

Lightweight Flyash Brick

By

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Introduction

The Coal Research Bureau of West Virginia University, under contract to the Department of Energy, has developed a process for producing fired structural products from flyash and bottom slag, both of which are recyclable minerals produced in electric utility boilers.

All of these fired structural products meet or exceed American Society for Testing and Materials specifications for facing brick. A study has been completed to reduce the weight of the fired structural products by replacing the bottom slag with lightweight flyash aggregate.

This paper will discuss the results of the study.

Discussion and Results

The fired structural products chosen for this study were in the form of a standard building brick having 40 percent core area.

A typical composition for a flyash brick will consist of approximately 72 percent flyash, 25 percent bottom slag, and 3 percent sodium silicate by weight.

Three different flyashes were used in this study. The flyashes were selected as being representative of different major coal seams. The flyashes are designated as Northern West Virginia, Southern West Virginia and Western Pennsylvania.

Flyash brick are generally lighter in weight than clay brick. In order to further reduce the weight of the flyash brick the bottom slag was replaced with lightweight flyash aggregate. A level of 20 percent by weight of lightweight flyash aggregate was chosen for this

study and if the initial results warranted it, a level of 40 percent by weight of lightweight flyash aggregate was also used.

At the present time there are two producers of lightweight flyash aggregate in the United States. Each one of the two producers makes several size fractions of the lightweight flyash aggregate. Samples of lightweight flyash aggregate in two (2) size fractions were obtained from each producer and used in this study. The lightweight flyash aggregate is designated as either producer "A" or producer "B" and the size fractions are designated as either "fine" or "coarse". The designations fine or coarse are arbitrary and may not correspond with the producers trade designations of size fractions.

The composition and physical properties of the lightweight flyash brick are presented in Tables 1 through 3. Control flyash brick were produced using compositions which had been determined previously during pilot scale operations conducted by the Coal Research Bureau. The ingredients were mixed in a mix-muller, formed in a hydraulic toggle press, dried in a humidity drier, and fired in a gas-fired shuttle kiln. Firing conditions were carefully monitored both by thermocouples and also pyrometric cones which indicate the combined effect of temperature and time, sometimes called "heat work".

All of the flyash brick were tested in accordance with American Society for Testing and Materials designation C67 and evaluated in accordance with ASTM designations C62 and C216 for grade severe weathering (SW) or moderate weathering (MW) brick.

The initial flyash to be studied in combination with lightweight flyash aggregate was a Northern West Virginia flyash. A control brick was made using bottom slag in the optimum proportion previously determined during pilot plant research by the Coal Research Bureau. The control brick with the Northern West Virginia flyash had a bulk density of 119.6 pounds per cubic foot. Lightweight flyash aggregate was initially introduced at a 20 percent by weight level and all of the brick were within the ASTM maximum limit of 17.0 percent water absorption after the 5 hour boiling test. The lightweight flyash aggregate was increased from 20 percent by weight to 30 percent by weight and all of the brick remained within ASTM specifications. A 40 percent by weight level of lightweight flyash aggregate resulted in two (2) grade SW brick and two (2) grade MW brick. The lightest grade SW brick had a bulk density of 107.7 pounds per cubic foot for a 9.9 percent weight reduction when compared with the control brick.

The next flyash to be studied in combination with lightweight flyash aggregate was a Southern West Virginia flyash. Again, a control brick was made using bottom slag in the optimum proportion previously determined during pilot plant research by the Coal Research Bureau. The control brick with the Southern West Virginia flyash had a bulk density of 114.0 pounds per cubic foot. Lightweight flyash aggregate was introduced at a 20 percent by weight level and this resulted in two (2) grade SW brick and two (2) grade MW brick. Since both of the grade SW brick were close to the ASTM maximum limit of 17.0 percent water ab-

sorption after the 5 hour boiling test it was decided not to increase the lightweight flyash aggregate above the 20 percent by weight level. The lightest grade SW brick had a bulk density of 104.9 pounds per cubic foot for a 8.0 percent weight reduction when compared with the control brick.

