

Use of Mineral Admixtures in Concrete

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Concrete



Admixtures

- A material other than water, aggregate, cement, used as an ingredient of concrete or mortar added to the batch immediately before or during mixing.
- There are two kinds of admixtures: Chemical admixtures and Mineral admixtures.

Mineral Admixtures

- -Pozzolanic (Low-calcium FA)
 - Cementitious (Granulated iron blast-furnace slag)
 - Both pozzolanic and cementitious (High-calcium FA)
- -Natural materials (Volcanic Ash)
- -By-product Material

Pozzolans (Definition)

- Siliceous or siliceous and aluminous materials which in themselves possess little or no cementitious value but will, in finely divided form and in the presence of moisture, chemical react with Ca(OH)_2 at ordinary temperatures to form compounds possessing cementitious properties.

The Pozzolanic Reaction

- Pozzolanic Reaction

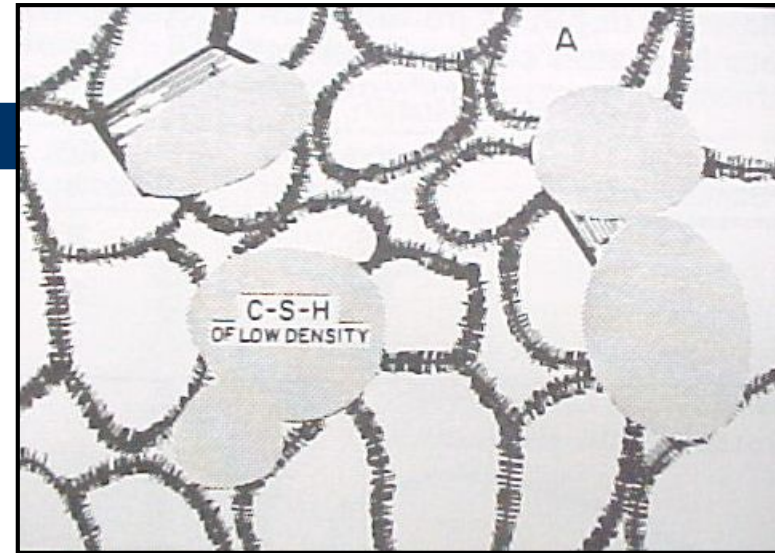
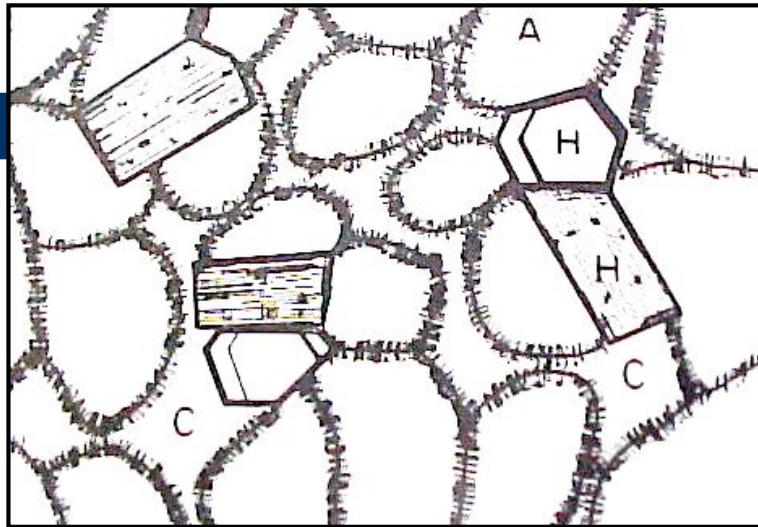


- Portland Cement Hydration



- The pozzolanic reaction is slow, so the rate of the strength development and the heat of hydration associated with this reaction are low. It may be noted that the pozzolanic reactions can be accelerated by temperature.

Diagrammatic representation of a well-hydrated portland cement paste (left) and a portland-pozzolan cement paste (right)



