-	-
	R	TWNI	124	58	35	24	17	13	9	7	4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	128	58	34	22	15	10	7	4	-
		WW	5.0	2.9	1.2	-	-	-	-	-	-
		WWNI	12.4	10.6	9.0	7.2	6.1	4.9	3.5	2.3	.8
	D	TW	5.3	3.4	1.8	.4	-	-	-	-	-
		TWNI	11.7	10.0	8.2	6.8	5.5	4.1	2.9	1.6	.6
		DG	-	-	-	-	-	-	-	-	-
		DGNI	11.6	9.4	7.3	5.6	4.0	2.6	1.4	.5	-

GREAT FALLS MONTANA

47.5 N, 7652 DD, T(JAN)=20

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	86	38	21	13	7	-	-	-	-
	L	WWNI	161	77	48	33	25	19	14	10	7
	C	TW	88	38	21	13	7	3	-	-	-
	R	TWNI	153	72	45	31	23	17	12	9	5
		DG	56	-	-	-	-	-	-	-	-
		DGNI	163	75	46	31	22	15	11	7	3
		WW	7.8	5.9	4.0	2.6	1.1	-	-	-	-
		WWNI	14.9	13.7	12.1	10.1	8.5	6.9	4.8	3.3	1.2
	D	TW	7.6	5.8	4.0	2.4	1.2	.2	-	-	-
		TWNI	14.3	12.7	10.9	9.2	7.5	5.6	4.0	2.3	.8
		DG	3.4	-	-	-	-	-	-	-	-
		DGNI	15.0	12.9	10.5	8.4	6.3	4.4	2.6	1.2	.2

HELENA MONTANA

46.6 N, 8190 DD, T(JAN)=18

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	77	34	19	11	6	-	-	-	-
	L	WWNI	151	71	45	31	23	17	13	10	6
	C	TW	80	34	19	11	6	-	-	-	-
	R	TWNI	144	67	42	29	21	16	12	8	5
		DG	41	-	-	-	-	-	-	-	-
		DGNI	151	69	42	29	20	14	10	6	2
		WW	6.9	5.2	3.5	2.1	.7	-	-	-	-
		WWNI	13.7	13.0	11.4	9.7	8.0	6.4	4.6	3.0	1.1
	D	TW	6.9	5.1	3.5	2.0	.8	-	-	-	-
		TWNI	13.1	11.9	10.4	8.7	7.1	5.3	3.8	2.1	.8
		DG	2.0	-	-	-	-	-	-	-	-
		DGNI	13.8	11.9	9.8	7.8	5.8	4.0	2.4	1.0	.1

LEWISTOWN MONTANA

47.0 N, 8586 DD, T(JAN)=19

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	76	33	19	11	6	-	-	-	-
	L	WWNI	153	71	45	31	23	18	13	10	7
	C	TW	80	34	19	11	6	-	-	-	-
	R	TWNI	144	67	42	29	21	16	12	9	5
		DG	41	-	-	-	-	-	-	-	-
		DGNI	151	69	42	29	20	14	10	6	3
		WW	6.5	5.2	3.5	2.2	.9	-	-	-	-
		WWNI	13.8	12.8	11.3	9.7	8.1	6.6	4.8	3.2	1.2
	D	TW	6.9	5.1	3.5	2.1	.9	-	-	-	-
		TWNI	13.2	11.8	10.3	8.8	7.3	5.5	3.9	2.2	.8
		DG	1.9	-	-	-	-	-	-	-	-
		DGNI	13.6	11.8	9.9	8.0	6.0	4.2	2.5	1.1	.2

MILES CITY MONTANA

46.4 N, 7889 DD, T(JAN)=15

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	78	33	18	10	5	-	-	-	-
	L	WWNI	151	72	44	31	22	17	13	10	6
	C	TW	80	34	18	10	5	-	-	-	-
	R	TWNI	144	67	41	28	21	15	11	8	5
		DG	39	-	-	-	-	-	-	-	-
		DGNI	151	69	41	28	19	14	9	6	2
		WW	6.8	4.7	3.1	1.8	.6	-	-	-	-
		WWNI	14.7	12.5	10.8	9.0	7.7	6.3	4.6	3.1	1.2
	D	TW	6.9	5.0	3.2	1.8	.7	-	-	-	-
		TWNI	13.7	11.7	9.9	8.3	6.9	5.3	3.7	2.2	.8
		DG	1.6	-	-	-	-	-	-	-	-
		DGNI	14.0	11.5	9.3	7.5	5.6	3.9	2.3	1.0	.1

MISSOULA MONTANA

46.9 N, 7931 DD, T(JAN)=21

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	66	27	13	-	-	-	-	-	-
	L	WWNI	140	65	40	28	20	15	11	8	5
	C	TW	71	28	15	7	-	-	-	-	-
	R	TWNI	133	61	38	26	18	13	10	7	4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	138	62	37	24	16	11	7	4	-
		WW	5.7	3.7	1.8	-	-	-	-	-	-
		WWNI	12.4	11.4	9.7	8.2	6.4	4.9	3.4	2.2	.8
	D	TW	5.8	3.9	2.2	.8	-	-	-	-	-
		TWNI	12.0	10.5	9.0	7.3	5.7	4.2	2.9	1.6	.5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	12.4	10.2	8.1	6.1	4.3	2.8	1.5	.5	-

GRAND ISLAND NEBRASKA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	98	43	25	16	11	7	4	-	-
41.0 N	L	WWNI	178	82	52	36	27	21	17	13	9
6425 DD	C	TW	99	43	25	16	10	6	3	-	-
T(JAN)=22	R	TWNI	168	78	48	34	25	19	15	11	7
		DG	73	18	-	-	-	-	-	-	-
		DGNI	179	82	50	34	25	18	13	9	5
		WW	8.4	6.7	5.2	4.2	3.0	1.6	.4	-	-
		WWNI	16.4	14.7	12.8	11.3	10.2	8.8	7.0	4.5	1.8
	D	TW	8.6	6.8	5.0	3.5	2.1	1.1	.3	-	-
		TWNI	15.4	13.6	11.9	10.6	9.1	7.3	5.1	3.1	1.2
		DG	5.1	.7	-	-	-	-	-	-	-
		DGNI	16.2	13.8	11.9	10.2	8.2	5.9	3.8	2.0	.6

NORTH OMAHA NEBRASKA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	85	36	20	13	9	5	-	-	-
41.4 N	L	WWNI	163	75	47	33	24	19	15	12	8
6601 DD	C	TW	87	37	21	13	8	4	-	-	-
T(JAN)=20	R	TWNI	154	71	44	30	23	17	13	10	6
		DG	52	-	-	-	-	-	-	-	-
		DGNI	162	73	44	31	22	16	12	8	4
		WW	7.2	5.4	4.1	3.2	2.1	.8	-	-	-
		WWNI	14.8	13.3	11.4	10.1	9.2	7.9	6.2	4.0	1.6
	D	TW	7.4	5.7	4.1	2.6	1.4	.6	-	-	-
		TWNI	13.9	12.2	10.7	9.6	8.1	6.5	4.6	2.7	1.1
		DG	3.1	-	-	-	-	-	-	-	-
		DGNI	14.5	12.2	10.5	8.9	7.1	5.0	3.2	1.6	.4

NORTH PLATTE NEBRASKA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	103	46	27	18	13	9	5	-	-
41.1 N	L	WWNI	181	85	54	38	29	22	18	14	10
6743 DD	C	TW	103	46	27	17	11	7	4	1	-
T(JAN)=23	R	TWNI	172	80	50	35	27	20	16	11	7
		DG	81	27	-	-	-	-	-	-	-
		DGNI	184	85	53	37	27	20	14	10	6
		WW	9.1	7.5	6.0	5.0	3.6	2.2	.9	-	-
		WWNI	17.3	15.1	13.9	12.3	10.9	9.7	7.6	4.9	2.0
	D	TW	9.2	7.4	5.7	3.9	2.6	1.5	.6	.1	-
		TWNI	16.1	14.4	12.7	11.3	9.8	7.8	5.5	3.3	1.3
		DG	6.1	2.3	-	-	-	-	-	-	-
		DGNI	17.0	14.8	12.8	11.1	9.0	6.5	4.2	2.3	.7

SCOTTSBLUFF NEBRASKA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	103	47	28	19	13	9	6	-	-
41.9 N	L	WWNI	180	86	55	39	29	23	18	14	10
6774 DD	C	TW	103	46	28	18	12	7	4	2	-
T(JAN)=25	R	TWNI	171	81	51	36	27	21	16	12	8
		DG	82	29	-	-	-	-	-	-	-
		DGNI	183	86	54	37	27	20	15	10	6
		WW	9.5	7.9	6.3	5.3	3.9	2.4	1.0	-	-
		WWNI	17.8	15.4	14.4	12.6	11.3	10.1	7.8	5.1	2.0
	D	TW	9.4	7.7	5.9	4.1	2.7	1.6	.7	.1	-
		TWNI	16.5	14.7	13.0	11.7	10.1	8.1	5.7	3.4	1.3
		DG	6.5	2.9	-	-	-	-	-	-	-
		DGNI	17.4	15.3	13.3	11.5	9.3	6.7	4.4	2.4	.7

ELKO NEVADA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	113	52	31	21	15	10	7	-	-
40.8 N	L	WWNI	195	92	58	42	31	24	19	15	10
7483 DD	C	TW	114	51	30	20	13	8	5	2	-
T(JAN)=23	R	TWNI	184	87	55	39	29	22	17	12	8
		DG	97	36	-	-	-	-	-	-	-
		DGNI	199	93	58	40	29	22	16	11	6
		WW	10.2	8.7	7.2	5.8	4.2	2.7	1.2	-	-
		WWNI	17.9	17.0	15.2	13.6	12.0	10.3	7.6	5.1	2.0
	D	TW	10.1	8.3	6.5	4.7	3.1	1.8	.8	.2	-
		TWNI	17.1	15.6	14.1	12.4	10.5	8.3	5.8	3.5	1.3
		DG	7.8	4.2	-	-	-	-	-	-	-
		DGNI	18.4	16.4	14.3	12.3	9.7	7.1	4.6	2.5	.7

ELY NEVADA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	111	52	32	22	16	12	8	4	-
39.3 N	L	WWNI	191	91	59	42	32	26	20	16	11
7814 DD	C	TW	111	51	31	20	14	9	6	3	1
T(JAN)=24	R	TWNI	180	86	55	39	30	23	18	13	9
		DG	96	38	16	-	-	-	-	-	-
		DGNI	195	92	58	41	31	23	17	12	7
		WW	10.1	9.1	7.8	6.7	5.2	3.5	1.8	.4	-
		WWNI	17.8	17.1	15.8	14.4	13.0	11.5	8.9	5.8	2.3
	D	TW	10.2	8.7	7.0	5.1	3.6	2.2	1.2	.5	.1
		TWNI	16.9	15.9	14.6	13.2	11.4	9.1	6.4	3.9	1.5
		DG	8.0	4.9	1.2	-	-	-	-	-	-
		DGNI	18.3	16.8	15.1	13.2	10.7	7.9	5.2	2.9	1.0

LAS VEGAS NEVADA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	311	144	90	64	48	37	28	20	12
36.1 N	L	WWNI	430	204	129	92	70	56	44	35	24
2601 DD	C	TW	291	134	83	56	40	29	21	15	9
T(JAN)=44	R	TWNI	405	191	120	86	64	50	38	28	19
		DG	350	158	95	62	42	28	17	9	-
		DGNI	461	216	136	96	71	54	41	29	19
		WW	29.2	25.4	22.7	20.9	17.5	14.0	9.8	5.4	1.7
		WWNI	41.4	36.4	33.2	31.2	28.6	24.0	19.1	12.7	5.3
	D	TW	26.6	23.4	19.8	15.8	12.3	9.2	6.3	3.9	1.7
		TWNI	38.2	34.1	31.2	28.2	24.0	19.6	13.9	8.5	3.4
		DG	31.5	26.5	21.2	15.4	10.6	6.5	3.2	.9	-
		DGNI	43.0	38.2	35.0	30.5	25.7	19.6	13.6	8.2	3.2

LOVELOCK NEVADA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	160	73	45	31	22	16	12	7	-
40.1 N	L	WWNI	248	118	74	53	40	31	25	19	13
5990 DD	C	TW	153	70	42	28	19	13	9	5	3
T(JAN)=29	R	TWNI	235	110	70	49	37	28	22	16	10
		DG	156	66	35	18	-	-	-	-	-
		DGNI	259	121	75	53	39	29	21	15	9
		WW	14.8	12.5	10.7	9.1	7.3	5.2	3.0	1.2	-
		WWNI	24.1	20.8	19.7	17.3	15.4	13.4	10.1	6.7	2.7
	D	TW	14.0	11.8	9.5	7.1	5.2	3.5	2.0	1.0	.3
		TWNI	22.3	19.9	17.8	15.8	13.5	10.8	7.6	4.6	1.8
		DG	13.5	9.6	5.7	2.2	-	-	-	-	-
		DGNI	24.2	21.5	18.8	16.3	13.2	9.9	6.6	3.7	1.3

RENO NEVADA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	166	77	47	33	24	18	13	8	-
39.5 N	L	WWNI	258	122	77	55	42	33	26	20	14
6022 DD	C	TW	161	74	45	30	21	14	10	6	3
T(JAN)=32	R	TWNI	243	115	73	51	39	30	23	17	11
		DG	166	71	39	22	-	-	-	-	-
		DGNI	269	126	79	56	41	31	23	16	10
		WW	15.3	13.2	11.7	10.0	8.2	5.9	3.6	1.5	-
		WWNI	24.0	22.3	20.1	18.5	16.5	14.4	10.9	7.2	2.9
	D	TW	14.6	12.5	10.2	7.8	5.7	3.9	2.4	1.1	.4
		TWNI	22.8	20.6	18.8	16.8	14.4	11.5	8.1	4.9	1.9
		DG	14.4	10.8	6.9	3.3	-	-	-	-	-
		DGNI	25.2	22.4	19.9	17.5	14.1	10.6	7.2	4.1	1.4

TONOPAH NEVADA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	163	75	47	33	24	18	13	9	4
38.1 N	L	WWNI	251	120	76	55	42	33	26	21	15
5900 DD	C	TW	156	72	44	30	21	14	10	6	3
T(JAN)=30	R	TWNI	238	113	72	51	39	30	23	17	11
		DG	161	70	39	22	9	-	-	-	-
		DGNI	263	124	78	55	41	31	23	16	10
		WW	15.3	13.1	11.5	10.1	8.5	6.3	3.8	1.7	.2
		WWNI	24.6	21.5	20.5	18.4	16.8	14.8	11.5	7.5	3.1
	D	TW	14.5	12.5	10.3	7.8	5.8	4.0	2.5	1.3	.4
		TWNI	22.8	20.5	18.6	16.9	14.7	11.8	8.3	5.1	2.0
		DG	14.2	10.8	6.9	3.4	.5	-	-	-	-
		DGNI	24.8	22.4	19.9	17.6	14.5	10.8	7.4	4.3	1.5

WINNEMUCCA NEVADA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	131	60	37	25	18	13	9	5	-
40.9 N	L	WWNI	214	103	65	47	35	28	22	17	12
6629 DD	C	TW	129	59	35	23	16	11	7	4	1
T(JAN)=28	R	TWNI	203	96	61	43	32	25	19	14	9
		DG	121	49	24	-	-	-	-	-	-
		DGNI	222	104	65	46	34	25	18	13	7
		WW	12.2	10.3	8.8	7.3	5.7	3.9	2.1	.6	-
		WWNI	20.2	18.8	16.9	15.4	13.7	11.8	8.8	5.9	2.4
	D	TW	11.7	9.9	7.9	5.8	4.0	2.6	1.5	.6	.1
		TWNI	19.2	17.4	15.8	14.0	11.9	9.4	6.7	4.0	1.6
		DG	10.2	6.7	2.9	-	-	-	-	-	-
		DGNI	21.0	18.6	16.4	14.2	11.3	8.4	5.6	3.1	1.0

