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BORAL RESOURCES

Fly Ash FOR BLOCK MANUFACTURING

Fly Ash improves block manufacturing in two basic ways. It gives producers the strength required and, at the same time, the added plasticity that fly ash contributes (reported by Belot, 1976) to the relatively harsh block mixes assures improved finish and texture, better mold life, and better, sharper corners. Additional benefits of fly ash in block include reduced permeability and shrinkage, increased durability and virtual elimination of efflorescence.

The manufacturing of concrete masonry units uses a dry, harsh concrete mixture compacted into molds with great mechanical energy. When unmolded, these units maintain their shape during handling and transportation into a curing environment. Curing methods consist of either the high-pressure, high-temperature autoclave; or the atmospheric-pressure, high-temperature kiln. The use of high-quality fly ash has become accepted practice in the industry.

Fly Ash Chemical Activity

Fly ash is produced by burning powdered coal to generate electricity. Fly ash is a chemically active, finely divided mineral product high in silica, alumina and iron. Fly ash that has been burned in the process of manufacturing (in the same sense that portland cement clinker is “burned”) seeks lime. One hundred pounds of portland cement usually liberates from 12 to 20 pounds or more of free lime (calcium hydroxide) during hydration. Fly ash then chemically reacts with this free lime to form additional stable cementitious compounds. The formation of insoluble cementing compounds is accelerated and can be secured in a matter of hours in the steam curing cycle of the concrete products plant (autoclave or atmospheric).

Steam Curing

Autoclave curing, though not as common as in the past, is still used to manufacture high quality masonry units. Concrete masonry units cured in high-pressure autoclaves show early strength equivalent to that of 28-day moist-cured strength and reduction in volume change in drying (Hope 1981). The process uses temperatures of 275° to 375°F (135° to 191°C) and pressures of 75 to 170 psi (0.52 to 1.17 MPa). These conditions allow for the use of fly ash as a cement replacement up to 35% for Class C and 30% for Class F fly ashes. Particular care should be taken to insure that the fly ash meets the soundness requirement

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of ASTM C618, indicated in Note C, Table 2 especially where the fly ash will constitute more than 20% of the total cementitious material.

Low-pressure steam curing is usually performed in insulated kilns at elevated temperatures, the exact temperature used being a function of the materials and operation of the specific plant. This process allows for the use of fly ash as a cement replacement up to 35% for Class C and 25% for Class F fly ash. Tests with 25% Class F fly ash were successful with a curing temperature above 160°F (71°C) and indicate that drying shrinkage of low pressure steam-cured concrete units can be reduced by the addition of fly ash.

Accelerated curing techniques allow for a period of preset before the concrete products are subjected to elevated temperatures. The preset period may lengthen slightly where cement is replaced with fly ash and if so, it must be allowed for.

Tests for resistance to freezing and thawing of concrete masonry units containing fly ash indicate that such units, in general, could be expected to perform well in vertical wall construction. For the more severe condition of horizontal exposure, a minimum compressive strength of 3,000 psi (21 MPa) based upon the net area of the unit is recommended when normal weight aggregates are used. This is true whether fly ash is used or not.

Air-entrainment is not practical at the extremely low or zero slumps used for concrete block. It could be applicable to slump block or quarry tile. To provide adequate freezing and thawing durability for units made with slump concrete, air-entrainment is needed (Redmond 1969).

Acceptance by the engineering profession and most code bodies to use concrete masonry units for high-strength, high-rise, load-bearing construction is increasing. To meet this demand, block producers find it necessary to produce both light and normal weight units testing 3,500 psi net area (1,860 gross area assuming 53% solid units) and 5,000 psi net area (2,650 gross area), respectively. The 1,860 psi gross area strength units are known as high strength block and those of 2,650 psi gross area strength are known as extra high strength block.

Trial Mixes

Proportioning mixtures for the manufacture of concrete masonry units is not an exact science. Conditions may vary widely from plant to plant. When proportioning mixtures, concrete producers should check the grading and types of aggregates, cements, equipment, and kiln temperatures, and then adjust trial batches with various amounts of fly ash to achieve specific technical or economic objectives (Valore 1970). For assistance in this regard, the reader is referred to “Siliceous Fines in the Cementing Medium of Steam Cured Concrete Masonry Units”, a 1967 publication by the National Concrete Masonry Association.

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Suggested Reading:

- "Concrete Block, Ready-Mix Concrete and Concrete Pipe", Concrete Industries Yearbook, 1974-75.
- "How Fly Ash Improves Concrete Block, Ready-Mix Concrete, Concrete Pipe", Concrete Industries Yearbook 1976-77.
- Grant, William, "Manufacture of Concrete Masonry Units", Concrete Publishing Corporation, Chicago, 1959.
- American Concrete Institute Committee 517, "Low Pressure Steam Curing of Concrete", Journal of the American Concrete Institute, Aug. 1969.
- "Recommended Practice for Atmospheric Pressure Steam Curing of Concrete", Journal of the American Concrete Institute, Aug. 1965.
- American Concrete Institute Committee 516, "High Pressure Steam Curing: Modern Practice and Properties of Autoclaved Products", Journal of the American Concrete Institute, Aug. 1965.
- Belot, J.R., Jr., "Fly Ash in Concrete and Concrete Block Manufacturing", Proceedings, 1st Fly Ash Utilization Symposium (Pittsburgh, Mar.) Information Circular No. 8348, Bureau of Mines, Washington D.C., 1967.
- Hope, Brian B., "Autoclaved Concrete Containing Fly Ash", Cement and Concrete Research, Vol. 11, No. 2, pp. 227-233, Mar. 1981.
- Redmond, T. B., Jr., "Freezing and Thawing Tests of Concrete Masonry Units with Cement and Cement-Fly Ash as Cementitious Materials", National Concrete Masonry Association, Herndon, Oct. 1969.
- Valore, R. C., Jr., "Laboratory Evaluation of Fly Ash and Other Pozzolans for Use in Concrete Products", Proceedings, 2nd Ash Utilization Symposium (Pittsburgh, Mar.), Information Circular No. 8488, U.S. Bureau of Mines, Washington, D.C., 1970.