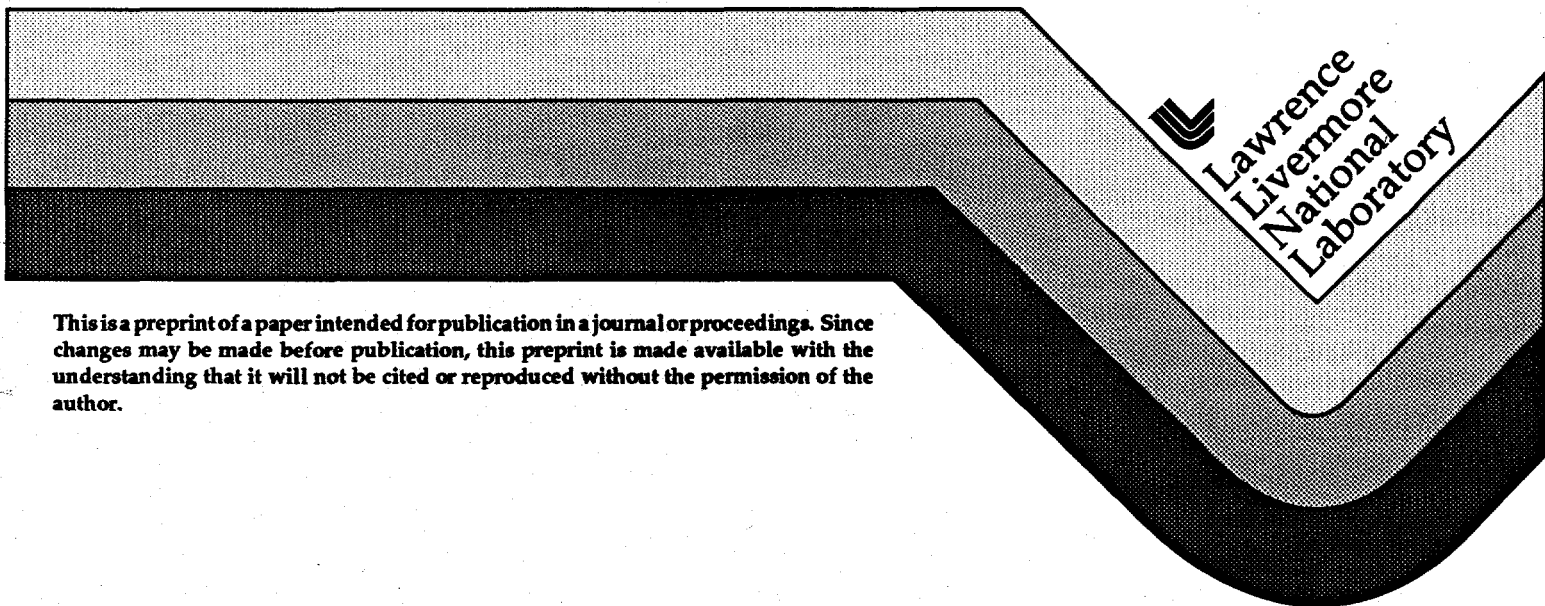


**Seismic Shock and Vibration Isolation 1995
Part II: Applications**

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**This paper was prepared for submittal to the
1995 American Society of Mechanical Engineers/
Japan's Society of Mechanical Engineers Pressure Vessel & Piping Conference,
Honolulu, Hawaii, July 23-27, 1995**

July 11, 1995



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Seismic Shock and Vibration Isolation 1995
PART II: APPLICATIONS

INTRODUCTION

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As pointed out in the introduction of Part I, the isolation strategy can be used to effectively decouple a structure from its environment and thus the structure can be protected from damaging seismic loads or unwanted vibrations and noises from the environment. The method has been used for solving vibration and shock problems in machinery and equipment for many years, but its application to the protection of structures from seismic loadings is relatively recent. Owing to the current interest generated by the Northridge and Kobe earthquakes, all but one of the papers in this publication deal with seismic isolation. The one paper on vibration isolation by Yonekura discusses a measure to protect buildings from detrimental excitations of running trains.