CONCORD NEW HAMPSHIRE		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	56	23	12	6	-	-	-	-	-
43.2 N	L	WWNI	129	59	37	26	19	15	12	9	6
7360 DD	C	TW	62	25	13	7	-	-	-	-	-
T(JAN)=21	R	TWNI	123	56	35	24	18	14	10	7	5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	125	56	34	23	16	12	8	5	-
		WW	4.4	3.1	2.0	.9	-	-	-	-	-
		WWNI	11.5	10.2	9.4	8.1	7.1	5.9	4.5	2.9	1.1
	D	TW	5.1	3.6	2.2	1.0	-	-	-	-	-
		TWNI	11.1	9.8	8.6	7.5	6.3	5.0	3.4	2.0	.7
		DG	-	-	-	-	-	-	-	-	-
		DGNI	11.0	9.4	7.9	6.5	5.0	3.4	2.0	.9	-

NEWARK NEW JERSEY		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	91	42	25	16	11	8	4	-	-
40.7 N	L	WWNI	167	80	51	36	27	21	17	13	9
5034 DD	C	TW	93	42	25	16	10	6	3	-	-
T(JAN)=31	R	TWNI	158	76	48	34	25	19	15	11	7
		DG	67	18	-	-	-	-	-	-	-
		DGNI	169	79	49	34	25	19	13	9	5
		WW	8.5	6.7	5.5	4.3	3.1	1.7	.5	-	-
		WWNI	15.7	15.1	12.9	11.8	10.6	8.9	7.1	4.6	1.8
	D	TW	8.3	6.8	5.2	3.5	2.1	1.2	.4	-	-
		TWNI	15.0	13.6	12.2	10.9	9.3	7.4	5.2	3.1	1.2
		DG	5.0	.8	-	-	-	-	-	-	-
		DGNI	16.0	13.9	12.3	10.4	8.4	6.0	3.9	2.1	.6

ALBUQUERQUE NEW MEXICO		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	178	84	53	37	28	21	16	11	6
35.0 N	L	WWNI	270	130	83	60	46	37	30	23	17
4292 DD	C	TW	171	80	50	34	24	17	12	8	5
T(JAN)=35	R	TWNI	255	122	78	56	43	33	26	19	13
		DG	183	82	47	29	16	-	-	-	-
		DGNI	283	135	86	61	46	35	26	19	12
		WW	16.8	14.9	13.3	12.1	10.3	8.0	5.0	2.5	.5
		WWNI	26.3	24.5	22.1	20.5	19.1	16.9	13.6	8.7	3.6
	D	TW	16.0	14.2	11.9	9.2	7.0	4.9	3.2	1.8	.8
		TWNI	24.5	22.5	20.6	19.1	16.6	13.3	9.5	5.8	2.4
		DG	16.5	13.3	9.3	5.6	2.6	-	-	-	-
		DGNI	27.1	24.6	22.3	20.0	16.6	12.5	8.6	5.1	1.9

CLAYTON NEW MEXICO		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	160	73	46	32	24	18	14	9	4
36.4 N	L	WWNI	251	117	75	54	41	33	27	21	15
5212 DD	C	TW	154	71	43	29	20	14	10	6	4
T(JAN)=33	R	TWNI	235	111	70	50	38	30	23	17	11
		DG	157	68	38	21	9	-	-	-	-
		DGNI	260	122	77	54	41	31	23	17	10
		WW	14.3	13.1	11.3	10.2	8.8	6.6	4.0	1.9	.3
		WWNI	23.6	21.3	20.1	18.1	16.9	15.3	12.5	7.9	3.3
	D	TW	14.2	12.2	10.1	7.8	5.8	4.1	2.5	1.4	.5
		TWNI	22.0	20.3	18.3	16.9	15.1	11.9	8.5	5.2	2.1
		DG	13.6	10.6	6.8	3.4	.6	-	-	-	-
		DGNI	24.1	21.8	19.7	17.8	14.7	11.0	7.6	4.4	1.7

FARMINGTON NEW MEXICO		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	145	66	41	29	21	16	11	7	-
36.7 N	L	WWNI	234	108	70	50	38	30	24	19	13
5713 DD	C	TW	142	64	39	26	18	13	8	5	3
T(JAN)=29	R	TWNI	220	103	65	47	35	27	21	16	10
		DG	138	58	31	15	-	-	-	-	-
		DGNI	241	112	70	50	37	28	21	15	9
		WW	12.7	11.7	10.1	9.0	7.3	5.4	3.1	1.3	-
		WWNI	21.3	19.8	18.7	16.8	15.5	13.7	10.6	6.9	2.9
	D	TW	12.8	10.9	9.0	6.9	5.0	3.4	2.0	1.0	.3
		TWNI	20.1	18.7	17.0	15.6	13.5	10.8	7.7	4.7	1.9
		DG	11.6	8.6	4.9	1.7	-	-	-	-	-
		DGNI	21.9	20.0	18.1	16.1	13.2	9.8	6.6	3.8	1.3

LOS ALAMOS
NEW MEXICO

35.9 N
6359 DD
T(JAN)=29

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	128	58	36	26	19	14	10	7	-
L	WWNI	210	100	64	46	35	28	23	18	13
C	TW	125	58	35	24	16	11	8	5	2
R	TWNI	199	94	60	43	33	26	20	15	10
	DG	116	49	25	-	-	-	-	-	-
	DGNI	217	102	64	46	34	26	19	14	9
	WW	11.9	10.0	9.2	8.2	7.0	4.9	2.8	1.1	-
	WWNI	19.9	18.1	16.8	16.1	14.8	13.4	10.9	6.8	2.9
D	TW	11.5	10.0	8.1	6.2	4.4	3.0	1.8	.9	.3
	TWNI	18.9	17.0	16.0	14.7	13.1	10.4	7.4	4.6	1.9
	DG	9.9	7.1	3.5	-	-	-	-	-	-
	DGNI	20.5	18.2	16.7	15.1	12.4	9.2	6.3	3.6	1.3

ROSWELL
NEW MEXICO

33.4 N
3697 DD
T(JAN)=38

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	200	95	59	42	32	24	18	13	7
L	WWNI	299	142	92	66	50	40	32	25	18
C	TW	194	89	55	38	27	19	14	9	6
R	TWNI	283	134	86	61	47	36	28	21	14
	DG	214	95	56	35	22	12	-	-	-
	DGNI	316	149	95	67	51	38	29	21	13
	WW	18.2	17.3	14.9	13.7	11.7	9.3	5.9	3.0	.7
	WWNI	27.3	27.0	24.6	22.1	20.9	18.3	14.8	9.5	4.0
D	TW	17.6	15.7	13.4	10.5	8.0	5.7	3.7	2.2	1.0
	TWNI	26.0	24.9	22.5	20.8	18.0	14.5	10.3	6.3	2.6
	DG	18.8	15.7	11.6	7.5	4.2	1.5	-	-	-
	DGNI	29.1	27.1	24.6	22.0	18.4	13.8	9.6	5.7	2.2

TRUTH OR CONSEQ.
NEW MEXICO

33.2 N
3392 DD
T(JAN)=40

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	229	109	69	49	37	29	22	16	9
L	WWNI	332	160	103	74	57	45	37	29	21
C	TW	220	102	64	44	31	23	16	11	7
R	TWNI	314	150	96	69	53	41	32	24	16
	DG	251	114	69	44	29	18	9	-	-
	DGNI	354	168	107	76	58	44	33	24	15
	WW	21.5	19.7	17.6	16.3	14.1	11.3	7.5	4.0	1.2
	WWNI	31.2	30.1	27.7	25.2	24.0	21.0	16.8	10.9	4.6
D	TW	20.4	18.3	15.6	12.4	9.6	6.9	4.8	2.8	1.3
	TWNI	29.7	27.7	25.4	23.7	20.4	16.4	11.7	7.2	3.0
	DG	22.8	19.4	15.0	10.4	6.5	3.4	1.0	-	-
	DGNI	33.5	30.8	28.1	25.2	21.2	16.0	11.2	6.7	2.6

TUCUMCARI
NEW MEXICO

35.2 N
4047 DD
T(JAN)=37

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	194	90	56	40	30	23	17	12	7
L	WWNI	291	138	88	63	48	39	31	25	18
C	TW	187	86	53	36	25	18	13	9	5
R	TWNI	274	130	82	59	45	35	27	20	13
	DG	203	90	53	32	20	10	-	-	-
	DGNI	306	144	91	65	49	37	28	20	13
	WW	17.7	16.0	14.3	12.9	11.2	8.8	5.6	2.9	.7
	WWNI	27.2	25.4	23.3	21.5	20.0	17.9	14.6	9.3	3.9
D	TW	17.0	15.0	12.7	9.9	7.6	5.5	3.6	2.0	.9
	TWNI	25.4	23.6	21.7	20.0	17.6	14.0	10.0	6.2	2.5
	DG	17.8	14.7	10.6	6.7	3.5	1.0	-	-	-
	DGNI	28.2	25.8	23.5	21.2	17.7	13.3	9.2	5.5	2.1

ZUNI
NEW MEXICO

35.1 N
5815 DD
T(JAN)=30

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	144	66	41	29	22	16	12	8	-
L	WWNI	231	109	69	50	38	31	25	19	14
C	TW	140	64	39	26	18	13	9	6	3
R	TWNI	218	103	65	47	36	28	21	16	11
	DG	137	59	32	16	-	-	-	-	-
	DGNI	238	112	71	50	38	28	21	15	9
	WW	13.1	11.6	10.2	9.2	7.7	5.7	3.3	1.4	-
	WWNI	22.5	19.5	18.9	17.1	15.8	14.2	11.4	7.2	3.0
D	TW	12.9	11.1	9.1	6.9	5.1	3.5	2.2	1.1	.4
	TWNI	20.5	18.6	17.2	15.8	13.9	11.1	7.9	4.8	2.0
	DG	11.9	8.8	5.1	2.0	-	-	-	-	-
	DGNI	22.2	20.2	18.2	16.4	13.5	10.1	6.9	4.0	1.4

ALBANY
NEW YORK

42.7 N
6888 DD
T(JAN)=21

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	56	23	12	6	-	-	-	-	-
L	WWNI	129	59	37	26	19	15	11	9	6
C	TW	62	25	13	7	-	-	-	-	-
R	TWNI	123	56	35	24	18	14	10	7	5
	DG	-	-	-	-	-	-	-	-	-
	DGNI	125	56	34	23	16	12	8	5	-
	WW	4.5	3.1	2.0	.8	-	-	-	-	-
	WWNI	11.8	10.4	9.2	8.0	7.0	5.8	4.4	2.9	1.1
D	TW	5.1	3.6	2.2	1.0	-	-	-	-	-
	TWNI	11.0	9.8	8.5	7.5	6.2	4.9	3.4	2.0	.7
	DG	-	-	-	-	-	-	-	-	-
	DGNI	11.0	9.3	7.8	6.4	4.9	3.3	1.9	.8	-

BINGHAMTON
NEW YORK

42.2 N
7285 DD
T(JAN)=22

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	42	15	-	-	-	-	-	-	-
L	WWNI	115	52	32	22	16	12	10	7	5
C	TW	50	19	8	-	-	-	-	-	-
R	TWNI	109	49	30	21	15	11	8	6	4
	DG	-	-	-	-	-	-	-	-	-
	DGNI	109	48	28	19	13	9	6	3	-
	WW	3.1	1.5	-	-	-	-	-	-	-
	WWNI	10.3	8.7	7.7	6.6	5.7	4.7	3.6	2.3	.8
D	TW	3.8	2.3	.9	-	-	-	-	-	-
	TWNI	9.7	8.4	7.2	6.1	5.1	4.0	2.8	1.6	.6
	DG	-	-	-	-	-	-	-	-	-
	DGNI	9.3	7.6	6.2	4.9	3.6	2.3	1.2	.4	-

BUFFALO
NEW YORK

42.9 N
6927 DD
T(JAN)=24

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	46	17	6	-	-	-	-	-	-
L	WWNI	121	54	33	23	17	13	10	7	5
C	TW	54	20	9	-	-	-	-	-	-
R	TWNI	115	51	31	21	16	12	9	6	4
	DG	-	-	-	-	-	-	-	-	-
	DGNI	115	50	29	20	13	9	6	3	-
	WW	3.4	1.8	.4	-	-	-	-	-	-
	WWNI	10.7	9.2	8.0	6.8	5.8	4.7	3.5	2.3	.8
D	TW	4.2	2.6	1.2	-	-	-	-	-	-
	TWNI	10.0	8.7	7.4	6.4	5.2	4.0	2.8	1.6	.6
	DG	-	-	-	-	-	-	-	-	-
	DGNI	9.7	8.0	6.5	5.1	3.8	2.4	1.3	.4	-

MASSENA NEW YORK		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	42	14	-	-	-	-	-	-	-
44.9 N	L	WWNI	115	51	32	22	16	12	9	7	5
8237 DD	C	TW	50	18	8	-	-	-	-	-	-
T(JAN)=14	R	TWNI	109	49	30	21	15	11	8	6	4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	109	47	28	18	13	9	6	3	-
		WW	3.0	1.4	-	-	-	-	-	-	-
		WWNI	10.1	8.7	7.8	6.5	5.6	4.4	3.3	2.1	.8
	D	TW	3.8	2.2	.8	-	-	-	-	-	-
		TWNI	9.7	8.3	7.1	6.1	5.0	3.8	2.6	1.5	.5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	9.3	7.6	6.1	4.8	3.4	2.2	1.1	.3	-

NYC (CNTRL. PARK) NEW YORK		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	85	37	22	14	10	6	-	-	-
40.8 N	L	WWNI	159	76	48	34	25	20	16	12	8
4848 DD	C	TW	87	38	22	14	8	5	2	-	-
T(JAN)=32	R	TWNI	151	72	45	32	24	18	14	10	6
		DG	56	-	-	-	-	-	-	-	-
		DGNI	161	74	46	32	23	17	12	8	4
		WW	8.0	5.8	4.7	3.6	2.4	1.1	-	-	-
		WWNI	15.0	13.8	11.8	10.9	9.8	8.2	6.5	4.2	1.7
	D	TW	7.6	6.1	4.5	3.0	1.7	.8	.1	-	-
		TWNI	14.3	12.6	11.3	10.1	8.5	6.8	4.8	2.9	1.1
		DG	3.8	-	-	-	-	-	-	-	-
		DGNI	15.2	12.9	11.2	9.4	7.6	5.4	3.5	1.8	.5

ROCHESTER NEW YORK		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	50	18	8	-	-	-	-	-	-
43.1 N	L	WWNI	124	55	34	24	17	13	10	8	5
6719 DD	C	TW	56	22	10	-	-	-	-	-	-
T(JAN)=24	R	TWNI	117	53	32	22	16	12	9	6	4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	118	52	31	20	14	10	6	4	-
		WW	3.8	2.1	.8	-	-	-	-	-	-
		WWNI	10.9	9.6	8.3	7.0	6.0	4.8	3.7	2.4	.9
	D	TW	4.4	2.8	1.4	-	-	-	-	-	-
		TWNI	10.2	9.0	7.6	6.6	5.3	4.2	2.9	1.7	.6
		DG	-	-	-	-	-	-	-	-	-
		DGNI	10.1	8.3	6.8	5.3	3.9	2.6	1.4	.5	-

SYRACUSE NEW YORK		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	50	18	8	-	-	-	-	-	-
43.1 N	L	WWNI	124	55	34	24	17	13	10	8	5
6678 DD	C	TW	56	22	11	4	-	-	-	-	-
T(JAN)=24	R	TWNI	117	53	32	22	16	12	9	6	4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	118	52	31	20	14	10	7	4	-
		WW	3.8	2.1	.9	-	-	-	-	-	-
		WWNI	10.9	9.7	8.3	7.0	6.1	5.0	3.8	2.4	.9
	D	TW	4.4	2.8	1.4	.1	-	-	-	-	-
		TWNI	10.3	9.0	7.7	6.6	5.4	4.3	2.9	1.7	.6
		DG	-	-	-	-	-	-	-	-	-
		DGNI	10.1	8.4	6.8	5.4	4.0	2.6	1.4	.5	-

