Technical Bulletin 10

Fly Ash for Structural Concrete

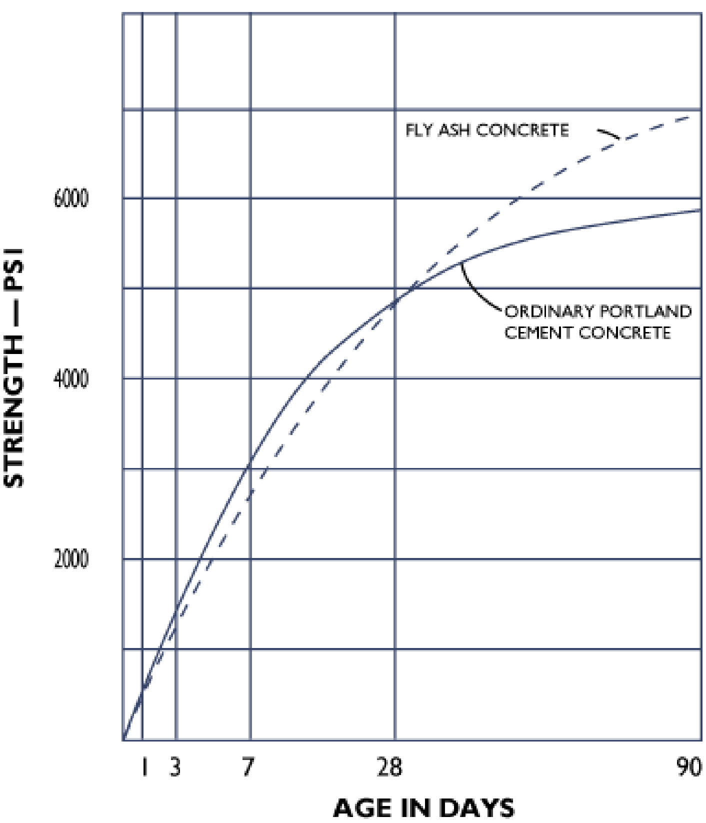
COMPRESSIVE STRENGTH. Specifications for normal strength concrete generally require a given level of strength in 28 days. Fly ash concrete is easily proportioned to meet strength requirements at this age or any other age desired.

A major use for fly ash in the construction industry is in the production of high quality structural concrete. Fly ash contributes beneficial properties to the concrete while helping to maintain economy. These properties include compressive strength, lubrication and increased durability.

Fly ash concrete designed to be equivalent in strength to ordinary concrete at 28 days will normally exhibit slightly lower strength at early ages. This slight early age strength reduction does not adversely affect job sequencing due to construction loading. (See strength gain curves in Fig. 1).

Fly ash concrete can be easily proportioned to meet strength specifications at early ages (3 to 7 days). Economics, although still attractive, will not be as great as when proportioning for 28 days of age or later. Fly ash has been utilized in many early strength projects because of many beneficial features other than economy.

Later age strength gain after 28 days can prove to be valuable. It may be used to obtain required strengths at lower cost. It may be relied upon in deciding structural acceptability where compressive strength tests indicate lower than specified strengths. It also plays a key role in producing high strength concrete.



Typical age-strength relationships (mixes designed for equal 28 day strengths)

High compressive strengths from 6,000 psi to 14,000 psi are often required in structural concrete. High quality fly ash complying with ASTM C-618 is most advantageous in achieving these strength levels. The strength gain derived from 10 to 25% fly ash (by weight of cementitious materials) cannot be equaled by adding cement.[1] It has also been found to produce the same high strength levels in concrete as silica fume without the high cost.

Lubrication. Fly ash spheres impart a ball bearing lubrication to plastic concrete, enhancing workability at the same slump as ordinary concrete while reducing water convenience. Enhanced workability contributes increased quality to structural concrete in several ways:

1. Concrete pumping is made easier. Flow rate may be increased without increasing line pressure, and line blockages are reduced. Record pumping time is achieved as a result of the use of fly ash. The technique of injecting concrete into the bottom of the form from the pump hose is made possible by the workability of the fly ash mix.
2. Form filling becomes easier. Fly ash concrete is more responsive to vibration, enabling forms to be fully filled more quickly and with less effort.
3. Segregation, voids, rock pockets and other defects are reduced because of increased cohesiveness and workability. (Cost savings from reduced corrective action required on defects alone can be significant.)

Increased Durability. The pozzolanic activity which contributes cementitious value to concrete also yields increased density and reduced permeability. As a result, penetration of aggressive media is slowed or eliminated, thereby increasing concrete durability.
Fly ash is especially effective in the effort to restrict chloride ion penetration and the accompanying disintegration it causes. Concrete for parking structures, highway structures or any other structures likely to be subject to chlorides should require fly ash.
Pozzolanic activity also chemically binds with cement alkalis, keeping them from combining with reactive aggregates, and also acts to reduce internal expansion.

Reduced cement content in fly ash concrete lowers the heat of hydration, which is especially beneficial in mass concrete applications. Reduced temperature gain results in reduced thermal shrinkage and less possibility of thermal cracking.

For more information or answers to questions about the use of fly ash in specific applications, contact your nearest Headwaters Resources Technical Sales Representative or call 1-888-236-6236.

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Fly Ash for Structural Concrete

Concrete structures subject to high wind loading are often designed for stiffness. Concrete for use in these structures contains fly ash to help develop the high modulus of elasticity required. Evaluations performed on concretes of normal strength levels shows that fly ash concrete has a higher modulus of elasticity than plain concrete at the same strength level.

Internal pressures generated during freeze/thaw cycles can rapidly destroy structural concrete. Fly ash concrete mixes exhibit lower permeability, greater density, and higher strength, enabling them to better resist freeze/thaw cycles. Concrete mixes containing fly ash perform as well as or better than ordinary mixes provided that comparable strength and air-entrainment factors are maintained in both mixes.[2]

Mix Selection. As with plant concrete mixes, sound laboratory methods or good field history of performance should be used to select fly ash concrete with the proper proportions for the needs of the project.

It is recommended that optimum fly ash curves be developed through testing local materials if the maximum benefits of fly ash in structural concrete are to be achieved.

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[1] Buck, Ronald L., Petersen, C. F. and Winter, M. E., "Proportioning and Controlling High Strength Concrete", Proportioning Concrete Mixes, SP-46, American Concrete Institute, Detroit, pp. 142, 145 (1964).

[2] Meilenz, Richard C., "Specifications and Methods of Using Fly Ash in Portland Cement Concrete", Ash Utilization, United States Department of the Interior, IC 8640, pp. 63-64 (1973).