Seismic or base isolation has been used to protect bridges, buildings, industrial facilities, and nuclear reactors from damaging seismic loads since 1970. For each of these applications base isolation offers some unique advantages that the conventional strengthening method cannot. Some of these advantages are discussed in papers presented in this publication.

Seismic isolators for bridges are usually placed at the top of supports (columns, piers, and abutments), between the supports and the bridge decks. Although isolators reduce lateral loads on both the decks and the supports, the isolation of bridges is often for protecting the supports other than the decks. Bridge supports are normally weaker than the decks under lateral loads. Moreover, in conventional fixed-free design, only one fixed support in each span of the bridge is used to bear the entire lateral load of the span

in the longitudinal direction of the bridge. Resilient isolators like rubber bearings can be used to control the distribution of the lateral load to more than one support. Bridges were the first group of structures to which the technology was applied, perhaps because seismic isolation is only a slight extension of the existing sliding- and elastomeric-plate design for thermal expansion. The application of seismic isolation to bridges began in early 1970 in New Zealand and Italy. Robinson in Chapter 1 provides an update report on the application in New Zealand and other countries. In Chapter 6, Sulston and Sheng describe a test program for isolators and dampers used for highway bridges in California. The use of isolation in bridges will certainly continue to grow.

Base isolation appears to have become a preferred method for seismically retrofitting historical buildings where extensive modification of the interior is limited, and for essential buildings where the relocation of operations is costly. By lowering the seismic demand or load on the building, base isolation can minimize the required interior reinforcements and thus can avoid prolonged interruption of normal activities in the building. In Chapter 1, Robinson describes the retrofit of two historical buildings in New Zealand: the old Parliament Building and the Parliament Library in central Wellington. In Chapter 6, Amin and Mokha in report the retrofit of the U.S. Court of Appeals building in San Francisco. Walters, Elsesser, and Honeck describe the retrofit of the Oakland City Hall, which is currently the tallest isolated building in the world. Youssef, Nuttall, Rahman, and Hata report the engineering evaluations that have led

*This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

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to the selection of base isolation for the retrofit of the Los Angeles City Hall, which, when finished, will replace the Oakland City Hall as the tallest isolated building in the world. Sassi, Kelly, and Masri in the same chapter present a follow-up monitoring and study plan for the building. The retrofit of the Kerckhoff Hall at the University of California at Los Angeles (mentioned by Naeim and Lew in Chapter 1) is a good example of the benefit of base isolation. The building is being retrofitted while normal activities in the building continue.

Base isolation has also been proven desirable for buildings containing sensitive equipment because the method protects both the building and contents. Several papers in this publication describe this benefit through analysis or observation of the dynamic response of base isolated buildings to earthquakes. The paper by Fujita, Furuya, Fujita, Kasahara, Suizu, Morikawa, Teramoto, and Kitamura summarizes the R&D results of a high-damping rubber damper for vibration control of tall buildings. They performed a series of dynamic tests to establish the design formula that considers environmental temperature, shear deformation, and forcing frequency. Takeda, Ohkawa, Akutsu, Komura and Hirofani compares the probabilities of failures of a fusion-reactor-like facility before and after base isolation. The authors report that while base isolation in this case has not significantly reduced the probability of failure of the building, it has significantly increased the reliability of the equipment in the building. Accordingly, one can expect that an isolated facility will be more likely to remain operational after a strong earthquake than an un-isolated facility. This expectation is consistent with the assessment of the performance of the isolated USC Hospital during the 1994 Northridge earthquake by Asher, Haskere, Ewing, Van Volkinburg, Mayes, and Button. The authors conclude in their paper in Chapter 4, "The base-isolated USC Hospital rode the Northridge earthquake with no damage to structure or contents, and maintained continuous operation, while other hospitals in the same events were forced to evacuate and close down operations." Perhaps for this reason, a number of recent hospitals, computer centers, and emergency response centers have been- or are being built-