ASHEVILLE NORTH CAROLINA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	138	64	39	27	20	15	11	7	-
35.4 N	L	WWNI	225	106	68	49	37	29	23	18	13
4237 DD	C	TW	136	62	38	25	17	12	8	5	2
T(JAN)=38	R	TWNI	212	100	64	45	34	26	20	15	10
		DG	131	55	28	12	-	-	-	-	-
		DGNI	232	109	68	48	36	27	20	14	9
		WW	12.5	11.2	9.5	8.2	6.7	4.9	2.8	1.1	-
		WWNI	21.0	19.5	18.0	16.2	14.6	12.7	10.4	6.6	2.7
	D	TW	12.4	10.5	8.6	6.5	4.6	3.1	1.8	.8	.2
		TWNI	19.8	18.3	16.5	14.9	12.9	10.4	7.3	4.5	1.8
		DG	11.1	7.9	4.2	.8	-	-	-	-	-
		DGNI	21.6	19.4	17.3	15.2	12.6	9.3	6.3	3.6	1.3

CAPE HATTERAS NORTH CAROLINA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	214	97	60	42	31	23	18	12	7
35.3 N	L	WWNI	312	148	93	66	50	39	31	25	18
2731 DD	C	TW	200	92	56	38	26	19	13	9	5
T(JAN)=45	R	TWNI	294	138	87	61	46	36	27	20	13
		DG	223	98	56	34	21	10	-	-	-
		DGNI	329	154	96	67	50	38	28	20	13
		WW	20.4	16.5	14.9	12.5	10.9	8.7	5.6	2.8	.6
		WWNI	31.2	25.7	24.1	21.9	19.1	17.2	14.3	9.1	3.8
	D	TW	18.6	15.7	13.1	10.0	7.6	5.5	3.6	1.9	.8
		TWNI	28.5	24.5	22.2	19.6	17.4	14.0	9.9	6.1	2.5
		DG	20.0	15.4	11.2	7.0	3.7	1.1	-	-	-
		DGNI	31.3	27.2	23.8	21.0	17.7	13.3	9.2	5.4	2.1

CHARLOTTE NORTH CAROLINA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	177	82	50	35	25	19	14	9	4
35.2 N	L	WWNI	270	129	81	57	43	34	27	21	15
3218 DD	C	TW	170	78	47	31	22	15	10	7	4
T(JAN)=42	R	TWNI	255	121	76	53	40	31	24	18	12
		DG	180	77	43	24	12	-	-	-	-
		DGNI	283	133	82	58	43	32	24	17	11
		WW	16.2	14.0	11.8	10.5	8.7	6.8	4.1	1.9	.3
		WWNI	25.3	23.7	20.4	18.5	17.2	14.8	12.3	7.9	3.3
	D	TW	15.5	13.2	10.8	8.3	6.1	4.2	2.6	1.4	.5
		TWNI	23.9	21.6	19.1	17.3	15.1	12.1	8.6	5.3	2.1
		DG	15.5	11.7	7.8	4.1	1.2	-	-	-	-
		DGNI	26.5	23.2	20.7	18.0	15.1	11.2	7.7	4.5	1.7

GREENSBORO NORTH CAROLINA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	151	70	43	29	22	16	12	7	-
36.1 N	L	WWNI	239	113	72	51	39	31	24	19	14
3825 DD	C	TW	147	67	41	27	19	13	9	5	3
T(JAN)=39	R	TWNI	226	107	67	48	36	28	21	16	10
		DG	147	62	33	16	-	-	-	-	-
		DGNI	249	117	73	51	38	28	21	15	9
		WW	13.8	12.2	10.1	8.9	7.2	5.4	3.1	1.3	-
		WWNI	22.6	20.9	18.8	16.6	15.4	13.2	10.9	7.0	2.9
	D	TW	13.5	11.4	9.3	7.0	5.1	3.4	2.0	1.0	.3
		TWNI	21.2	19.4	17.2	15.6	13.5	10.8	7.7	4.7	1.9
		DG	12.5	9.1	5.3	1.9	-	-	-	-	-
		DGNI	23.1	20.7	18.3	15.9	13.3	9.8	6.6	3.8	1.4

RALEIGH-DURHAM
NORTH CAROLINA

35.9 N
3514 DD
T(JAN)=40

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	155	73	45	31	23	17	12	8	-
L	WWNI	244	117	75	53	40	31	25	20	14
C	TW	151	69	42	28	19	13	9	6	3
R	TWNI	230	110	69	49	37	29	22	16	11
	DG	153	65	36	19	-	-	-	-	-
	DGNI	254	120	75	53	39	29	22	15	9
	WW	14.4	12.8	10.6	9.3	7.6	5.8	3.4	1.4	-
	WWNI	23.4	21.8	19.3	17.2	15.8	13.6	11.2	7.2	3.0
D	TW	13.9	11.9	9.7	7.3	5.4	3.6	2.2	1.1	.3
	TWNI	21.8	20.1	17.8	16.1	13.9	11.2	7.9	4.8	1.9
	DG	13.3	9.8	5.9	2.5	-	-	-	-	-
	DGNI	23.9	21.4	19.0	16.5	13.7	10.2	6.9	4.0	1.4

BISMARCK
NORTH DAKOTA

46.8 N
9044 DD
T(JAN)= 8

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	60	24	11	5	-	-	-	-	-
L	WWNI	132	61	38	26	19	14	11	8	5
C	TW	64	26	13	7	-	-	-	-	-
R	TWNI	125	58	36	24	18	13	10	7	4
	DG	-	-	-	-	-	-	-	-	-
	DGNI	129	58	34	23	16	11	7	4	-
	WW	4.9	3.1	1.6	.3	-	-	-	-	-
	WWNI	12.3	10.6	9.2	7.7	6.6	5.4	3.9	2.6	1.0
D	TW	5.3	3.6	2.1	.8	-	-	-	-	-
	TWNI	11.6	10.0	8.4	7.1	5.8	4.5	3.1	1.8	.7
	DG	-	-	-	-	-	-	-	-	-
	DGNI	11.6	9.5	7.7	6.1	4.5	3.0	1.7	.7	-

FARGO
NORTH DAKOTA

46.9 N
9271 DD
T(JAN)= 6

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	48	17	-	-	-	-	-	-	-
L	WWNI	119	55	34	23	17	12	9	7	5
C	TW	54	20	9	-	-	-	-	-	-
R	TWNI	114	52	31	21	15	11	8	6	4
	DG	-	-	-	-	-	-	-	-	-
	DGNI	114	51	29	19	13	9	6	3	-
	WW	3.7	1.6	-	-	-	-	-	-	-
	WWNI	10.9	9.4	7.9	6.5	5.5	4.5	3.2	2.1	.8
D	TW	4.3	2.5	1.0	-	-	-	-	-	-
	TWNI	10.3	8.8	7.3	6.1	4.9	3.8	2.6	1.5	.5
	DG	-	-	-	-	-	-	-	-	-
	DGNI	10.1	8.1	6.3	4.8	3.4	2.2	1.1	.3	-

MINOT
NORTH DAKOTA

48.3 N
9407 DD
T(JAN)= 8

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	54	19	7	-	-	-	-	-	-
L	WWNI	126	58	35	24	17	13	10	7	5
C	TW	59	22	10	-	-	-	-	-	-
R	TWNI	120	55	33	22	16	12	9	6	4
	DG	-	-	-	-	-	-	-	-	-
	DGNI	122	54	31	20	14	9	6	3	-
	WW	4.2	2.1	.4	-	-	-	-	-	-
	WWNI	11.5	9.9	8.3	6.6	5.5	4.5	3.2	2.1	.8
D	TW	4.7	2.8	1.2	-	-	-	-	-	-
	TWNI	10.9	9.3	7.6	6.2	5.0	3.8	2.6	1.5	.5
	DG	-	-	-	-	-	-	-	-	-
	DGNI	10.8	8.6	6.6	5.0	3.5	2.3	1.2	.3	-

AKRON-CANTON
OHIO

40.9 N
6224 DD
T(JAN)=26

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	61	25	13	7	-	-	-	-	-
L	WWNI	137	62	39	27	20	15	12	9	6
C	TW	67	27	14	8	-	-	-	-	-
R	TWNI	130	59	36	25	18	14	10	7	5
	DG	-	-	-	-	-	-	-	-	-
	DGNI	133	59	35	24	17	12	8	5	2
	WW	4.9	3.3	2.2	1.0	-	-	-	-	-
	WWNI	12.0	10.9	9.3	8.1	7.2	5.9	4.5	2.9	1.1
D	TW	5.4	3.8	2.4	1.1	-	-	-	-	-
	TWNI	11.4	10.1	8.7	7.6	6.3	5.0	3.5	2.0	.8
	DG	-	-	-	-	-	-	-	-	-
	DGNI	11.5	9.7	8.1	6.6	5.1	3.4	2.0	.9	.1

CINCINNATI
OHIO

39.1 N
5070 DD
T(JAN)=31

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	81	36	20	13	8	5	-	-	-
L	WWNI	156	74	46	32	24	19	15	11	8
C	TW	84	36	21	13	8	4	-	-	-
R	TWNI	148	70	43	30	22	17	13	9	6
	DG	49	-	-	-	-	-	-	-	-
	DGNI	157	72	44	30	22	16	11	8	4
	WW	7.3	5.4	4.1	3.0	1.9	.7	-	-	-
	WWNI	14.3	13.6	11.5	10.0	9.2	7.7	6.1	3.9	1.6
D	TW	7.3	5.6	4.1	2.6	1.4	.5	-	-	-
	TWNI	13.7	12.2	10.7	9.5	8.0	6.4	4.5	2.7	1.0
	DG	3.0	-	-	-	-	-	-	-	-
	DGNI	14.4	12.3	10.5	8.8	7.0	4.9	3.1	1.6	.4

CLEVELAND
OHIO

41.4 N
6154 DD
T(JAN)=27

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	59	23	11	5	-	-	-	-	-
L	WWNI	135	60	37	26	19	14	11	8	6
C	TW	65	26	13	7	-	-	-	-	-
R	TWNI	128	57	35	24	18	13	10	7	4
	DG	-	-	-	-	-	-	-	-	-
	DGNI	130	57	34	23	16	11	8	5	-
	WW	4.6	3.0	1.7	.5	-	-	-	-	-
	WWNI	11.7	10.6	8.9	7.7	6.7	5.4	4.2	2.7	1.0
D	TW	5.1	3.4	2.1	.8	-	-	-	-	-
	TWNI	11.1	9.7	8.3	7.2	5.9	4.7	3.2	1.9	.7
	DG	-	-	-	-	-	-	-	-	-
	DGNI	11.2	9.2	7.6	6.1	4.6	3.1	1.8	.7	-

COLUMBUS
OHIO

40.0 N
5702 DD
T(JAN)=28

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	67	28	15	9	5	-	-	-	-
L	WWNI	141	65	41	29	21	16	13	10	7
C	TW	71	30	16	9	5	-	-	-	-
R	TWNI	133	62	38	27	20	15	11	8	5
	DG	-	-	-	-	-	-	-	-	-
	DGNI	138	63	38	26	19	13	9	6	3
	WW	5.7	4.1	2.9	1.8	.7	-	-	-	-
	WWNI	12.7	11.8	10.1	8.8	7.9	6.5	5.1	3.3	1.3
D	TW	6.0	4.4	3.0	1.7	.6	-	-	-	-
	TWNI	12.1	10.8	9.4	8.3	6.9	5.5	3.8	2.3	.9
	DG	-	-	-	-	-	-	-	-	-
	DGNI	12.5	10.6	8.9	7.3	5.7	4.0	2.4	1.1	.2

DAYTON OHIO		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	72	30	17	10	6	-	-	-	-
39.9 N	L	WWNI	146	68	43	30	22	17	13	10	7
5641 DD	C	TW	76	32	18	10	6	-	-	-	-
T(JAN)=28	R	TWNI	139	64	40	28	21	16	12	9	6
		DG	30	-	-	-	-	-	-	-	-
		DGNI	145	66	40	27	20	14	10	7	3
		WW	6.2	4.4	3.3	2.2	1.1	-	-	-	-
		WWNI	13.1	12.4	10.4	9.2	8.4	6.9	5.4	3.5	1.4
	D	TW	6.4	4.8	3.3	2.0	.8	-	-	-	-
		TWNI	12.6	11.2	9.8	8.7	7.3	5.8	4.1	2.4	.9
		DG	.9	-	-	-	-	-	-	-	-
		DGNI	13.1	11.1	9.4	7.8	6.2	4.3	2.7	1.3	.3

TOLEDO OHIO		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	62	25	13	7	-	-	-	-	-
41.6 N	L	WWNI	138	62	39	27	20	15	12	9	6
6381 DD	C	TW	68	27	15	8	3	-	-	-	-
T(JAN)=25	R	TWNI	130	59	36	25	19	14	10	8	5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	134	60	36	24	17	12	8	5	2
		WW	5.0	3.4	2.3	1.0	-	-	-	-	-
		WWNI	12.1	11.1	9.4	8.2	7.2	5.9	4.5	2.9	1.1
	D	TW	5.5	3.8	2.4	1.2	.0	-	-	-	-
		TWNI	11.5	10.2	8.8	7.7	6.4	5.0	3.5	2.0	.8
		DG	-	-	-	-	-	-	-	-	-
		DGNI	11.6	9.8	8.2	6.7	5.1	3.5	2.0	.9	.1

YOUNGSTOWN OHIO		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	52	20	9	-	-	-	-	-	-
41.3 N	L	WWNI	126	57	35	24	18	14	10	8	5
6426 DD	C	TW	58	23	11	5	-	-	-	-	-
T(JAN)=26	R	TWNI	120	54	33	23	17	12	9	7	4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	121	53	32	21	15	10	7	4	-
		WW	4.0	2.4	1.1	-	-	-	-	-	-
		WWNI	11.2	9.9	8.4	7.2	6.3	5.1	3.9	2.6	1.0
	D	TW	4.6	3.0	1.6	.4	-	-	-	-	-
		TWNI	10.5	9.2	7.9	6.8	5.6	4.4	3.1	1.8	.6
		DG	-	-	-	-	-	-	-	-	-
		DGNI	10.4	8.6	7.0	5.6	4.2	2.8	1.6	.6	-

OKLAHOMA CITY OKLAHOMA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	161	74	45	31	23	17	13	8	-
35.4 N	L	WWNI	251	119	75	53	40	32	26	20	14
3695 DD	C	TW	156	71	43	28	20	14	9	6	3
T(JAN)=37	R	TWNI	237	111	70	50	37	29	22	16	11
		DG	158	67	36	19	-	-	-	-	-
		DGNI	262	122	76	53	40	30	22	16	10
		WW	14.7	12.5	10.7	9.6	8.0	6.0	3.6	1.6	-
		WWNI	23.5	21.3	19.0	17.4	16.3	14.1	11.6	7.4	3.1
	D	TW	14.0	11.9	9.8	7.5	5.4	3.7	2.3	1.2	.4
		TWNI	22.2	19.9	17.8	16.3	14.2	11.4	8.1	5.0	2.0
		DG	13.4	10.0	6.1	2.8	-	-	-	-	-
		DGNI	24.4	21.3	19.1	16.8	14.0	10.4	7.1	4.1	1.5

TULSA OKLAHOMA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	147	67	41	28	21	15	11	7	-
36.2 N	L	WWNI	235	111	70	49	38	30	24	19	13
3680 DD	C	TW	144	65	39	26	18	12	8	5	3
T(JAN)=37	R	TWNI	222	104	65	46	35	27	21	15	10
		DG	141	58	30	14	-	-	-	-	-
		DGNI	245	113	70	49	37	28	20	14	9
		WW	13.5	11.2	9.7	8.6	7.0	5.2	3.0	1.2	-
		WWNI	21.8	19.8	17.7	16.4	15.2	13.1	10.7	6.8	2.8
	D	TW	12.9	10.8	8.8	6.7	4.8	3.2	1.9	1.0	.2
		TWNI	20.8	18.5	16.7	15.2	13.2	10.6	7.5	4.6	1.8
		DG	11.7	8.4	4.7	1.3	-	-	-	-	-
		DGNI	22.7	19.7	17.8	15.5	12.9	9.5	6.5	3.7	1.3