In a similar manner a Western Pennsylvania flyash was studied in combination with lightweight flyash aggregate. The bulk density of the control brick was 123.3 pounds per cubic foot as compared with a bulk density of 105.7 pounds per cubic foot for the lightest grade SW brick. This amounts to a 14.3 percent weight reduction.

Several trends can be seen in the data presented in the tables. The coarse lightweight flyash aggregate produces a lighter brick than the fine lightweight flyash aggregate. Also, the lightweight flyash aggregate from supplier "B" produces a lighter brick than the lightweight flyash aggregate from supplier "A".

From previous research performed at the Coal Research Bureau an average bulk density of 141.7 pounds per cubic foot was determined for clay brick. The lightweight flyash aggregates when used with three (3) different flyashes have resulted in lightweight flyash brick having bulk densities of 107.7, 104.9 and 105.7 pounds per cubic foot for an average bulk density of 106.1 pounds per cubic foot. This amounts to a 25.1 percent weight reduction when compared with clay brick.

Some of the numerous advantages of the lightweight flyash brick are reduced shrinkage in firing, a reduction in fuel consumption when firing the brick, and shipping costs are reduced. At the same time the insulating qualities of brick will be improved.

Conclusion

The use of lightweight flyash aggregate in flyash brick results in a brick having a significantly reduced bulk density. The resulting lightweight flyash brick possesses many desirable qualities, perhaps the most important of which is the improved thermal insulating characteristics.

References

**Final Report, Office of Coal Research, Research and Development Report
No. 69, Contract No. 14-01-0001-488.**

TABLE 1

COMPOSITION AND PROPERTIES OF LIGHTWEIGHT FLYASH BRICK
WITH NORTHERN WEST VIRGINIA FLYASH

	1	2	3	4	5
Northern West Virginia Flyash	69.62	77.00	77.00	77.00	77.00
Bottom Slag -20 Mesh	27.38	-	-	-	-
Lightweight Flyash Aggregate, Producer A, Fine	-	20.00	-	-	-
Lightweight Flyash Aggregate, Producer A, Coarse	-	-	20.00	-	-
Lightweight Flyash Aggregate, Producer B, Fine	-	-	-	20.00	-
Lightweight Flyash Aggregate, Producer B, Coarse	-	-	-	-	20.00
Silicate	3.0	3.0	3.0	3.0	3.0
Silicate Grade	47	47	47	47	47
Water	7.0	7.0	7.0	7.0	7.0
Firing Rate, °F./Hr.	119	119	119	119	119
Final Firing Temp., °F.	2190	2190	2190	2190	2190
Cone	6	6	6	6	6
% Abs. 24 Hr. Soak	7.93	9.08	9.02	8.54	10.62
% Abs. 5 Hr. Boil	11.77	14.16	14.13	13.72	16.33
Saturation Coefficient	0.67	0.64	0.63	0.62	0.65
Apparent Porosity, %	22.54	25.70	25.47	24.96	28.31
Bulk Density, Lbs./Cu. Ft.	119.6	113.3	112.5	113.6	108.2
% Shrinkage	5.3	7.4	7.5	7.1	6.3
Unfired Compressive Strength, P.S.I.	1092	778	772	768	882
Fired Compressive Strength, P.S.I.	7341	7881	7794	7732	5448
Suction, Gms. H ₂ O/30 Sq. In./Min.	87	91	86	81	105
A.S.T.M. Grade	SW	SW	SW	SW	SW

TABLE 1 (Continued)

