SUPPLEMENTARY CEMENTITIOUS MATERIALS

Supplementary Cementitious Materials (SCM's) are added to concrete mixtures for various reasons including improving durability, decreasing permeability, aiding in pumpability and finishability, mitigating alkali reactivity and improving the overall hardened properties of concrete through hydraulic or pozzolanic activity or both. SCM's are added to concrete in addition to or as a partial replacement of Portland cement or blended cements and are usually considered as a part of the total cementing system. The use of these materials in concrete has also grown considerably over the past 30 years in that they are typically byproducts of industrial processes and their use can contribute to environmental and energy conservation practices.

THE MOST COMMON SCM'S USED IN THE READY-MIXED CONCRETE MARKET INCLUDE:

- Fly Ash
- Ground Granulated Blast Furnace Slag
- Silica Fume
- Calcium Carbonate
- Natural Pozzolans - such as calcined clays, shale, and metakaolin

FLY ASH:

Fly Ash is the most widely used SCM in concrete and is a byproduct of coal combustion in electric power generating plants. The use of fly ash in concrete can contribute to LEED points through local materials, recycled contents and innovation credits. Fly ash can compensate for fine materials that may be lacking in sand quantities and can be very beneficial in improving the flowability and finishability of concrete mixtures. The two designations for fly ash used in concrete are Class C and F and are described in ASTM C618.

Class C Ash: high calcium contents with low carbon and good pozzolanic and cementitious properties lend this material to use in higher performance mixtures where early age strength is important.

Class F Ash: low calcium ash effectively moderating heat gain during concrete curing and therefore ideal for mass placement conditions and high strength mixtures or use in hot weather climates; Also provides good sulfide and sulfate resistance to concrete through same capacity as Type V (CSA Type 50) cement.

SLAG:

Ground granulated blast furnace slag (GGBFS) is manufactured through the process of rapidly quenching molten slag produced during iron making. This granulated material is ground down to powder form and acts with hydraulic properties when combined with water. GGBFS is also sometimes referred to as slag cement. Concretes made with slag cement will usually exhibit higher compressive strengths, better durability and lower permeability compared to portland cement concrete. GGBFS for concrete must meet the specifications of ASTM C989 (CSA A23.5). Additional information on the use, benefits and applications can be found at the Slag Cement Association at www.slagcement.org

SILICA FUME:

Also referred to as microsilica, this byproduct material is used as a pozzolan and is manufactured from the reduction of high purity quartz with coal in an electric arc furnace. Silica fume can also be provided in a liquid form and is an extremely fine material. Appropriate safety precautions must be employed when using silica fume. These materials are defined within ASTM C1240 (CSA A23.5) and are typically used where a high degree of impermeability is required. The use of silica fume in concrete will create the effect of the mixture becoming "sticky" and appropriate adjustments may be required. Additional information on the use of silica fume can be found at the Silica Fume Association at www.silicafume.org.

CALCIUM CARBONATE:

Calcium Carbonate Fines (CCF's) are a limestone filler material that can help to accelerate the hydration of cement leading to earlier strengths and improving durability of concrete. This hydraulic material can also provide better packing density in concrete which can decrease permeability. Available in a powder form, CCF's are usually very light in color and can also provide aesthetic considerations for creating "white" structures.

NATURAL POZZOLANS:

The term of "pozzolan" actually refers to a volcanic ash mined in Pozzuoli, Italy over 2000 years ago. Today, natural pozzolans are classified by ASTM C618 with their use in concrete referenced in ACI 232.1. In general, these processed clay and shale materials are heat treated and ground to powder form to help control temperature effects in mass concrete, improve resistance to sulfate attack and mitigate alkali silica reaction. They are typically used as a cement replacement material in the range of 15% to 35% depending upon the project application. A particular pozzolan, metakaolin, is used in special applications where very low permeability or very high strength is required.

Table of Properties for Fly Ash, Slag and Silica Fume with Impact on Concrete Properties

	Fly Ash	Slag	Silica Fume
Specific Gravity	1.9 - 2.8	2.8 - 3.0	2.2 - 2.5
Typical addition rates as percentage of total cementitious materials	C Ash: 10% - 40% F Ash: 10% - 30%	20% - 50%	5% - 10%
Impact on setting times	C Ash: can retard or accelerate F Ash: typically retards	Typically retards but can accelerate	Generally retards
Impact on pumpability and finishability	Generally improves	Little effect	More difficult to finish, can improve pump-ability of a lean mix
Curing considerations	Similar to cement; normal curing methods	Similar to cement; normal curing methods	Reduces bleed water - requires immediate curing
Effect on strength gain	C Ash: can accelerate early F Ash: slow early, increased ultimate	Similar to normal concrete	Improved early and ultimate
Effect on impact and abrasion resistance	Some improvement - governed by compressive strength of mixture and aggregate types		
Effect on scaling resistance	Little impact - can be improved - governed by low w/c ratio and proper air entrainment system		
Effect on permeability and corrosion resistance	Improves	Improves	Greatly Improves
Effect on alkali aggregate reactivity	Improves - testing needed to veryify with local material availability		

Portions of the material included above have been provided by the PCA Design and Control of Concrete Mixtures Publication.

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