ASTORIA OREGON		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	122	59	36	24	17	11	7	-	-
46.1 N	L	WWNI	201	100	64	46	34	26	20	15	10
5295 DD	C	TW	121	56	34	22	14	9	6	2	-
T(JAN)=41	R	TWNI	191	94	60	42	31	23	17	13	8
		DG	112	46	19	-	-	-	-	-	-
		DGNI	208	101	64	44	32	23	17	11	6
		WW	12.2	10.2	8.3	6.4	4.5	2.6	1.1	-	-
		WWNI	20.1	19.7	16.6	14.7	12.4	10.1	7.2	4.6	1.8
	D	TW	11.5	9.6	7.3	5.3	3.5	2.0	.9	.2	-
		TWNI	19.1	17.5	15.5	13.2	10.8	8.2	5.8	3.4	1.2
		DG	9.9	5.8	1.7	-	-	-	-	-	-
		DGNI	20.8	18.4	15.8	13.0	10.0	7.3	4.6	2.4	.7

BURNS OREGON		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	100	44	26	17	11	7	-	-	-
43.6 N	L	WWNI	179	84	52	37	28	21	16	12	8
7212 DD	C	TW	101	44	25	16	10	6	2	-	-
T(JAN)=25	R	TWNI	170	79	49	34	25	19	14	10	6
		DG	76	19	-	-	-	-	-	-	-
		DGNI	182	83	51	35	25	18	13	8	4
		WW	8.9	7.0	5.5	4.0	2.4	1.2	-	-	-
		WWNI	16.3	15.0	13.3	11.7	9.9	8.2	5.9	4.0	1.5
	D	TW	8.8	6.9	5.1	3.4	2.0	1.0	.1	-	-
		TWNI	15.6	13.8	12.3	10.5	8.8	6.7	4.8	2.8	1.0
		DG	5.5	.8	-	-	-	-	-	-	-
		DGNI	16.6	14.3	12.2	10.0	7.7	5.6	3.5	1.7	.4

MEDFORD OREGON		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	134	57	34	22	15	9	5	-	-
42.4 N	L	WWNI	222	100	62	44	32	25	19	14	9
4930 DD	C	TW	130	56	32	20	13	8	4	-	-
T(JAN)=37	R	TWNI	209	94	58	40	29	22	16	12	7
		DG	118	42	-	-	-	-	-	-	-
		DGNI	227	102	62	42	30	21	15	10	5
		WW	11.3	9.4	7.4	5.4	3.5	1.9	.6	-	-
		WWNI	20.2	16.9	15.9	13.6	11.4	9.0	6.3	4.2	1.6
	D	TW	11.2	8.7	6.4	4.5	2.9	1.6	.6	-	-
		TWNI	18.7	16.2	14.2	12.1	9.8	7.4	5.2	3.0	1.1
		DG	9.0	4.5	-	-	-	-	-	-	-
		DGNI	19.9	17.2	14.4	11.8	8.9	6.5	4.1	2.0	.5

NORTH BEND OREGON		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	172	86	55	39	29	21	15	10	5
43.4 N	L	WWNI	260	130	86	63	48	37	29	23	16
4688 DD	C	TW	168	81	51	34	24	17	12	8	4
T(JAN)=45	R	TWNI	247	123	80	58	44	33	25	19	12
		DG	181	84	49	30	17	-	-	-	-
		DGNI	275	137	88	63	47	35	26	18	11
		WW	17.2	16.8	14.4	11.9	9.9	7.0	4.5	2.0	.3
		WWNI	26.0	26.0	24.4	21.4	18.3	15.9	11.8	7.9	3.2
	D	TW	16.6	14.7	12.1	9.5	7.0	4.9	2.9	1.5	.5
		TWNI	24.7	24.2	21.9	19.1	16.3	12.6	9.0	5.4	2.1
		DG	17.4	14.0	9.7	5.7	2.5	-	-	-	-
		DGNI	27.5	26.3	23.2	20.2	16.1	12.1	8.1	4.6	1.7

PENDLETON OREGON		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	117	49	28	17	10	5	-	-	-
45.7 N	L	WWNI	204	90	56	39	28	21	15	11	7
5240 DD	C	TW	115	48	26	16	9	5	-	-	-
T(JAN)=32	R	TWNI	190	85	52	35	25	19	14	10	6
		DG	94	22	-	-	-	-	-	-	-
		DGNI	205	91	54	36	25	17	12	8	3
		WW	9.5	7.5	5.3	3.3	1.7	.5	-	-	-
		WWNI	18.4	15.3	13.7	11.2	8.9	7.1	5.0	3.4	1.3
	D	TW	9.7	7.1	4.9	3.2	1.7	.6	-	-	-
		TWNI	16.9	14.4	12.2	10.0	8.0	6.0	4.2	2.4	.9
		DG	6.5	.9	-	-	-	-	-	-	-
		DGNI	17.8	14.8	12.0	9.5	7.0	4.9	2.9	1.4	.3

PORTLAND OREGON		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	135	56	32	20	13	8	-	-	-
45.6 N	L	WWNI	223	100	61	42	31	23	17	13	8
4792 DD	C	TW	130	55	31	19	12	7	3	-	-
T(JAN)=38	R	TWNI	209	94	57	39	28	21	15	11	7
		DG	117	38	-	-	-	-	-	-	-
		DGNI	228	100	60	40	28	20	14	9	4
		WW	11.4	8.5	6.6	4.6	2.8	1.4	-	-	-
		WWNI	20.2	16.6	14.8	12.7	10.5	8.2	5.8	3.8	1.5
	D	TW	11.2	8.1	6.0	4.0	2.4	1.2	.3	-	-
		TWNI	19.0	15.6	13.5	11.3	9.1	6.8	4.8	2.8	1.0
		DG	8.6	3.5	-	-	-	-	-	-	-
		DGNI	20.3	16.4	13.5	10.8	8.2	5.9	3.6	1.8	.4

REDMOND OREGON		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	125	56	33	22	15	10	6	-	-
44.3 N	L	WWNI	209	98	61	43	32	25	19	15	10
6643 DD	C	TW	122	54	32	20	13	9	5	2	-
T(JAN)=30	R	TWNI	196	92	57	40	30	22	17	12	8
		DG	110	41	12	-	-	-	-	-	-
		DGNI	213	98	61	42	30	22	16	11	6
		WW	11.1	9.0	7.5	5.9	4.2	2.5	1.1	-	-
		WWNI	19.8	17.4	15.4	14.0	12.0	9.9	7.3	4.9	1.9
	D	TW	11.0	8.7	6.6	4.8	3.1	1.8	.9	.1	-
		TWNI	18.4	16.1	14.5	12.5	10.4	8.1	5.7	3.4	1.3
		DG	8.8	4.7	.2	-	-	-	-	-	-
		DGNI	19.8	16.9	14.7	12.3	9.6	7.1	4.5	2.4	.7

SALEM OREGON		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	137	57	34	22	15	9	5	-	-
44.9 N	L	WWNI	226	101	62	43	32	24	18	14	9
4852 DD	C	TW	133	56	32	20	13	8	4	-	-
T(JAN)=39	R	TWNI	212	95	58	40	29	22	16	11	7
		DG	121	41	-	-	-	-	-	-	-
		DGNI	231	102	62	42	30	21	15	10	5
		WW	11.5	8.8	7.2	5.3	3.5	1.9	.6	-	-
		WWNI	20.3	16.9	15.1	13.4	11.3	8.9	6.3	4.2	1.6
	D	TW	11.3	8.5	6.4	4.5	2.8	1.5	.5	-	-
		TWNI	19.1	15.8	14.0	12.0	9.7	7.4	5.2	3.0	1.1
		DG	9.1	4.3	-	-	-	-	-	-	-
		DGNI	20.4	16.8	14.2	11.6	8.9	6.4	4.0	2.0	.5

ALLENTOWN PENNSYLVANIA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	76	33	19	12	8	5	-	-	-
40.6 N	L	WWNI	152	71	45	32	24	18	15	11	8
5827 DD	C	TW	80	35	20	12	7	4	-	-	-
T(JAN)=28	R	TWNI	143	67	42	30	22	17	13	9	6
		DG	43	-	-	-	-	-	-	-	-
		DGNI	150	69	43	29	21	16	11	7	4
		WW	6.6	5.2	4.0	2.9	1.8	.6	-	-	-
		WWNI	13.9	12.9	11.4	10.1	9.1	7.6	5.9	3.9	1.5
	D	TW	6.9	5.4	3.9	2.5	1.3	.4	-	-	-
		TWNI	13.1	12.0	10.6	9.4	8.0	6.3	4.4	2.6	1.0
		DG	2.4	-	-	-	-	-	-	-	-
		DGNI	13.6	11.9	10.3	8.7	6.9	4.8	3.0	1.5	.4

ERIE PENNSYLVANIA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	53	19	8	-	-	-	-	-	-
42.1 N	L	WWNI	129	57	35	24	17	13	10	7	5
6851 DD	C	TW	59	22	11	4	-	-	-	-	-
T(JAN)=25	R	TWNI	122	54	33	22	16	12	9	6	4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	124	53	31	21	14	10	6	4	-
		WW	3.8	2.2	.8	-	-	-	-	-	-
		WWNI	11.5	9.4	8.3	7.1	6.0	4.8	3.6	2.3	.9
	D	TW	4.6	2.8	1.4	.1	-	-	-	-	-
		TWNI	10.7	9.1	7.7	6.6	5.3	4.1	2.9	1.6	.6
		DG	-	-	-	-	-	-	-	-	-
		DGNI	10.4	8.4	6.8	5.3	3.9	2.6	1.4	.5	-

HARRISBURG PENNSYLVANIA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	83	37	22	14	10	6	-	-	-
40.2 N	L	WWNI	158	75	47	34	25	20	16	12	8
5224 DD	C	TW	86	38	22	14	8	5	2	-	-
T(JAN)=30	R	TWNI	150	71	44	31	23	18	14	10	6
		DG	55	-	-	-	-	-	-	-	-
		DGNI	158	74	46	32	23	17	12	8	4
		WW	7.5	5.9	4.6	3.5	2.4	1.1	-	-	-
		WWNI	14.7	13.8	12.1	10.7	9.8	8.2	6.5	4.2	1.7
	D	TW	7.6	6.0	4.4	2.9	1.7	.8	.1	-	-
		TWNI	14.1	12.7	11.2	10.1	8.5	6.8	4.8	2.8	1.1
		DG	3.6	-	-	-	-	-	-	-	-
		DGNI	14.8	12.8	11.2	9.4	7.5	5.3	3.4	1.8	.5

PHILADELPHIA PENNSYLVANIA
39.9 N 4865 DD T(JAN)=32

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	95	43	26	17	12	8	5	-	-
L		WWNI	171	82	52	37	28	22	17	13	9
C		TW	96	43	25	16	10	6	4	-	-
R		TWNI	162	77	49	34	26	20	15	11	7
		DG	72	22	-	-	-	-	-	-	-
		DGNI	174	81	51	35	26	19	14	9	5
		WW	8.8	6.9	5.7	4.5	3.3	1.9	.6	-	-
		WWNI	16.0	15.3	13.2	12.0	10.8	9.1	7.3	4.7	1.9
D		TW	8.6	7.0	5.3	3.7	2.3	1.3	.5	-	-
		TWNI	15.3	13.8	12.4	11.1	9.4	7.6	5.3	3.2	1.2
		DG	5.4	1.4	-	-	-	-	-	-	-
		DGNI	16.3	14.2	12.5	10.6	8.6	6.2	4.0	2.1	.6

PITTSBURGH PENNSYLVANIA
40.5 N 5930 DD T(JAN)=28

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	62	25	13	7	-	-	-	-	-
L		WWNI	137	62	39	27	20	15	12	9	6
C		TW	68	28	15	8	3	-	-	-	-
R		TWNI	130	59	37	25	19	14	11	8	5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	134	60	36	24	17	12	8	5	2
		WW	5.1	3.5	2.3	1.1	-	-	-	-	-
		WWNI	12.2	11.1	9.6	8.2	7.2	5.9	4.6	3.0	1.1
D		TW	5.5	3.9	2.5	1.2	.1	-	-	-	-
		TWNI	11.5	10.3	8.9	7.7	6.4	5.0	3.5	2.1	.8
		DG	-	-	-	-	-	-	-	-	-
		DGNI	11.7	9.9	8.2	6.7	5.1	3.5	2.1	.9	.1

SCRANTON PENNSYLVANIA
41.3 N 6277 DD T(JAN)=26

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	63	26	14	8	4	-	-	-	-
L		WWNI	137	63	40	28	20	16	12	9	6
C		TW	68	28	15	9	4	-	-	-	-
R		TWNI	130	60	37	26	19	14	11	8	5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	134	61	37	25	18	13	9	6	2
		WW	5.2	3.7	2.5	1.4	.3	-	-	-	-
		WWNI	12.5	11.2	9.8	8.5	7.5	6.3	4.9	3.1	1.2
D		TW	5.6	4.1	2.7	1.4	.4	-	-	-	-
		TWNI	11.7	10.5	9.1	8.0	6.7	5.3	3.7	2.2	.8
		DG	-	-	-	-	-	-	-	-	-
		DGNI	11.9	10.1	8.5	7.0	5.4	3.7	2.2	1.0	.1

PROVIDENCE RHODE ISLAND
41.7 N 5972 DD T(JAN)=28

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	77	34	20	13	8	5	-	-	-
L		WWNI	153	71	45	32	24	19	15	11	8
C		TW	81	35	20	12	7	4	-	-	-
R		TWNI	145	67	42	30	22	17	13	9	6
		DG	44	-	-	-	-	-	-	-	-
		DGNI	152	69	43	30	22	16	11	8	4
		WW	6.5	5.3	4.2	3.1	1.9	.7	-	-	-
		WWNI	14.0	12.7	11.6	10.3	9.2	7.8	6.1	3.9	1.6
D		TW	7.0	5.5	3.9	2.5	1.4	.5	-	-	-
		TWNI	13.2	12.1	10.7	9.6	8.1	6.5	4.5	2.7	1.0
		DG	2.5	-	-	-	-	-	-	-	-
		DGNI	13.6	11.9	10.5	8.8	7.0	5.0	3.1	1.6	.4

CHARLESTON SOUTH CAROLINA
32.9 N 2146 DD T(JAN)=49

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	252	118	72	51	38	29	22	16	9
L		WWNI	358	173	108	76	58	46	37	29	21
C		TW	238	110	67	46	32	23	17	11	7
R		TWNI	339	161	101	71	54	42	32	24	16
		DG	276	124	73	47	30	19	10	-	-
		DGNI	384	180	113	79	59	45	34	24	16
		WW	24.6	19.9	17.9	16.1	13.7	11.3	7.5	4.0	1.2
		WWNI	35.0	30.8	27.0	25.9	23.5	20.3	17.0	10.9	4.6
D		TW	21.9	19.0	16.0	12.6	9.5	7.0	4.8	2.9	1.3
		TWNI	33.0	28.4	25.9	23.2	20.5	16.5	11.8	7.2	3.0
		DG	24.8	20.1	15.5	10.7	6.7	3.5	1.1	-	-
		DGNI	36.8	31.6	28.4	24.9	21.2	16.0	11.2	6.7	2.7

COLUMBIA SOUTH CAROLINA
33.9 N 2598 DD T(JAN)=45

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	215	102	62	43	32	25	19	13	7
L		WWNI	315	153	96	68	52	41	33	26	18
C		TW	206	95	58	39	28	20	14	9	6
R		TWNI	298	142	89	63	48	37	28	21	14
		DG	231	102	60	37	23	12	-	-	-
		DGNI	335	158	99	69	52	39	29	21	13
		WW	20.6	17.2	15.1	13.7	11.6	9.4	6.1	3.1	.8
		WWNI	30.2	27.9	23.8	22.4	20.9	18.0	15.1	9.6	4.0
D		TW	18.9	16.4	13.7	10.7	7.9	5.7	3.9	2.3	.9
		TWNI	28.6	25.3	22.8	20.6	18.1	14.6	10.4	6.4	2.6
		DG	20.5	16.4	12.1	7.8	4.3	1.7	-	-	-
		DGNI	32.2	27.8	25.1	21.9	18.5	13.9	9.7	5.7	2.2