COMPOSITION AND PROPERTIES OF LIGHTWEIGHT FLYASH BRICK
WITH NORTHERN WEST VIRGINIA FLYASH

	6	7	8	9	10
Northern West Virginia Flyash	67.00	67.00	67.00	67.00	57.00
Bottom Slag -20 Mesh	-	-	-	-	-
Lightweight Flyash Aggregate, Producer A, Fine	30.00	-	-	-	40.00
Lightweight Flyash Aggregate, Producer A, Coarse	-	30.00	-	-	-
Lightweight Flyash Aggregate, Producer B, Fine	-	-	30.00	-	-
Lightweight Flyash Aggregate, Producer B, Coarse	-	-	-	30.00	-
Silicate	3.0	3.0	3.0	3.0	3.0
Silicate Grade	47	47	47	47	47
Water	7.0	7.0	7.0	7.0	7.0
Firing Rate, °F./Hr.	119	119	119	119	119
Final Firing Temp., °F.	2190	2190	2190	2190	2190
Cone	6	6	6	6	6
% Abs. 24 Hr. Soak	8.68	10.43	9.35	10.30	10.13
% Abs. 5 Hr. Boil	13.47	15.80	14.82	15.94	14.73
Saturation Coefficient	0.64	0.65	0.63	0.64	0.69
Apparent Porosity, %	24.45	27.53	26.30	27.55	26.03
Bulk Density, Lbs./Cu. Ft.	113.2	108.7	110.7	107.8	110.3
% Shrinkage	7.1	7.2	6.3	5.1	6.3
Unfired Compressive Strength, P.S.I.	677	741	668	943	854
Fired Compressive Strength, P.S.I.	7618	6853	7637	3788	5910
Suction, Gms. H ₂ O/30 Sq. In./Min.	89	114	99	98	100
A.S.T.M. Grade	SW	SW	SW	SW	SW

TABLE 1 (Continued)

COMPOSITION AND PROPERTIES OF LIGHTWEIGHT FLYASH BRICK
WITH NORTHERN WEST VIRGINIA FLYASH

	11	12	13
Northern West Virginia Flyash	57.00	57.00	57.00
Bottom Slag -20 Mesh	-	-	-
Lightweight Flyash Aggregate, Producer A, Fine	-	-	-
Lightweight Flyash Aggregate, Producer A, Coarse	40.00	-	-
Lightweight Flyash Aggregate, Producer B, Fine	-	40.00	-
Lightweight Flyash Aggregate, Producer B, Coarse	-	-	40.00
Silicate	3.0	3.0	3.0
Silicate Grade	47	47	47
Water	7.0	7.0	7.0
Firing Rate, °F./Hr.	119	119	119
Final Firing Temp., °F.	2190	2190	2190
Cone	6	6	6
% Abs. 24 Hr. Soak	10.92	11.65	12.96
% Abs. 5 Hr. Boil	16.11	17.21	19.00
Saturation Coefficient	0.67	0.68	0.68
Apparent Porosity, %	27.81	29.28	31.08
Bulk Density, Lbs./Cu. Ft.	107.7	106.1	102.0
% Shrinkage	6.2	5.3	3.3
Unfired Compressive Strength, P.S.I.	1030	774	1105
Fired Compressive Strength, P.S.I.	4358	4896	2234
Suction, Gms. H ₂ O/30 Sq. In./Min.	109	124	138
A.S.T.M. Grade	SW	MW	MW

TABLE 2

COMPOSITION AND PROPERTIES OF LIGHTWEIGHT FLYASH BRICK
WITH SOUTHERN WEST VIRGINIA FLYASH

	1	2	3	4	5
Southern West Virginia Flyash	76.66	77.90	77.90	77.90	77.90
Bottom Slag -20 Mesh	21.24	-	-	-	-
Lightweight Flyash Aggregate, Producer A, Fine	-	20.00	-	-	-
Lightweight Flyash Aggregate, Producer A, Coarse	-	-	20.00	-	-
Lightweight Flyash Aggregate, Producer B, Fine	-	-	-	20.00	-
Lightweight Flyash Aggregate, Producer B, Coarse	-	-	-	-	20.00
Silicate	2.1	2.1	2.1	2.1	2.1
Silicate Grade	47	47	47	47	47
Water	6.0	6.0	6.0	6.0	6.0
Firing Rate, °F./Hr.	119	119	119	119	119
Final Firing Temp., °F.	2100	2100	2100	2100	2100
Cone	3	3	3	3	3
% Abs. 24 Hr. Soak	9.80	11.47	11.78	12.26	11.79
% Abs. 5 Hr. Boil	13.41	16.18	16.78	17.36	17.28
Saturation Coefficient	0.73	0.70	0.70	0.70	0.68
Apparent Porosity, %	24.50	27.59	28.22	29.13	28.85
Bulk Density, Lbs./Cu. Ft.	114.0	106.4	104.9	104.7	104.2
% Shrinkage	3.6	4.1	3.9	3.7	3.5
Unfired Compressive Strength, P.S.I.	321	292	355	291	393
Fired Compressive Strength, P.S.I.	7168	6598	7376	6658	5192
Suction, Gms. H ₂ O/30 Sq. In./Min.	93	106	111	116	106
A.S.T.M. Grade	SW	SW	SW	MW	MW

