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## WHAT ARE TERNARY CONCRETE MIXTURES?

Ternary concrete mixtures include three different cementitious materials. This report addresses those combinations of portland cement, slag cement, and a third cementitious material. The third component is often fly ash, but silica fume is not uncommon. ASTM C595 blended cement used in combination with a third cementitious material also is considered a ternary mixture. Other materials in combination with portland and slag cement, such as metakaolin or rice husk ash, are not currently in common usage and will not be discussed here.

Slag cement has been used in ternary mixtures for decades. For example, the Empire State Building was constructed using combinations of slag cement, portland and lime in the masonry. Ternary mixtures using slag cement, fly ash and portland have stabilized soils and hazardous wastes.

## WHAT ARE THE BENEFITS OF A TERNARY MIXTURE?

Ternary mixtures can be designed for:

- High strength
- Low permeability
- Corrosion resistance
- Sulfate resistance
- ASR resistance
- Elimination of thermal cracking

Compressive strengths exceeding 10,000 psi were achieved in 1989 in the construction of Scotia Plaza in Toronto. More recently, compressive strengths over 13,000 psi were attained in Reliant Stadium.



*Reliant Stadium (NFL) in Houston, which opened in 2002, used a portland-slag cement-fly ash mixture to achieve both high strength and low heat in its four massive "super columns," supporting the retractable roof.*

Cementitious Component	Scotia Plaza		Reliant Stadium	
	Lb / cu yd	% of Total Cementitious	Lb / cu yd	% of Total Cementitious
<b>Portland</b>	530	65%	450	50%
<b>Slag Cement</b>	228	28%	270	30%
<b>Silica Fume</b>	60	7%	0	0%
<b>Fly Ash</b>	0	0%	180	20%

## WHERE CAN TERNARY BLENDS BE USED?

Ternary mixtures can be used—and have been used—in virtually any concrete application.

- General construction (residential, commercial, industrial)
- Paving
- High performance concrete
- Precast concrete
- Masonry and masonry units
- Mass concrete
- Shotcrete

## TERNARY CONCRETE MIXTURES WITH SLAG CEMENT

### CAN TERNARY BLENDS BE USED IN EXTERIOR CONCRETE EXPOSED TO FREEZING AND THAWING?

Ternary blends have been used in concrete exposed to freezing and thawing and de-icing chemicals. Proper air entrainment, adequate curing, and good concrete practices will maximize the ability of any concrete to resist freezing and thawing and de-icing chemicals. A number of mixture proportions have been used with good results. Some paving projects have performed for over five years in severe conditions with no apparent loss of durability.



*In 1998, airfield pavements were constructed at the Minneapolis Airport using a portland blast-furnace slag blended cement consisting of 35% slag cement, with an addition of 10% Class C fly ash. Performance of the concrete has been excellent.*



*Structural concrete in the Key Tower (formerly Society Tower) in Cleveland achieved over 13,000 psi using a portland-slag cement-silica fume ternary mixture.*

### WHAT MIXTURE PROPORTION SHOULD BE USED?

The optimum mixture proportions for ternary blends, as with other concrete, will be dependent on the final use of the concrete, construction requirements and seasonal considerations. As with other concrete, cold weather will affect the early strength gain and mixture proportions may need to be adjusted to assure job-site performance.

In low W/CM applications such as paving, mixtures with 15 percent fly ash and 30 percent slag cement component have been used successfully. Key Tower in Cleveland, completed in 1990, used 65 percent portland, 27 percent slag cement and 7 percent silica fume to achieve strengths exceeding 14,000 psi.

*As with all concrete mixtures, trial batches should be performed to verify concrete properties. Results may vary due to a variety of circumstances, including temperature and mixture components, among other things. You should consult your slag cement professional for assistance. Nothing contained herein shall be considered or construed as a warranty or guarantee, either expressed or implied, including any warranty of fitness for a particular purpose.*

*Ternary blends have been used in general construction, high performance concrete, paving, precast, mass concrete, masonry and masonry units, and shotcrete.*



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### About the Slag Cement Association...

The Slag Cement Association is the leading source of knowledge on blast-furnace slag-based cementitious products. We promote the increased use and acceptance of these products by coordinating the resources of member companies. We educate customers, specifiers and other end-users on the varied attributes, benefits and uses of these products.