GREENVILLE SOUTH CAROLINA
34.9 N 3163 DD T(JAN)=42

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	178	83	51	35	26	20	14	10	4
L		WWNI	272	129	82	58	44	35	28	22	15
C		TW	172	78	48	32	22	16	11	7	4
R		TWNI	257	121	76	54	41	31	24	18	12
		DG	182	78	44	25	13	-	-	-	-
		DGNI	285	134	83	58	43	33	24	17	11
		WW	16.4	14.2	12.0	10.8	8.9	7.0	4.3	2.0	.3
		WWNI	25.4	23.8	20.7	18.8	17.5	15.1	12.5	8.0	3.3
D		TW	15.6	13.4	11.0	8.5	6.3	4.3	2.7	1.5	.5
		TWNI	24.0	21.8	19.4	17.6	15.3	12.3	8.7	5.4	2.2
		DG	15.7	12.0	8.1	4.4	1.4	-	-	-	-
		DGNI	26.7	23.4	21.0	18.3	15.3	11.4	7.8	4.6	1.7

HURON SOUTH DAKOTA
44.4 N 8054 DD T(JAN)=13

		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	63	25	12	6	-	-	-	-	-
L		WWNI	136	62	39	27	19	15	11	9	6
C		TW	67	27	14	7	-	-	-	-	-
R		TWNI	129	59	36	25	18	14	10	7	5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	133	59	35	24	16	12	8	5	-
		WW	5.0	3.2	1.9	.7	-	-	-	-	-
		WWNI	12.7	10.9	9.3	7.8	6.9	5.6	4.2	2.8	1.1
D		TW	5.5	3.7	2.2	1.0	-	-	-	-	-
		TWNI	11.8	10.1	8.5	7.4	6.1	4.8	3.3	1.9	.7
		DG	-	-	-	-	-	-	-	-	-
		DGNI	11.8	9.7	7.9	6.3	4.8	3.2	1.9	.8	-

PIERRE SOUTH DAKOTA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	77	32	17	10	6	-	-	-	-
44.4 N	L	WWNI	153	70	44	30	22	17	13	10	7
7677 DD	C	TW	80	33	18	10	6	-	-	-	-
T(JAN)=16	R	TWNI	144	67	41	28	21	16	12	8	5
		DG	36	-	-	-	-	-	-	-	-
		DGNI	151	68	41	28	20	14	10	6	3
		WW	6.4	4.5	3.1	2.0	.9	-	-	-	-
		WWNI	14.4	12.3	10.5	9.0	8.0	6.6	5.0	3.3	1.3
	D	TW	6.8	4.8	3.2	1.9	.7	-	-	-	-
		TWNI	13.3	11.5	9.8	8.5	7.0	5.6	3.9	2.3	.9
		DG	1.3	-	-	-	-	-	-	-	-
		DGNI	13.6	11.2	9.3	7.6	5.9	4.1	2.5	1.2	.2

RAPID CITY SOUTH DAKOTA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	91	40	23	15	10	6	-	-	-
44.0 N	L	WWNI	166	79	50	35	26	20	16	12	8
7324 DD	C	TW	92	40	23	14	9	5	2	-	-
T(JAN)=22	R	TWNI	158	75	47	33	24	18	14	10	6
		DG	64	-	-	-	-	-	-	-	-
		DGNI	168	78	48	33	24	17	12	8	4
		WW	8.3	6.4	4.8	3.7	2.3	1.1	-	-	-
		WWNI	15.9	14.1	12.7	10.9	9.5	8.2	6.2	4.1	1.6
	D	TW	8.2	6.4	4.7	3.0	1.8	.8	.1	-	-
		TWNI	15.1	13.4	11.5	10.1	8.5	6.7	4.7	2.8	1.1
		DG	4.4	-	-	-	-	-	-	-	-
		DGNI	15.7	13.5	11.4	9.6	7.5	5.4	3.4	1.7	.4

SIOUX FALLS SOUTH DAKOTA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	68	28	15	8	4	-	-	-	-
43.6 N	L	WWNI	143	66	41	28	21	16	12	9	6
7838 DD	C	TW	72	30	16	9	4	-	-	-	-
T(JAN)=14	R	TWNI	135	62	38	26	19	15	11	8	5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	140	63	38	25	18	13	9	6	2
		WW	5.6	3.8	2.6	1.4	.3	-	-	-	-
		WWNI	13.2	11.5	9.9	8.5	7.5	6.2	4.7	3.1	1.2
	D	TW	6.0	4.3	2.7	1.5	.4	-	-	-	-
		TWNI	12.3	10.7	9.1	8.0	6.6	5.3	3.7	2.1	.8
		DG	-	-	-	-	-	-	-	-	-
		DGNI	12.5	10.4	8.6	7.0	5.4	3.7	2.2	1.0	.1

CHATTANOOGA TENNESSEE		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	136	63	38	26	19	14	10	6	-
35.0 N	L	WWNI	220	106	67	47	35	28	22	17	12
3505 DD	C	TW	133	61	36	24	16	11	7	4	2
T(JAN)=40	R	TWNI	208	99	62	44	33	25	19	14	9
		DG	127	52	25	-	-	-	-	-	-
		DGNI	228	108	67	47	34	26	19	13	8
		WW	12.7	10.6	8.7	7.6	6.0	4.3	2.4	.8	-
		WWNI	21.4	19.7	16.8	15.0	14.1	11.9	9.8	6.3	2.6
	D	TW	12.2	10.2	8.1	6.0	4.2	2.7	1.5	.7	.1
		TWNI	19.9	17.9	15.6	14.2	12.2	9.8	6.9	4.2	1.7
		DG	10.6	7.1	3.3	-	-	-	-	-	-
		DGNI	21.6	18.8	16.5	14.3	11.8	8.7	5.8	3.3	1.1

KNOXVILLE TENNESSEE		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	143	66	39	27	20	14	10	6	-
35.8 N	L	WWNI	230	110	69	48	37	29	23	18	13
3478 DD	C	TW	140	63	38	25	17	11	8	5	2
T(JAN)=41	R	TWNI	217	103	64	45	34	26	20	15	10
		DG	136	56	28	10	-	-	-	-	-
		DGNI	238	111	69	48	35	26	19	14	8
		WW	13.2	11.0	9.0	7.9	6.4	4.6	2.6	.9	-
		WWNI	21.9	20.1	17.2	15.4	14.5	12.2	10.0	6.5	2.7
	D	TW	12.7	10.6	8.4	6.3	4.4	2.9	1.7	.8	.2
		TWNI	20.5	18.4	16.0	14.5	12.5	10.1	7.1	4.3	1.7
		DG	11.3	7.7	3.9	.3	-	-	-	-	-
		DGNI	22.4	19.4	17.0	14.7	12.2	9.0	6.0	3.4	1.2

MEMPHIS TENNESSEE		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	161	74	44	31	22	17	12	8	-
35.0 N	L	WWNI	251	119	75	52	40	31	25	20	14
3227 DD	C	TW	156	70	42	28	19	13	9	6	3
T(JAN)=40	R	TWNI	237	112	70	49	37	28	22	16	11
		DG	159	66	35	18	-	-	-	-	-
		DGNI	263	122	75	53	39	29	22	15	9
		WW	14.8	12.1	10.4	9.2	7.6	5.7	3.3	1.4	-
		WWNI	23.3	21.7	18.4	17.0	15.9	13.6	11.1	7.2	3.0
	D	TW	14.0	11.8	9.6	7.3	5.2	3.5	2.2	1.1	.3
		TWNI	22.2	19.6	17.5	15.9	13.7	11.1	7.9	4.8	1.9
		DG	13.3	9.7	5.8	2.4	-	-	-	-	-
		DGNI	24.6	21.0	18.8	16.3	13.6	10.1	6.9	3.9	1.4

NASHVILLE TENNESSEE		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	124	56	32	22	16	11	8	4	-
36.1 N	L	WWNI	207	98	61	42	32	25	20	16	11
3696 DD	C	TW	122	54	32	21	14	9	6	3	-
T(JAN)=38	R	TWNI	195	92	57	40	30	23	17	13	8
		DG	108	41	15	-	-	-	-	-	-
		DGNI	212	98	60	42	31	23	17	11	7
		WW	11.2	8.8	7.2	6.1	4.8	3.2	1.6	.3	-
		WWNI	19.4	17.6	14.8	13.4	12.6	10.7	8.6	5.6	2.3
	D	TW	10.8	8.8	6.8	4.9	3.3	2.0	1.1	.4	-
		TWNI	18.3	16.0	14.0	12.7	10.9	8.8	6.2	3.8	1.5
		DG	8.5	4.9	.8	-	-	-	-	-	-
		DGNI	19.8	16.7	14.6	12.5	10.3	7.5	5.0	2.8	.9

ABILENE TEXAS		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	236	111	69	49	37	28	22	15	9
32.4 N	L	WWNI	339	164	104	74	57	45	36	29	20
2610 DD	C	TW	224	104	64	44	31	22	16	11	7
T(JAN)=44	R	TWNI	321	153	97	69	52	41	31	23	16
		DG	257	116	69	44	29	18	9	-	-
		DGNI	362	171	108	77	57	44	33	24	15
		WW	22.6	19.5	17.3	16.0	13.7	11.0	7.3	3.9	1.1
		WWNI	32.6	30.0	26.7	25.1	23.6	20.3	16.6	10.7	4.5
	D	TW	20.8	18.3	15.5	12.3	9.3	6.9	4.6	2.8	1.2
		TWNI	30.9	27.7	25.3	23.1	20.2	16.2	11.6	7.2	2.9
		DG	23.2	19.3	14.8	10.2	6.3	3.2	.9	-	-
		DGNI	34.5	30.6	28.1	24.7	20.9	15.8	11.0	6.6	2.6

AMARILLO TEXAS		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	178	83	52	36	27	21	16	11	5
35.2 N	L	WWNI	271	130	83	59	45	36	29	23	16
4183 DD	C	TW	173	79	49	33	23	16	11	8	5
T(JAN)=36	R	TWNI	256	122	77	55	42	33	25	19	12
		DG	183	80	46	27	15	-	-	-	-
		DGNI	285	134	85	60	45	34	25	18	12
		WW	16.5	14.5	12.8	11.6	9.9	7.7	4.8	2.4	.5
		WWNI	25.2	24.2	21.5	19.8	18.4	16.5	13.5	8.6	3.6
	D	TW	15.6	13.8	11.5	9.0	6.7	4.7	3.1	1.7	.7
		TWNI	24.0	22.1	20.1	18.5	16.3	13.0	9.3	5.7	2.3
		DG	15.9	12.8	8.9	5.2	2.2	-	-	-	-
		DGNI	26.6	24.0	21.7	19.4	16.2	12.1	8.4	5.0	1.9

AUSTIN TEXAS		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	311	143	89	63	48	37	28	21	13
30.3 N	L	WWNI	432	203	127	91	70	55	45	35	25
1737 DD	C	TW	288	134	82	56	40	29	21	15	10
T(JAN)=50	R	TWNI	404	189	119	85	64	50	39	29	19
		DG	348	157	95	62	42	28	18	9	-
		DGNI	460	214	135	95	71	54	41	30	19
		WW	29.0	24.4	23.0	20.8	18.0	14.7	10.2	5.7	1.9
		WWNI	41.6	35.3	33.0	31.8	28.5	25.0	20.1	13.1	5.5
	D	TW	26.7	23.2	19.6	15.9	12.4	9.3	6.5	4.1	1.7
		TWNI	38.3	33.3	31.2	28.1	25.0	20.0	14.3	8.8	3.6
		DG	31.4	26.2	21.2	15.6	10.8	6.7	3.5	1.1	-
		DGNI	43.4	37.7	34.7	30.8	26.0	20.0	14.0	8.4	3.4

BROWNSVILLE TEXAS		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	656	308	192	137	105	82	65	49	33
25.9 N	L	WWNI	846	402	252	180	138	111	89	70	50
650 DD	C	TW	609	280	175	121	88	65	48	35	24
T(JAN)=60	R	TWNI	797	373	235	168	128	99	77	57	38
		DG	799	365	226	155	111	80	58	40	24
		DGNI	929	432	272	194	146	112	85	63	42
		WW	60.7	53.8	49.0	46.4	41.9	34.5	25.8	15.6	6.3
		WWNI	78.3	71.7	64.3	62.0	57.7	50.8	40.0	26.6	11.3
	D	TW	54.4	49.4	43.2	35.8	28.2	22.0	16.2	10.7	5.3
		TWNI	74.1	66.0	61.2	56.5	49.2	39.9	28.6	17.7	7.3
		DG	71.5	63.6	54.7	44.2	34.0	24.8	16.7	9.7	3.9
		DGNI	86.3	76.2	70.7	63.6	53.8	42.0	30.0	18.6	7.9

CORPUS CHRISTI TEXAS		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW'	469	225	146	105	80	62	49	37	24
27.8 N	L	WWNI	621	299	195	141	109	86	69	55	39
930 DD	C	TW	442	208	131	92	67	50	37	26	18
T(JAN)=56	R	TWNI	586	282	182	131	100	78	60	45	30
		DG	564	264	165	113	81	58	41	27	15
		DGNI	677	325	208	149	113	87	66	48	32
		WW	43.4	43.4	39.0	35.3	31.5	25.6	18.8	11.1	4.3
		WWNI	57.6	57.5	53.8	49.2	44.2	40.3	30.9	20.5	8.7
	D	TW	40.8	37.6	33.2	27.5	21.9	16.8	11.6	7.6	3.7
		TWNI	54.5	53.4	49.2	44.5	38.8	31.2	22.2	13.7	5.6
		DG	52.3	47.2	40.5	32.1	24.1	17.1	10.9	5.7	1.9
		DGNI	63.0	60.5	55.8	50.3	41.9	32.4	22.9	14.1	5.9

DALLAS TEXAS		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	237	109	68	48	36	28	21	15	9
32.8 N	L	WWNI	343	162	102	73	56	45	36	28	20
2290 DD	C	TW	223	103	64	43	31	22	16	11	7
T(JAN)=45	R	TWNI	321	151	95	68	52	40	31	23	15
		DG	255	114	68	43	28	17	8	-	-
		DGNI	362	169	106	75	57	43	32	23	15
		WW	22.2	18.6	17.4	15.8	13.5	10.8	7.2	3.8	1.1
		WWNI	33.4	28.7	26.3	25.6	23.2	20.2	16.3	10.5	4.4
	D	TW	20.7	17.9	15.2	12.0	9.3	6.7	4.6	2.8	1.1
		TWNI	30.6	26.8	25.1	22.8	20.1	16.1	11.5	7.1	2.9
		DG	22.9	18.7	14.4	9.9	6.1	3.1	.8	-	-
		DGNI	34.2	29.9	27.5	24.4	20.6	15.6	10.9	6.5	2.5

DEL RIO TEXAS		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	375	167	105	75	57	44	34	25	16
29.4 N	L	WWNI	512	232	146	106	81	64	51	40	29
1523 DD	C	TW	343	158	97	66	48	35	26	18	12
T(JAN)=51	R	TWNI	476	218	138	98	74	58	44	33	22
		DG	424	191	115	77	53	36	24	14	5
		DGNI	543	248	157	111	83	63	48	35	23
		WW	33.4	28.8	28.3	24.5	21.3	17.6	12.4	7.0	2.5
		WWNI	47.5	39.9	39.2	37.8	32.2	28.1	22.9	14.9	6.3
	D	TW	31.3	27.0	23.0	19.0	15.0	11.3	8.0	5.0	2.2
		TWNI	43.4	38.2	36.6	32.3	28.3	22.9	16.3	10.0	4.1
		DG	37.7	31.8	26.4	20.1	14.4	9.5	5.4	2.3	.3
		DGNI	49.3	43.7	40.2	35.8	30.4	23.3	16.3	9.8	4.0

