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SUPPLEMENTARY CEMENTITIOUS MATERIALS

Modern concrete often includes the use of supplementary cementitious materials (SCM). These materials are often co-products of other processes or natural materials. Some require further processing before they are suitable for concrete. Some of these materials have cementitious properties when used alone; others, called pozzolans, do not.

COMPOSITION AND CONSISTENCY

Slag cement and fly ash are the two most common SCMs used in concrete. Most concrete produced today includes one or both of these materials. For this reason their properties are frequently compared to each other by mix designers seeking to optimize concrete mixtures.

While chemical similarities exist, these materials have different effects on concrete. These differences are based in part on the proportion of oxides in each material (Table 1).

The ternary diagram, shown in Figure 1 shows that slag cement is more closely related to portland cement than fly ash. This is one reason why slag cement can be used in much larger amounts. Both are used as a replacement for a portion of the portland cement. Slag cement replaces as much as 50 percent in normal concrete (and up to 80 percent in special applications such as mass concrete). Fly ash is usually limited to 20 or 30 percent.

Slag cement is the co-product of a controlled process, iron production, which results in a very uniform composition from source to source. Fly ash is a byproduct of electric power generation that varies from source to source.

Table 1: Typical Chemical Oxides for Various Cementitious Materials

	Portland Cement	Slag Cement	Fly Ash C	Fly Ash F
CaO	65	45	25	3
SiO ₂	20	33	37	58
Al ₂ O ₃	4	10	16	20
Fe ₂ O ₃	3	1	7	10
MgO	3	6	7	1

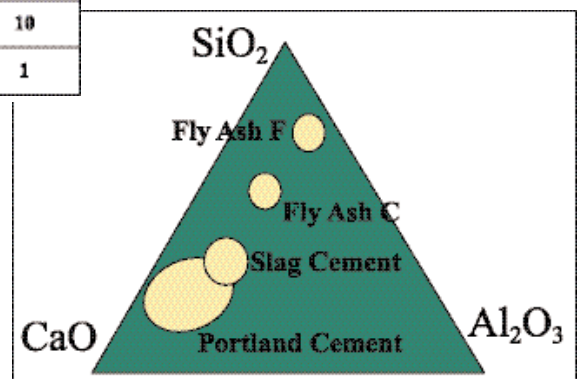


Figure 1: Ternary diagram of cementitious materials

SLAG CEMENT AND FLY ASH

Concrete Properties

Slag cement is a more uniform product than fly ash. As a result, concrete made with slag cement will generally have more uniform properties than concrete made with fly ash.

Plastic Properties

Water Reduction. The use of either material should result in a reduction of the required water content to reach a given consistency. This effect with slag cement is due to its influence on paste characteristics and absorption. With fly ash, this is primarily due to the particle shape and size distribution. This allows for small reductions in water reducing admixtures.

Air Entrainment. Air contents can vary depending on any number of factors. Carbon content variability in fly ash is one of the major causes of fluctuating air contents. Slag cement does not contain carbon and does not cause instability in the entrained air content.

Time of Set. Time of initial set is influenced by the use of slag cement and fly ash. Concrete made with slag cement can have faster set times than concrete made with fly ash (Figure 2).

Pumpability and Finishability. Pumpability with slag cement and fly ash is generally improved largely due to the addition of fines to the matrix. Finishability is also improved.

Hardened Properties

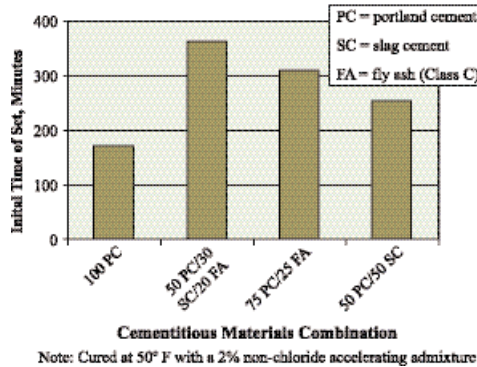
Strength. At 28 days, both slag cement and Class C fly ash will achieve higher strength than Class F fly ash and straight portland cement in concrete mixtures.

Permeability. At normally specified replacement levels, concrete made with slag cement will have lower permeability than concrete made with Class F or C fly ash when tested according to ASTM 1206 (rapid chloride permeability test).

Sulfate Attack and Alkali-Silica Reaction (ASR). Slag cement and Class F fly ash will both provide protection against sulfate attack and ASR. Class C fly ash may not provide this protection.

Color. Slag cement will provide lighter concrete with higher reflectivity than plain portland cement concrete. Class C and Class F fly ash will produce, respectively, a buff or darker gray concrete.

Figure 2: Effect of Slag Cement and Fly Ash on Initial Time of Set



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.



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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.