TABLE 3

COMPOSITION AND PROPERTIES OF LIGHTWEIGHT FLYASH BRICK
WITH WESTERN PENNSYLVANIA FLYASH

	1	2	3	4	5
Western Pennsylvania Flyash	72.00	77.00	77.00	77.00	77.00
Bottom Slag -20 Mesh	25.00	-	-	-	-
Lightweight Flyash Aggregate, Producer A, Fine	-	20.00	-	-	-
Lightweight Flyash Aggregate, Producer A, Coarse	-	-	20.00	-	-
Lightweight Flyash Aggregate, Producer B, Fine	-	-	-	20.00	-
Lightweight Flyash Aggregate, Producer B, Coarse	-	-	-	-	20.00
Silicate	3.0	3.0	3.0	3.0	3.0
Silicate Grade	47	47	47	47	47
Water	7.0	7.0	7.0	7.0	7.0
Sodium Hydroxide	1.0	1.0	1.0	1.0	1.0
Firing Rate, °F./Hr.	119	119	119	119	119
Final Firing Temp., °F	2150	2150	2150	2150	2150
Cone	5	5	5	5	5
% Abs. 24 Hr. Soak	5.63	5.07	4.79	7.59	7.65
% Abs. 5 Hr. Boil	9.75	9.75	9.79	13.00	12.84
Saturation Coefficient	0.57	0.52	0.48	0.58	0.59
Apparent Porosity, %	19.28	18.95	19.00	23.95	23.64
Bulk Density, Lbs./Cu. Ft.	123.3	121.3	121.1	114.9	114.9
% Shrinkage	10.6	13.4	13.4	11.7	11.6
Unfired Compressive Strength, P.S.I.	926	1189	1065	1035	1139
Fired Compressive Strength, P.S.I.	5991	8911	6540	8683	7296
Suction, Gms, H ₂ O/30 Sq. In./Min.	51	36	35	69	64
A.S.T.M. Grade	SW	SW	SW	SW	SW

TABLE 3 (Continued)

COMPOSITION AND PROPERTIES OF LIGHTWEIGHT FLYASH BRICK
WITH WESTERN PENNSYLVANIA FLYASH

	6	7	8	9
Western Pennsylvania Flyash	57.00	57.00	57.00	57.00
Bottom Slag -20 Mesh	-	-	-	-
Lightweight Flyash Aggregate, Producer A, Fine	40.00	-	-	-
Lightweight Flyash Aggregate, Producer A, Coarse	-	40.00	-	-
Lightweight Flyash Aggregate, Producer B, Fine	-	-	40.00	-
Lightweight Flyash Aggregate, Producer B, Coarse	-	-	-	40.00
Silicate	3.0	3.0	3.0	3.0
Silicate Grade	47	47	47	47
Water	7.0	7.0	7.0	7.0
Sodium Hydroxide	1.0	1.0	1.0	1.0
Firing Rate, °F./Hr.	119	119	119	119
Final Firing Temp., °F	2150	2150	2150	2150
Cone	5	5	5	5
% Abs. 24 Hr. Soak	6.83	6.86	9.85	10.41
% Abs. 5 Hr. Boil	11.87	12.21	15.66	16.84
Saturation Coefficient	0.57	0.56	0.63	0.62
Apparent Porosity, %	22.10	22.55	27.36	28.54
Bulk Density, Lbs./Cu. Ft.	116.1	115.2	109.0	105.7
% Shrinkage	10.4	10.5	8.3	7.3
Unfired Compressive Strength, P.S.I.	697	652	905	1119
Fired Compressive Strength, P.S.I.	8255	6903	7066	4438
Suction, Gms, H ₂ O/30 Sq. In./Min.	55	58	100	102
A.S.T.M. Grade	SW	SW	SW	SW