EL PASO TEXAS		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	274	131	82	58	44	34	26	19	12
31.8 N	L	WWNI	384	189	119	85	65	52	42	33	24
2678 DD	C	TW	258	122	76	52	37	27	19	14	9
T(JAN)=44	R	TWNI	363	175	111	79	60	47	36	27	18
		DG	307	141	85	56	37	25	15	7	-
		DGNI	413	197	125	89	66	51	38	28	18
		WW	27.4	22.9	20.5	19.4	16.7	13.6	9.3	5.1	1.6
		WWNI	38.4	34.5	30.2	28.9	27.6	23.7	19.2	12.4	5.2
	D	TW	24.5	21.8	18.5	14.7	11.3	8.4	5.9	3.6	1.6
		TWNI	36.2	31.6	28.9	26.7	23.1	18.7	13.4	8.3	3.4
		DG	28.5	24.1	19.1	13.8	9.2	5.5	2.6	.6	-
		DGNI	40.6	35.4	32.5	28.8	24.4	18.5	13.0	7.9	3.2

FORT WORTH TEXAS		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	225	104	65	46	34	26	20	14	8
32.8 N	L	WWNI	328	155	98	71	54	43	34	27	19
2382 DD	C	TW	212	99	61	41	29	21	15	10	6
T(JAN)=45	R	TWNI	307	146	92	66	50	39	30	22	15
		DG	240	108	64	40	25	15	6	-	-
		DGNI	345	162	102	73	54	41	31	22	14
		WW	21.0	18.1	16.6	14.9	12.7	10.0	6.7	3.5	.9
		WWNI	32.1	28.1	25.6	24.6	22.2	19.2	15.5	10.1	4.2
	D	TW	19.8	17.2	14.5	11.4	8.8	6.3	4.3	2.5	1.1
		TWNI	29.4	26.1	24.3	21.9	19.3	15.4	11.0	6.7	2.7
		DG	21.6	17.6	13.4	9.0	5.4	2.4	.2	-	-
		DGNI	32.7	28.9	26.4	23.4	19.6	14.9	10.3	6.1	2.4

HOUSTON TEXAS
30.0 N 1434 DD T(JAN)=52

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	336	148	93	66	50	39	30	22	14
L	WWNI	466	209	131	95	73	58	46	36	26
C	TW	309	140	86	59	42	31	22	16	10
R	TWNI	433	196	124	88	67	52	40	30	20
	DG	375	166	99	66	45	30	19	11	-
	DGNI	492	223	140	99	74	57	43	31	20
	WW	29.1	25.4	24.1	21.7	18.9	15.3	10.7	6.0	2.0
	WWNI	42.2	35.9	35.3	32.7	29.3	25.9	20.6	13.5	5.7
D	TW	27.7	23.8	20.5	16.6	13.1	9.8	6.9	4.1	1.8
	TWNI	38.8	34.3	32.2	29.2	25.9	20.7	14.7	9.1	3.7
	DG	32.7	27.3	22.4	16.7	11.7	7.4	3.9	1.3	-
	DGNI	43.9	39.0	35.9	32.1	27.1	20.8	14.5	8.8	3.5

LAREDO TEXAS
27.5 N 876 DD T(JAN)=56

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	528	252	163	115	87	67	52	39	26
L	WWNI	693	331	216	156	117	92	74	58	41
C	TW	495	231	145	101	73	54	40	28	19
R	TWNI	652	312	200	143	108	83	64	48	32
	DG	639	297	184	126	89	64	45	30	17
	DGNI	756	360	230	163	122	93	70	51	34
	WW	48.3	48.1	43.3	36.9	33.0	27.1	20.0	11.9	4.7
	WWNI	63.4	63.1	59.6	51.5	45.1	40.5	32.4	21.5	9.2
D	TW	46.0	41.0	36.2	29.8	23.7	18.0	12.5	7.7	4.0
	TWNI	60.2	58.9	52.7	46.8	41.0	32.8	23.3	14.3	5.9
	DG	59.0	51.9	44.7	35.4	26.6	18.8	12.1	6.4	2.2
	DGNI	69.8	67.0	59.5	53.1	44.5	34.3	24.1	14.8	6.2

LUBBOCK TEXAS
33.6 N 3545 DD T(JAN)=39

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	206	97	61	43	32	25	19	13	8
L	WWNI	306	146	94	67	51	41	33	26	19
C	TW	198	92	57	39	28	20	14	10	6
R	TWNI	288	137	87	63	48	37	29	21	14
	DG	220	99	58	37	23	13	-	-	-
	DGNI	323	153	97	69	52	39	30	21	14
	WW	19.1	17.4	15.3	14.1	12.2	9.7	6.3	3.3	.9
	WWNI	28.6	27.5	25.0	22.6	21.5	18.8	15.6	9.9	4.2
D	TW	18.3	16.2	13.7	10.8	8.3	5.9	4.0	2.3	1.1
	TWNI	27.1	25.2	22.9	21.2	18.6	14.9	10.6	6.6	2.7
	DG	19.7	16.4	12.2	8.0	4.6	1.9	-	-	-
	DGNI	30.3	27.7	25.1	22.5	18.9	14.3	9.9	5.9	2.3

LUFKIN TEXAS
31.2 N 1940 DD T(JAN)=49

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	273	125	78	55	42	32	25	18	11
L	WWNI	385	182	113	81	63	50	40	32	22
C	TW	254	118	73	49	35	25	18	13	8
R	TWNI	361	170	107	76	58	45	35	26	17
	DG	299	135	80	52	34	22	13	-	-
	DGNI	409	191	120	85	63	48	36	26	17
	WW	25.8	21.2	19.7	18.2	15.6	12.6	8.6	4.7	1.4
	WWNI	38.0	31.8	29.1	28.4	25.8	22.4	18.1	11.8	4.9
D	TW	23.6	20.5	17.3	13.8	10.6	7.9	5.5	3.4	1.5
	TWNI	34.6	29.8	27.8	25.3	22.3	17.9	12.8	7.9	3.2
	DG	27.0	22.3	17.6	12.5	8.3	4.8	2.1	-	-
	DGNI	38.8	33.5	30.8	27.3	23.1	17.6	12.3	7.4	2.9

MIDLAND-ODESSA TEXAS
31.9 N 2621 DD T(JAN)=44

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	265	127	79	56	43	33	26	19	11
L	WWNI	373	182	115	83	64	51	41	32	23
C	TW	249	118	74	50	36	26	19	13	9
R	TWNI	352	170	108	77	59	46	35	27	18
	DG	294	136	82	54	36	24	14	6	-
	DGNI	400	191	121	86	65	50	37	27	18
	WW	26.4	22.4	20.1	19.0	16.3	13.4	9.1	5.0	1.6
	WWNI	37.3	33.7	29.9	28.5	26.9	23.3	19.1	12.3	5.2
D	TW	23.7	21.1	18.0	14.4	11.1	8.2	5.7	3.5	1.7
	TWNI	34.8	30.9	28.4	26.1	23.0	18.4	13.2	8.2	3.4
	DG	27.4	23.2	18.4	13.3	8.9	5.2	2.4	.5	-
	DGNI	39.0	34.6	31.9	28.3	24.0	18.2	12.8	7.7	3.1

PORT ARTHUR TEXAS
29.9 N 1518 DD T(JAN)=52

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	339	153	95	67	51	40	31	22	14
L	WWNI	466	215	134	96	74	59	47	37	27
C	TW	311	143	88	60	43	31	23	16	11
R	TWNI	435	201	126	90	68	53	41	30	20
	DG	380	170	102	68	46	31	20	11	-
	DGNI	496	228	143	101	76	58	44	32	21
	WW	31.5	25.6	24.5	22.4	19.4	15.8	11.1	6.3	2.1
	WWNI	44.7	36.5	34.7	33.6	30.3	26.6	21.3	13.9	5.8
D	TW	28.5	24.7	20.8	17.0	13.3	10.1	7.1	4.4	2.1
	TWNI	40.9	34.9	32.8	29.7	26.4	21.2	15.1	9.3	3.8
	DG	33.9	28.3	23.1	17.2	12.1	7.8	4.2	1.6	-
	DGNI	46.0	39.6	36.5	32.6	27.6	21.3	15.0	9.0	3.7

SAN ANGELO TEXAS
31.4 N 2240 DD T(JAN)=46

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	269	129	80	57	43	33	26	19	11
L	WWNI	377	185	117	84	65	51	41	33	23
C	TW	253	120	75	51	36	26	19	13	9
R	TWNI	357	172	109	78	59	46	36	27	18
	DG	300	138	84	55	37	24	15	6	-
	DGNI	405	194	123	87	66	50	38	27	18
	WW	26.9	22.6	20.4	19.0	16.3	13.4	9.1	5.0	1.6
	WWNI	37.7	34.2	30.2	28.8	26.8	23.2	19.2	12.3	5.2
D	TW	24.1	21.4	18.2	14.6	11.2	8.3	5.8	3.6	1.6
	TWNI	35.5	31.3	28.8	26.2	23.1	18.5	13.3	8.2	3.4
	DG	27.9	23.6	18.8	13.5	9.0	5.3	2.5	.5	-
	DGNI	39.7	35.0	32.3	28.4	24.1	18.3	12.9	7.8	3.1

SAN ANTONIO TEXAS
29.5 N 1570 DD T(JAN)=51

		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
	WW	345	156	97	70	52	41	31	23	14
L	WWNI	474	219	137	99	76	60	48	38	27
C	TW	318	146	90	62	44	32	24	17	11
R	TWNI	443	204	129	92	70	54	42	31	21
	DG	389	175	105	70	48	33	21	12	-
	DGNI	505	232	146	103	78	59	45	33	21
	WW	31.9	26.6	25.6	22.8	19.9	16.3	11.4	6.5	2.2
	WWNI	44.9	37.5	36.0	34.5	30.6	27.0	21.7	14.2	6.0
D	TW	29.2	25.2	21.5	17.4	13.8	10.4	7.3	4.6	2.0
	TWNI	41.4	35.8	33.7	30.4	27.0	21.6	15.4	9.5	3.9
	DG	34.8	29.1	23.8	18.0	12.7	8.2	4.5	1.8	-
	DGNI	46.6	40.8	37.6	33.4	28.4	21.8	15.3	9.2	3.8

SHERMAN TEXAS		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	191	88	54	38	28	21	16	11	6
33.7 N	L	WWNI	286	136	85	61	47	37	30	23	17
2864 DD	C	TW	182	83	51	34	24	17	12	8	5
T(JAN)=42	R	TWNI	271	127	80	57	43	33	26	19	13
		DG	197	86	49	29	17	-	-	-	-
		DGNI	302	141	88	62	46	35	26	19	12
		WW	17.8	14.9	13.4	11.9	10.2	7.9	5.0	2.4	.5
		WWNI	27.5	24.2	21.8	20.7	18.9	16.5	13.4	8.6	3.6
	D	TW	16.6	14.3	11.9	9.2	6.9	4.9	3.2	1.8	.7
		TWNI	25.6	22.6	20.7	18.8	16.5	13.2	9.4	5.8	2.3
		DG	17.1	13.5	9.5	5.6	2.6	-	-	-	-
		DGNI	28.1	24.7	22.3	19.8	16.6	12.4	8.6	5.0	1.9

WACO TEXAS		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	263	121	75	53	40	31	24	17	10
31.6 N	L	WWNI	373	176	110	79	61	48	39	30	22
2058 DD	C	TW	245	114	70	47	34	24	18	12	8
T(JAN)=47	R	TWNI	350	164	103	74	56	43	33	25	17
		DG	287	129	77	49	32	21	12	-	-
		DGNI	396	185	116	82	61	47	35	25	16
		WW	24.7	20.5	19.2	17.3	14.9	11.9	8.1	4.4	1.3
		WWNI	36.6	30.8	28.5	27.4	24.8	21.6	17.4	11.3	4.7
	D	TW	22.7	19.7	16.7	13.2	10.2	7.5	5.2	3.2	1.4
		TWNI	33.5	29.0	27.0	24.4	21.6	17.3	12.3	7.6	3.1
		DG	25.8	21.2	16.6	11.7	7.6	4.2	1.7	-	-
		DGNI	37.6	32.5	29.7	26.4	22.2	17.0	11.8	7.1	2.8

WICHITA FALLS TEXAS		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	207	96	59	41	31	24	18	13	7
34.0 N	L	WWNI	304	145	91	65	50	40	32	25	18
2904 DD	C	TW	197	90	55	37	26	19	13	9	5
T(JAN)=41	R	TWNI	288	136	85	61	46	36	28	21	14
		DG	217	96	56	34	21	11	-	-	-
		DGNI	322	151	94	67	50	38	28	20	13
		WW	19.6	16.3	14.6	13.4	11.4	9.0	5.8	2.9	.7
		WWNI	29.2	26.1	23.2	22.1	20.6	17.9	14.6	9.4	3.9
	D	TW	18.0	15.6	13.1	10.1	7.7	5.5	3.7	2.2	.9
		TWNI	27.4	24.2	22.1	20.2	17.7	14.3	10.2	6.3	2.5
		DG	19.1	15.4	11.2	7.1	3.9	1.3	-	-	-
		DGNI	30.3	26.5	24.2	21.4	18.0	13.6	9.4	5.6	2.1

BRYCE CANYON UTAH		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	98	47	29	20	15	11	7	3	-
37.7 N	L	WWNI	171	85	55	40	30	24	19	15	11
9133 DD	C	TW	99	46	28	19	12	8	5	3	-
T(JAN)=20	R	TWNI	163	80	52	37	28	22	17	12	8
		DG	80	32	-	-	-	-	-	-	-
		DGNI	175	85	54	39	29	22	16	11	7
		WW	9.7	8.3	7.1	6.0	4.7	3.0	1.4	.2	-
		WWNI	17.1	16.2	15.0	13.7	12.2	11.0	8.6	5.5	2.3
	D	TW	9.5	8.1	6.4	4.6	3.1	1.9	1.0	.3	-
		TWNI	16.3	15.2	13.9	12.5	10.9	8.6	6.1	3.7	1.5
		DG	6.9	3.7	-	-	-	-	-	-	-
		DGNI	17.4	15.9	14.1	12.5	10.1	7.3	4.9	2.7	.9

CEDAR CITY UTAH		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	139	64	39	27	20	15	11	7	-
37.7 N	L	WWNI	223	106	68	49	37	29	23	18	13
6137 DD	C	TW	135	62	38	25	17	12	8	5	2
T(JAN)=29	R	TWNI	211	100	64	45	34	27	20	15	10
		DG	130	55	29	12	-	-	-	-	-
		DGNI	231	109	68	48	36	27	20	14	9
		WW	12.9	11.1	9.6	8.4	6.9	5.0	2.8	1.1	-
		WWNI	22.1	19.0	18.3	16.3	14.9	13.2	10.4	6.7	2.8
	D	TW	12.5	10.6	8.6	6.4	4.7	3.2	1.9	.9	.3
		TWNI	20.3	18.2	16.5	15.0	13.1	10.5	7.4	4.5	1.8
		DG	11.3	8.0	4.3	1.0	-	-	-	-	-
		DGNI	21.8	19.7	17.4	15.4	12.7	9.4	6.4	3.6	1.3

SALT LAKE CITY UTAH		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	131	59	35	23	16	11	7	3	-
40.8 N	L	WWNI	215	101	64	45	33	26	20	15	11
5983 DD	C	TW	127	57	34	22	14	9	6	3	-
T(JAN)=28	R	TWNI	203	95	59	42	31	23	18	13	8
		DG	118	45	18	-	-	-	-	-	-
		DGNI	221	102	63	44	32	23	17	11	6
		WW	11.7	9.9	7.9	6.4	4.6	3.1	1.4	.2	-
		WWNI	20.9	17.8	16.2	14.2	12.4	10.5	7.8	5.2	2.1
	D	TW	11.6	9.3	7.1	5.2	3.5	2.1	1.0	.3	-
		TWNI	19.1	16.9	14.8	13.0	10.8	8.6	6.0	3.6	1.4
		DG	9.5	5.5	1.5	-	-	-	-	-	-
		DGNI	20.5	17.7	15.2	12.9	10.2	7.5	4.9	2.6	.8

