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FLYASH

The following is a summary of Bill Sioulas' (Blue Circle Southern Cement) presentation at the AbiPave Conference on 25 February 2008.

- Flyash is the incombustible residue from fine coal dust captured by electrostatic precipitators or Baghouse filters.
- It consists of about 70% of silicon oxide (SiO_2).
- For "Fine Grade" flyash, it must have at least 75% of particles smaller than 45 μm . (The average thickness of human hair is 50 μm).
- Flyash particles are spherical which greatly enhance the workability of concrete. From the electron micrographs hereunder, compare this with the angular cement particles which are crushed from clinker and generally much larger.
- Flyash is about $\frac{1}{3}$ lighter than cement. Their densities being 2.14 and 3.14 respectively.
- When used in concrete, there is a pozzolanic reaction with the hydrated lime and water. The free hydrated lime is a product from the hydration of cement.
- This pozzolanic reaction is slower and more temperature dependant than applicable to cement. The reaction continues past 28 days and provides additional strength at later ages of concrete.

Benefits

- The spherical particles significantly increase the workability of the concrete.
- The reaction uses up the free hydrated lime and blocks the pores. This makes the concrete less permeable.
- Flyash being silica rich, can inhibit the alkali silica reaction.
- Besides workability, it also increases the durability of the concrete. The latter includes AAR, sulphate and chloride resistance and permeability.
- Increased setting time results in the reduction of heat evolution and hence the risk of thermal cracking.
- There is a reduction in drying shrinkage, if the mix design reduces the sand content.

Disadvantages

- Lower early age strength gain and slow setting in cold weather. Can be partially overcome with suitable admixtures.

Properties that may not be beneficial

- The slower strength development.

- Air entrainment is more difficult to control.
- The setting time is extended as cement is replaced. (In hot weather, this results in abnormal temperature expansion of the plastic concrete – the Coefficient of Thermal Expansion of plastic concrete is about three times that of the set concrete – and the subsequent shrinkage cracking).
- More attention to curing is required.

Tips

- 1 If reducing the cement content, should keep the flyash content the same or only with a slight increase.
- 2 The flyash proportion should not be greater than $0.6 \times$ Flyash weight in cement in the concrete mix.

ELECTRON MICROGRAPH OF FLYASH PARTICLES, SHOWING TYPICAL RANGE OF PARTICLE SIZES AND SPHERICITY OF FLYASH



Photo courtesy Blue Circle Southern Cement

**ELECTRON MICROGRAPH OF TYPICAL PORTLAND CEMENT, SHOWING
THE ANGULAR NATURE OF PARTICLES PRODUCED BY MILLING OF
LARGE CLINKER MATERIAL**