with base isolation. Naeim and Lew in Chapter 1, Lee, Hussain, and Retamal in Chapter 3, and Walters, Elsesser, and Honeck in Chapter 6 identify eight base-isolated hospitals, emergency centers, and computer centers in southern California, including the now well-known USC Hospital. The retrofit of the Rockwell International Office building in Seal Beach exemplifies the benefits of base isolation. The base isolation reduced the amount of retrofit needed for the building structure and thus allowed the continued full operation of the computer facility while the retrofit was in progress. The relocation cost would more than pay for the retrofit.

The paper by Yonekura describes a countermeasure for reducing the vibration response of a building constructed over a railway and thus subject to running trains. He used several vibration reduction schemes which include the adjusting Floating Slab (FS) beam.

Base isolation has also been found to offer special opportunities for nuclear power plants. One of the expectations for this application is the possible standardization of power plant design. Many nuclear-power-plant designers believe that standardization can help achieve greater safety and lower costs for nuclear power plants. Using base isolation to reduce the seismic demand to within the seismic capacity of a standard design, the designers hope to use the same standard design for all sites with varying seismic intensities. Investigating this possibility appears to be one of the objectives of the study by Takeda, Ohkawa, Akutsu, Komura and Hirofani in Chapter 8. Base isolation is being considered for several new reactor development projects. The other papers in Chapter 8 describe the results of these activities. Clark, Aiken, Kelly, Gluekler, and Tajirian report test results of rubber bearings designed for the Advanced Liquid Metal Reactor (ALMR) in the United States. Ishida, Yabana, and Shibata outline the technical guidelines being proposed for the design of a seismically isolated Fast Breeder Reactor (FBR) in Japan.

Base isolation has recently found a new role in the seismic protection of industrial facilities. Zayas and Low state in Chapter 7 that one of the advantages of using base isolation in tank design

is being able to use elastic design criteria and thus avoid the uncertainties of plastic design criteria. In the same paper, the authors give a state-of-the-art review of this application, although the discussion focuses on the use of the friction pendulum isolator. The authors report that the retrofit of the Dow Chemical Emergency Fire Water Tank frame with isolators cost less than one-half of the cost for strengthening the frame and replacing the foundation. The paper by Kim in the same chapter provides further details on the response analysis of isolated fluid containers, and the comparison of several isolation systems under the excitation of various earthquakes. Fujimoto, Kondo, Gunyasu, Takamatsu, Niwa, Shibata, Hara, Fujita, Kubo, Terada, and Sasaki conducted a series of seismic proving tests to evaluate functional capabilities of process computer systems with a seismic floor isolation system. The seismic isolation system was composed of a floor frame (13 m x 13 m), ball bearing units, and spring-damper units. Based on the test results, a seismic design method for interfacing the seismic isolation floor and the computer systems is proposed.

As an indication of the increasing popularity of base isolation, several countries have established codes, standards, and regulations. In Chapter 1, Kitagawa and Midorikawa describe the regulations for safety evaluation of base-isolated buildings in Japan. Naeim and Lew provide a summary of the current code requirements for isolated buildings in the U.S. Taylor, Shenton, and Chung outline proposed standards for testing isolators and isolation systems. In Chapter 8, Ishida, Yabana, and Shibata highlight the key elements of proposed technical guidelines for FBR applications. The authors emphasize the higher reliability and quality required for nuclear applications than for other applications. Clark, Aiken, Kelly, Gluekler, and Tajirian express similar view in their paper in the same chapter.

Summing up, seismic or base isolation has found its place not only in common structures like highway bridges and storage tanks but also in special facilities like historical buildings, hospitals, nuclear power plants, computer and communication centers. The wide range of applications indicates the general confidence in the technology. The satisfactory performance of

the existing isolated structures during the recent Northridge and Kobe earthquakes can only help accelerate the application of the technology. It is hoped that this publication will stimulate new ideas and increasing applications of the technology.