BURLINGTON VERMONT		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	42	14	-	-	-	-	-	-	-
44.5 N	L	WWNI	115	51	32	22	16	12	9	7	5
7876 DD	C	TW	50	18	8	-	-	-	-	-	-
T(JAN)=17	R	TWNI	109	49	30	21	15	11	8	6	4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	109	47	28	19	13	9	6	3	-
		WW	3.1	1.5	-	-	-	-	-	-	-
		WWNI	10.0	8.8	7.8	6.6	5.6	4.5	3.3	2.2	.8
	D	TW	3.8	2.3	.9	-	-	-	-	-	-
		TWNI	9.6	8.4	7.2	6.1	5.0	3.9	2.7	1.5	.5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	9.2	7.6	6.2	4.8	3.5	2.2	1.1	.3	-

NORFOLK VIRGINIA		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	162	75	46	32	23	17	13	8	-
36.9 N	L	WWNI	251	120	76	54	41	32	26	20	14
3488 DD	C	TW	156	72	43	29	20	14	9	6	3
T(JAN)=40	R	TWNI	237	113	71	50	38	29	22	17	11
		DG	160	68	37	20	-	-	-	-	-
		DGNI	263	123	77	54	40	30	22	16	10
		WW	15.2	12.6	11.1	9.5	7.9	6.0	3.6	1.6	-
		WWNI	24.5	21.6	19.5	17.9	15.9	13.9	11.6	7.3	3.1
	D	TW	14.3	12.1	10.0	7.5	5.4	3.8	2.3	1.2	.4
		TWNI	22.7	20.1	18.2	16.2	14.2	11.4	8.1	4.9	2.0
		DG	13.9	10.2	6.3	2.9	-	-	-	-	-
		DGNI	24.9	21.9	19.3	16.8	14.1	10.4	7.1	4.1	1.5

RICHMOND VIRGINIA		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 132	61	37	25	18	13	9	5	-
37.5 N	L	WWNI 216	103	65	46	35	27	22	17	12
3939 DD	C	TW 130	59	35	23	16	11	7	4	2
T(JAN)=37	R	TWNI 205	97	61	43	32	25	19	14	9
		DG 122	49	24	-	-	-	-	-	-
		DGNI 223	105	65	45	34	25	18	13	8
		WW 12.1	10.3	8.5	7.3	5.7	4.1	2.2	.7	-
		WWNI 20.5	19.0	16.9	14.9	13.6	11.5	9.4	6.1	2.5
	D	TW 11.7	9.8	7.9	5.8	4.1	2.6	1.4	.6	.1
		TWNI 19.2	17.5	15.5	13.9	11.9	9.6	6.7	4.1	1.6
		DG 10.1	6.7	2.9	-	-	-	-	-	-
		DGNI 20.8	18.5	16.3	13.9	11.5	8.4	5.6	3.2	1.1

ROANOKE VIRGINIA		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 124	58	35	24	18	13	9	5	-
37.3 N	L	WWNI 206	99	63	45	34	27	21	17	12
4307 DD	C	TW 123	56	34	22	15	10	7	4	1
T(JAN)=36	R	TWNI 195	93	59	42	32	24	19	14	9
		DG 113	46	21	-	-	-	-	-	-
		DGNI 212	100	63	44	33	24	18	13	7
		WW 11.6	9.9	8.3	7.1	5.6	3.9	2.1	.6	-
		WWNI 19.3	18.5	16.4	14.7	13.5	11.5	9.4	6.0	2.5
	D	TW 11.3	9.5	7.6	5.6	3.9	2.5	1.4	.6	.1
		TWNI 18.5	17.0	15.3	13.7	11.8	9.5	6.7	4.1	1.6
		DG 9.5	6.2	2.4	-	-	-	-	-	-
		DGNI 20.1	18.0	15.9	13.7	11.3	8.3	5.5	3.1	1.0

OLYMPIA WASHINGTON		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 112	48	28	17	10	5	-	-	-
47.0 N	L	WWNI 191	90	55	38	28	21	16	11	7
5530 DD	C	TW 109	48	27	16	10	5	-	-	-
T(JAN)=37	R	TWNI 181	84	52	36	26	19	14	10	6
		DG 90	23	-	-	-	-	-	-	-
		DGNI 195	89	54	36	25	18	12	8	3
		WW 10.1	7.3	5.6	3.6	1.9	.5	-	-	-
		WWNI 19.1	15.6	13.3	11.7	9.5	7.2	5.0	3.2	1.2
	D	TW 9.8	7.3	4.9	3.2	1.8	.7	-	-	-
		TWNI 17.3	14.5	12.4	10.3	8.2	6.1	4.2	2.4	.8
		DG 6.6	1.1	-	-	-	-	-	-	-
		DGNI 18.3	14.9	12.3	9.6	7.1	5.0	3.0	1.4	.2

SEATTLE-TACOMA WASHINGTON		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 128	54	30	19	11	6	-	-	-
47.4 N	L	WWNI 213	98	59	41	30	22	16	11	7
5185 DD	C	TW 123	53	29	18	11	6	-	-	-
T(JAN)=38	R	TWNI 199	91	55	38	27	20	14	10	6
		DG 108	33	-	-	-	-	-	-	-
		DGNI 217	97	58	38	27	19	13	8	3
		WW 11.1	8.0	6.0	3.9	2.1	.7	-	-	-
		WWNI 20.3	16.5	14.0	12.1	9.7	7.3	5.1	3.2	1.2
	D	TW 10.8	7.9	5.4	3.6	2.0	.8	-	-	-
		TWNI 18.6	15.3	13.0	10.7	8.4	6.2	4.3	2.4	.8
		DG 8.0	2.5	-	-	-	-	-	-	-
		DGNI 19.9	15.9	12.9	10.0	7.4	5.1	3.1	1.4	.2

SPOKANE WASHINGTON		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 91	37	20	10	-	-	-	-	-
47.6 N	L	WWNI 169	78	47	32	23	17	12	9	6
6835 DD	C	TW 92	38	20	11	5	-	-	-	-
T(JAN)=25	R	TWNI 161	73	44	30	21	15	11	8	4
		DG 56	-	-	-	-	-	-	-	-
		DGNI 171	75	45	29	20	13	9	5	-
		WW 7.6	5.3	3.3	1.4	-	-	-	-	-
		WWNI 15.4	13.0	11.2	9.3	7.2	5.5	3.7	2.5	.9
	D	TW 7.6	5.3	3.3	1.7	.5	-	-	-	-
		TWNI 14.7	12.3	10.3	8.2	6.4	4.7	3.3	1.8	.6
		DG 2.9	-	-	-	-	-	-	-	-
		DGNI 15.0	12.3	9.7	7.3	5.2	3.5	1.9	.7	-

YAKIMA WASHINGTON		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 117	48	26	15	8	-	-	-	-
46.6 N	L	WWNI 201	90	55	38	27	20	14	10	7
6009 DD	C	TW 114	47	25	15	8	4	-	-	-
T(JAN)=28	R	TWNI 190	85	51	35	25	18	13	9	5
		DG 92	-	-	-	-	-	-	-	-
		DGNI 205	89	53	35	24	16	11	7	3
		WW 9.6	7.0	4.9	2.8	1.2	-	-	-	-
		WWNI 18.3	14.9	13.0	10.8	8.4	6.5	4.5	3.1	1.2
	D	TW 9.5	6.8	4.5	2.8	1.4	.2	-	-	-
		TWNI 16.9	14.0	11.8	9.5	7.5	5.5	3.9	2.2	.8
		DG 6.1	-	-	-	-	-	-	-	-
		DGNI 17.7	14.4	11.5	8.8	6.4	4.5	2.6	1.1	.2

CHARLESTON WEST VIRGINIA		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 93	41	23	15	10	7	3	-	-
38.4 N	L	WWNI 170	80	50	35	26	20	16	12	9
4590 DD	C	TW 94	41	24	15	9	5	2	-	-
T(JAN)=34	R	TWNI 161	75	47	33	24	19	14	10	7
		DG 66	-	-	-	-	-	-	-	-
		DGNI 172	79	48	33	24	18	13	8	5
		WW 8.2	6.4	4.9	3.7	2.6	1.3	.1	-	-
		WWNI 15.5	14.5	12.6	10.9	9.9	8.2	6.6	4.3	1.7
	D	TW 8.2	6.4	4.8	3.1	1.9	.9	.2	-	-
		TWNI 14.9	13.3	11.6	10.3	8.6	7.0	4.9	2.9	1.1
		DG 4.5	-	-	-	-	-	-	-	-
		DGNI 15.7	13.5	11.5	9.7	7.8	5.5	3.5	1.8	.5

HUNTINGTON WEST VIRGINIA		SSF = .1	.2	.3	.4	.5	.6	.7	.8	.9
		WW 99	44	26	17	12	8	4	-	-
38.4 N	L	WWNI 178	84	53	37	28	21	17	13	9
4624 DD	C	TW 101	44	26	16	10	6	3	-	-
T(JAN)=34	R	TWNI 169	79	49	34	26	20	15	11	7
		DG 76	22	-	-	-	-	-	-	-
		DGNI 181	83	51	35	26	19	14	9	5
		WW 8.9	7.1	5.4	4.3	3.1	1.7	.5	-	-
		WWNI 16.3	15.2	13.2	11.5	10.5	8.7	7.0	4.5	1.8
	D	TW 8.8	7.0	5.3	3.6	2.2	1.1	.4	-	-
		TWNI 15.6	14.0	12.2	10.8	9.1	7.3	5.1	3.1	1.2
		DG 5.5	1.3	-	-	-	-	-	-	-
		DGNI 16.6	14.3	12.3	10.3	8.4	6.0	3.9	2.0	.6

EAU CLAIRE WISCONSIN		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	50	19	8	-	-	-	-	-	-
44.9 N	L	WWNI	121	56	34	24	17	13	10	8	5
8388 DD	C	TW	56	22	11	4	-	-	-	-	-
T(JAN)=12	R	TWNI	115	53	32	22	16	12	9	6	4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	117	52	31	20	14	10	7	4	-
		WW	3.9	2.2	.9	-	-	-	-	-	-
		WWNI	10.9	9.7	8.4	7.0	6.1	5.1	3.7	2.4	.9
	D	TW	4.5	2.9	1.4	.1	-	-	-	-	-
		TWNI	10.4	9.1	7.7	6.6	5.4	4.2	2.9	1.7	.6
		DG	-	-	-	-	-	-	-	-	-
		DGNI	10.2	8.5	6.9	5.4	4.0	2.6	1.4	.5	-

GREEN BAY WISCONSIN		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	57	22	11	5	-	-	-	-	-
44.5 N	L	WWNI	132	59	37	26	19	14	11	8	5
8098 DD	C	TW	63	25	13	6	-	-	-	-	-
T(JAN)=15	R	TWNI	125	56	35	24	17	13	10	7	4
		DG	-	-	-	-	-	-	-	-	-
		DGNI	127	56	34	22	16	11	7	4	-
		WW	4.4	2.9	1.6	.3	-	-	-	-	-
		WWNI	11.8	10.1	9.1	7.7	6.6	5.4	4.0	2.6	1.0
	D	TW	5.1	3.4	1.9	.7	-	-	-	-	-
		TWNI	11.2	9.7	8.3	7.1	5.9	4.6	3.2	1.8	.7
		DG	-	-	-	-	-	-	-	-	-
		DGNI	11.1	9.2	7.5	6.0	4.5	3.0	1.7	.7	-

LA CROSSE WISCONSIN		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	59	23	12	6	-	-	-	-	-
43.9 N	L	WWNI	133	61	37	26	19	15	11	9	6
7417 DD	C	TW	64	26	13	7	-	-	-	-	-
T(JAN)=16	R	TWNI	126	57	35	24	18	13	10	7	5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	129	57	34	23	16	11	8	5	-
		WW	4.8	3.0	1.9	.7	-	-	-	-	-
		WWNI	12.0	10.5	9.1	7.8	6.9	5.8	4.3	2.8	1.1
	D	TW	5.2	3.6	2.1	.9	-	-	-	-	-
		TWNI	11.2	9.9	8.4	7.3	6.1	4.8	3.3	1.9	.7
		DG	-	-	-	-	-	-	-	-	-
		DGNI	11.3	9.4	7.8	6.3	4.8	3.2	1.9	.8	-

MADISON WISCONSIN		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	62	25	13	7	-	-	-	-	-
43.1 N	L	WWNI	137	62	39	27	20	15	12	9	6
7730 DD	C	TW	67	27	15	8	3	-	-	-	-
T(JAN)=17	R	TWNI	130	59	36	25	19	14	11	8	5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	133	59	36	24	17	12	8	5	2
		WW	4.9	3.4	2.3	1.1	-	-	-	-	-
		WWNI	12.3	10.7	9.6	8.3	7.3	6.2	4.6	3.0	1.1
	D	TW	5.5	3.9	2.4	1.2	.1	-	-	-	-
		TWNI	11.7	10.2	8.9	7.7	6.5	5.1	3.5	2.1	.8
		DG	-	-	-	-	-	-	-	-	-
		DGNI	11.7	9.8	8.2	6.8	5.2	3.5	2.1	.9	.1

MILWAUKEE WISCONSIN		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	64	26	14	8	-	-	-	-	-
42.9 N	L	WWNI	140	63	39	27	20	16	12	9	6
7444 DD	C	TW	69	28	15	8	4	-	-	-	-
T(JAN)=19	R	TWNI	132	60	37	26	19	14	11	8	5
		DG	-	-	-	-	-	-	-	-	-
		DGNI	136	60	36	25	17	12	9	5	2
		WW	5.0	3.6	2.4	1.2	-	-	-	-	-
		WWNI	12.9	10.7	9.8	8.5	7.4	6.1	4.6	3.0	1.1
	D	TW	5.6	4.0	2.5	1.3	.2	-	-	-	-
		TWNI	11.8	10.4	9.0	7.8	6.5	5.1	3.6	2.1	.8
		DG	-	-	-	-	-	-	-	-	-
		DGNI	11.8	10.0	8.3	6.8	5.2	3.6	2.1	.9	.1

CASPER WYOMING		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	107	49	30	20	14	10	7	-	-
42.9 N	L	WWNI	184	90	57	41	31	24	19	15	10
7555 DD	C	TW	107	49	29	19	12	8	5	2	-
T(JAN)=23	R	TWNI	175	84	53	38	28	22	17	12	8
		DG	90	34	-	-	-	-	-	-	-
		DGNI	190	90	56	39	29	21	16	11	6
		WW	10.3	8.4	6.9	5.7	4.3	2.8	1.2	-	-
		WWNI	17.7	16.4	14.9	13.3	11.8	10.4	7.9	5.2	2.1
	D	TW	9.8	8.2	6.4	4.6	3.0	1.8	.8	.2	-
		TWNI	16.9	15.3	13.7	12.2	10.5	8.4	5.9	3.5	1.4
		DG	7.3	3.8	-	-	-	-	-	-	-
		DGNI	18.1	16.1	14.0	12.1	9.7	7.1	4.7	2.5	.8

CHEYENNE WYOMING		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	111	52	32	22	16	12	8	5	-
41.1 N	L	WWNI	190	91	58	42	32	25	21	16	11
7255 DD	C	TW	112	51	31	20	14	9	6	3	1
T(JAN)=27	R	TWNI	181	86	55	39	30	23	18	13	9
		DG	96	38	16	-	-	-	-	-	-
		DGNI	195	92	58	41	31	23	17	12	7
		WW	10.3	8.9	7.7	6.6	5.4	3.6	1.9	.5	-
		WWNI	17.7	17.2	15.5	14.3	12.9	11.7	9.3	5.9	2.4
	D	TW	10.1	8.7	7.0	5.1	3.5	2.3	1.3	.5	.1
		TWNI	16.9	15.8	14.5	13.1	11.6	9.2	6.5	4.0	1.6
		DG	7.9	5.0	1.2	-	-	-	-	-	-
		DGNI	18.3	16.7	14.9	13.3	10.8	7.9	5.3	3.0	1.0

ROCK SPRINGS WYOMING		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	98	45	28	19	13	9	6	-	-
41.6 N	L	WWNI	176	84	54	38	29	23	18	14	10
8410 DD	C	TW	100	45	27	17	11	7	4	2	-
T(JAN)=19	R	TWNI	167	79	50	36	27	21	16	12	8
		DG	78	28	-	-	-	-	-	-	-
		DGNI	179	84	53	37	27	20	15	10	6
		WW	9.1	7.7	6.3	5.2	3.8	2.4	.9	-	-
		WWNI	16.4	15.7	14.1	12.8	11.4	9.9	7.6	5.0	2.0
	D	TW	9.0	7.5	5.8	4.1	2.6	1.5	.7	.1	-
		TWNI	15.7	14.4	13.1	11.7	10.0	8.0	5.6	3.4	1.3
		DG	6.2	2.6	-	-	-	-	-	-	-
		DGNI	16.8	15.1	13.3	11.5	9.2	6.7	4.4	2.3	.7

SHERIDAN WYOMING		SSF =	.1	.2	.3	.4	.5	.6	.7	.8	.9
		WW	86	38	22	14	9	5	-	-	-
44.8 N	L	WWNI	161	77	48	34	25	19	15	12	8
7708 DD	C	TW	88	38	22	14	8	4	-	-	-
T(JAN)=21	R	TWNI	153	72	45	32	23	18	13	10	6
		DG	57	-	-	-	-	-	-	-	-
		DGNI	163	75	46	32	23	17	12	8	4
		WW	8.0	6.2	4.5	3.3	1.9	.8	-	-	-
		WWNI	14.9	13.8	12.4	10.6	9.1	7.8	5.8	3.9	1.5
	D	TW	7.7	6.0	4.4	2.8	1.5	.6	-	-	-
		TWNI	14.2	12.8	11.2	9.7	8.2	6.4	4.5	2.7	1.0
		DG	3.7	-	-	-	-	-	-	-	-
		DGNI	15.1	13.1	11.0	9.2	7.1	5.1	3.2	1.6	.4

The following tables provide an overview of the methods available for analyzing the performance of solar designs. This information has been extracted directly from a publication by the Solar Energy Research Institute (SERI) entitled Analysis Methods for Solar Heating and Cooling Applications (see BIBLIOGRAPHY, reference no. 2).

The tables provide very general information concerning availability and applications of common solar analysis methods. They are not intended as statements of advocacy of any of the methods described.

Special attention should be paid, in the table on pages B.2 and B.3, to the column entitled "Tools Required." The categories listed follow the same organization as the "Energy Use Analysis" description (Section 2.2100) in Passive Solar Fundamentals.

For example, the column entitled "Tables/ Graphs" indicates what are referred to as Manual Methods in Section 2.2100. If such a method is desired, simply read down this column to find a variety of possible options. The next three columns ("4 Function Calculator," "Scientific Calculator," and "Programmable Calculator") cover the Programmable Calculator Programs discussed in the text. The final column, missing its title, indicates those methods that are designed to be used with a microcomputer (in Section 2.2100 under Microcomputer Methods).

The table on page B.4 is devoted exclusively to the methods discussed under Computer Programs in Section 2.2100.

For further information on a specific analysis method, contact the Reference/ Source listed. For general information, contact:

Public Information Office
Solar Energy Research Institute
1617 Cole Boulevard
Golden, Colorado 80401
(303) 321-1000

or:

National Solar Heating and Cooling
Information Center
P.O. Box 1607
Rockville, Maryland 20850
(800) 523-2929

Description	Author	Availability			Applications										Tools Required					Output			
					Active				Passive														
		Cost ($)	Date	Reference/Source	Space Heating	Domestic Hot Water	Liquid Collector	Air Collector	Direct Gain	Thermal Storage Wall	Attached Sunspace	Thermal Storage Roof	Convective Loop		Tables/ Graphs	4 Function Calculator	Scientific Calculator	Programmable Calculator		Solar Fraction	Optimum Area	Economic Analysis	Other
A Simplified Method for Calculating Solar Collector Array Size for Space Heating	J. D. Balcomb J. C. Hedstrom		197€	Sharing the Sun: Solar Technology in the Seventies, Vol. 4, American Section, International Solar Energy Society, 1976, pp 281-284.	●	●	●	●							●	●					●		
Passive Solar Design Handbook SLR Method	J. D. Balcomb Bruce Anderson	14	1980	NTIS 5285 Port Royal Road Springfield, VA 22161					●	●	△				●	●				●	●	●	
Predicting the performance of Solar Energy Systems	U.S. Army Construction Engineering Research Lab		1977	Rept. No. AD-A035 608 9 ST (NTIS)	●	●	●	●							●	●				●	●	●	
Copper Brass Bronze Design Handbook —Solar Energy Systems	Copper Development Association	3	1978	Copper Development Association, Inc 1011 High Ridge Road Stamford, CN 06905	●		●	●							●	●				●			
Copper Brass Bronze Technical Report: How to Design and Build a Swimming Pool Heater	Cooper Development Association	Free	1978	Copper Development Association, Inc.			●								●	●				●		●	
PEGFIX and PEGFLOAT	W. Glennie	75 both	1978	Princeton Energy Group 729 Alexander Road Princeton, NJ 08540 (609) 452-8235					●		●							●					●
IMPSLR interactive SLR	PEG	250	1980	Princeton Energy Group					●	●									●	●			
NEATWORK thermal network	PEG	250	1980	Princeton Energy Group					●	●									●	●			●
PEGSOL two-zone	PEG	400	1980	Princeton Energy Group					●	●	●								●	●			●
Solarcon Programs for Comprehensive Active System Design (5 programs & 5 sets. weather data) (5 Insolation models)	R. W. Graeff	383 data	1977	Solarcon, Inc. 607 Church Street Ann Arbor, MI 48104 (313) 769-6588	●	●	●	●									●	●	●	●		●	
Solarcon Programs for Passive System Design(5 programs & 5 sets. weather data)	R. W. Graeff	495	1979	Solarcon, Inc.					●	●								●	●	●			
Solar Heating Systems Design Manual	ITT Corporation Fluid Handling Division	2.50	1977	Bulletin TESE-576, Rev. 1 ITT Training & Education Dept Fluid Handling Division Morton Grove, IL 60053	●	●	●	●							●	●				●			
A General Design Method for Closed-Loop Solar Energy Systems	S. A. Klein W. A. Beckman		1977	Proceedings of the 1977 Annual Meeting, Vol. 1, American Section, International Solar Energy Society, 1977, pp 8.1-8.5			●								●		●			●			
Solar Heating Design by the F-CHART Method	S. A. Klein, W. A. Beckman, J. A. Duffie	10	1977	John Wiley and Sons, New York, N.Y., 1977 (Publisher)	●	●	●	●							●	●				●		●	
TEANET thermal network model	J. T. Kohler P. W. Sullivan	95	1978	Total Environmental Action, Inc Church Hill Harrisville, NH 03450 (603) 827-3374					●	●	●	●	●					●					●
The GFL Method for Sizing Solar Energy Space and Water Heating Systems	G. F. Lameiro P. Bendt		1978	Rept. No. SERI-30 Solar Energy Research Institute 1617 Cole Boulevard Golden, CO 80401	●	●	●	●							●		●			●			
A Rational Procedure for Predicting the Long-Term Average Performance of Flat-Plate Solar Energy Collectors	B.Y.H. Liu R. C. Jordan		1963	Solar Energy, Vol. 7, No. 2, 1963, pp. 53-70	●	●	●	●							●		●			●			
Pacific Regional Solar Heating Handbook	Los Alamos Scientific Lab		1976	Rept. No. TID-27630 (NTIS)	●	●	●	●							●		●			●			

McClintock Corp.	R. McClintock	195 Therm. alone, 175 econ anal alone, 75	1977	McClintock Corp P.O. Box 430980 Miami, FL 33143 (305) 666-1300	•	•	•	•									•	•	•	•	•		
Minimum Cost Sizing of Solar Heating Systems	J. C. Ward		1976	Sharing the Sun, Vol. 4, 1976, pp. 336-348	•	•	•	•						•		•			•	•	•		
Designing and Building a Solar House. Your Place in the Sun	D. Watson	9	1977	Garden Way Publishing Charlotte, VT 05445	•	•	•	•						•	•				•		•		
Optimal Sizing of Solar Collectors by the Method of Relative Areas	C. D. Barley C. B. Winn	95	1978	Solar Environmental Engr. Co., Inc.	•	•	•	•						•		•				•	•		
SEEC I—Heat Load, Monthly Solar Fraction, Economics (*F-CHART*)	C. B. Winn	125	1976	Solar Environmental Engineering Co., Inc *2524 East Vine Drive* Fort Collins, CO 80524 (303) 221-5166	•	•	•	•									•	•	•		•		
SEEC II—Collector Optimization, Annual Solar Fraction, Economics	C. B. Winn, D. Barley, G. Johnson J. Leflar	95	1978	Solar Environmental Engineering Co., Inc	•	•	•	•									•		•	•	•		
SEEC III-SEEC II Plus Insulation *Optimization*	C. B. Winn, *D. Barley,* G. Johnson J. Leflar	125 (Calculator version)	1978	Solar Environmental Engineering Co., Inc	•	•	•	•									•		•	•	•		
SEEC IV—Collector Heat Exchanger Sizing and Analysis	C. Byron Winn J. Leflar	95	1978	Solar Environmental Engineering Co., Inc	•	•	•										•					•	
SEEC V—Duct design and Air Flow Analysis	J. Leflar	95	1978	Solar Environmental Engineering Co., Inc	•			•									•					•	
SEEC VI—Passive Solar Heating	K. Sharp	125	1978	Solar Environmental Engineering Co., Inc					•	•							•	•	•	•	•		
SEEC VII—Sun Angles and Shading	K. Sharp	75	1979	Solar Environmental Engineering Co., Inc													•					•	
SEEC VIII—Swimming Pools	P. Jacobs K. Sharp	125	1980	Solar Environmental Engineering Co., Inc			•										•		•	•	•	•	
Sunshine Power Programs for Modeling Solar Energy Components and Systems: Solar Energy Library (9 programs)	G. Shramek		1977	Sunshine Power Co 1018 Lancer Drive San Jose, CA 95129 (408) 446-2446	•	•	•	•									•		•				
Mazria Design Patterns (Rule-of-Thumb) in The Passive Solar Energy Book	Edward Mazria	11	1979	Rodale Press Emmaus, PA 18049					•	•	•	•	•	•					•	•			
PASCALC Los Alamos SLR	J. T. Kohler	PASCALC therm., 75 econ., 20	1979	Total Environmental Action, Inc Church Hill Harrisville, NH 03450					•	•	•						•		•	•	•		
SOLARGRAF/DHW nomographs	W. Wright	10	1980	Northeast Solar Energy Center 470 Atlantic Ave. Boston, MA 02110		•	•	•						•	•				•				
SOLARGRAF/SLR nomographs	W. Wright	10	1980	Northeast Solar Energy Center					•	•				•	•				•				
SUN-PULSE II	G. Tully	100	1980	McGraw-Hill Book Company P.O. Box 400 Hightstown, NJ 08520	•	•	•	•	•	•							•		•			•	
G-CHART	SEDCLA	25 + tax	1979	Solar Energy Design Corp. of America	•	•	•	•						•		•			•		•		
P-CHART SLR nomograph	SEDCLA	20 + tax	1980	Solar Energy Design Corp of America					•	•				•	•				•	•	•		
Solar Energy Programs	S. A. Klein W. A. Beckman	40	1980	F-CHART P.O. Box 5562 Madison, WI 53705	•	•	•	•	•								•		•		•	•	
PASODEI SLR	L-P-M	300	1980	Londe-Parker-Michels, Inc Mr. Steve Andes 7438 Forsyth, Suite 202 St. Louis, MO (314) 725-5501					•	•	•						•	•	•	•			
OVERHANG shading	L-P-M	350	1980	Londe-Parker-Michels, Inc													•					•	
EXFIND hour sim. Trombe	L-P-M	300	1980	Londe-Parker-Michels, Inc						•	•						•					•	
INSULATE econ. optimized	L-P-M	300	1980	Londe-Parker-Michels, Inc													•					•	
LPMTZ two-zone passive	L-P-M	1500	1980	Londe-Parker-Michels, Inc					•	•	•						•	•					

Δ McFarland, R. D. and Jones, R. W., "Performance Estimates for Attached-Sunspace Passive Solar Heated Buildings," Proc. 1980 AS/ISES, Vol. 3.2, pp. 784-788, Phoenix, AZ, June 1980.

Program Name	Latest Version	Availability				Application							Intended Users			Computation Interval		Computer Versions Available	Economic Analysis	Sponsor
		Purchase ($)	Time Share	Special Arrangements	Comments	User Manual	Service Hot Water	Space Heating	Space Cooling	Process Heat	Active System	Passive System	Research Engineers	Architect/Engineers	Builders	Hour	Month			
BLAST*	1980	Nom.	●		Training available	●	●	●	●		●	●	●	●		●		CDC	●	USAF, USA, GSA
DEROB	1979	200				●		●	●			●	●	●		●		CDC		NSF, ERDA, DOE
DOE-2*	1980	400	●			●	●	●	●		●	●	●	●		●		CDC	●	LASL, DOE
EMPSS	1978	500		●	Consulting with ADL	●	●	●	●		●	△	●	●		●		IBM	●	EPRI
F-CHART	1978	100	●		Training available	●	●	●			●			●	●		●	CDC, IBM UNIVAC †	●	DOE
FREHEAT	1979	150			Limited documentation			●				●	●			●		CDC	●	DOE
HISPER	1978	Avail. on request			Limited documentation	△	●	●	●		●		●			●		UNIVAC PDP		NASA, MSFC
HUD-RSVP/2	1979	175	●		Based on F-CHART	●	●	●			●			●	●		●	CDC UNIVAC	●	HUD
PACE	1980	100	●		Based on F-CHART, SLR	●	●	●			●	●		●	●		●	CDC UNIVAC	●	DOE, SERI
SHASP	1978	Avail. on request				●	●	●	●		●		●			●		UNIVAC	●	DOE
SOLAR-5	1979		●		Not Distributed			●	●			●		●	●	●	●	CDC		UCLA, DOE
SOLCOST	1979	300	●			●	●	●			●	●	●	●	●		●	CDC, IBM UNIVAC	●	DOE
SOLFIN 2	1980	Nom.		●	Documentation Cost $6.	●	●	●	●	●	●	●	●	●	●	Annual		IBM, CDC	●	California Energy Commission
SOLOPT	1978	20				●	●	●			●		●				●	AMDAHL	●	Texas A&M Univ.
SOLTES	1979	175			No Cost for DOE	●	●	●	●	●	●		●			●		CDC		DOE, Sandia
SUNCAT	1979	Nom.			Limited documentation	●		●				●	●	●		●		Data General Eclipse	●	NCAT
SUNSYM®	1979		●	●	Offered as service only	●	●	●	●		●			●		●		IBM	●	Sunworks Comp. Systems
SYRSOL	1978	Nom.			Avail. but not actively marketed		●	●	●		●		●	●	●	●		IBM	●	ERDA, NSF, DOE
TRACE SOLAR*	1980		●	●	Offered as service only	●	●	●	●	●	●		●	●		●	●	IBM	●	The Trane Co.
TRNSYS	1979	200	●		Training required	●	●	●	●	●	●	●	●			●		CDC, IBM, UNIVAC †	△	DOE
TWO ZONE	1977	No Charge		●		●		●	●		●	●	●			●		CDC	●	LBL
UWENSOL	1980	200				●		●				●	●			●		CDC		State of Wash.
WATSUN II, III	1980	Contact Author				●	●	●			●		●			●		IBM	●	Nat'l Research Center of Can.

*Programs are primarily developed for large-scale, multi-zone applications

△ Being added

† ANSI 1966 Std. Fortran