A represents C-S-H

H represents CH

C represents capillary cavities or voids

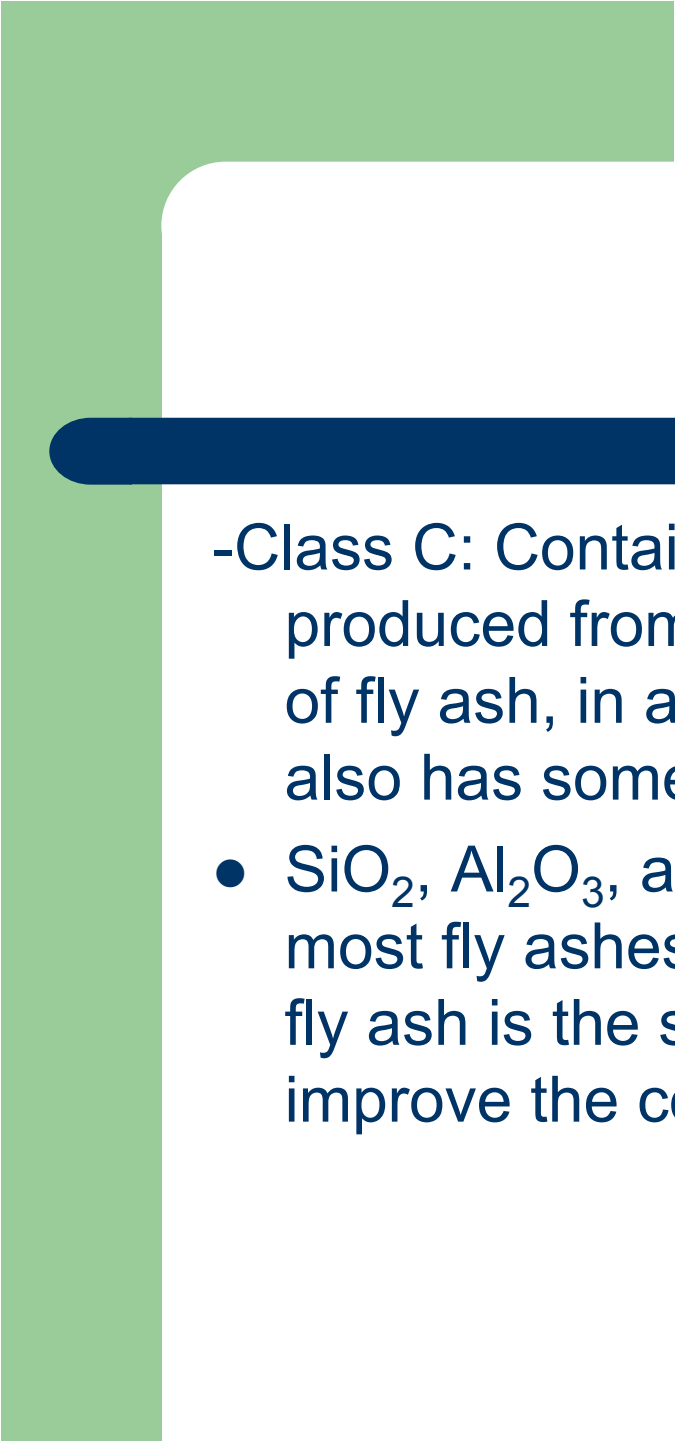

CH+S → C-S-H of low density. Pozzolanic reaction converts the less dense CH phase and larger pores into denser C-S-H and smaller pore

Fly Ash

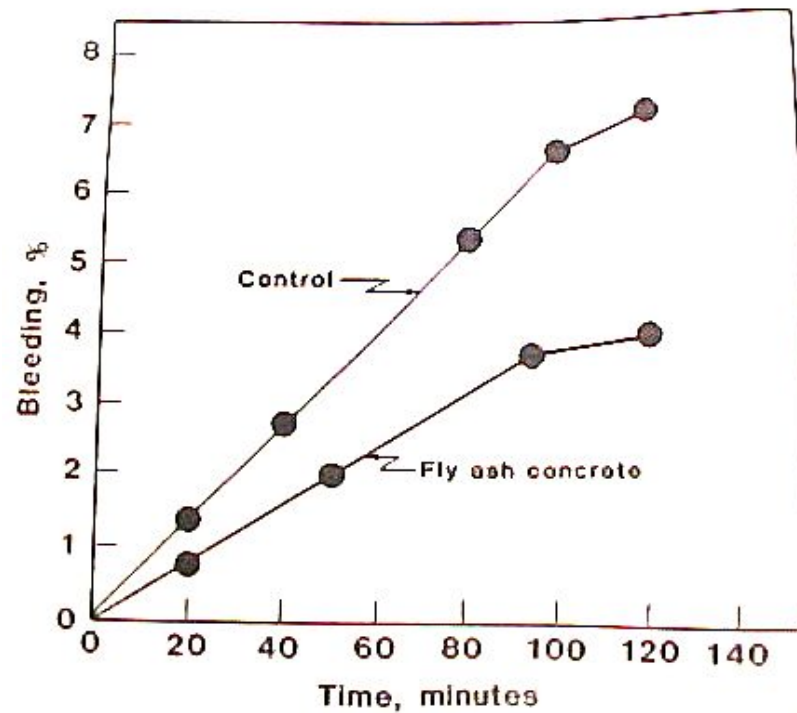
- Photo



- Fly ash is a by-product of the combustion of pulverized coal in thermal power plants. The dust-collection system removes the fly ash, as a fine particulate residue, from the combustion gases before they are discharged into the atmosphere.

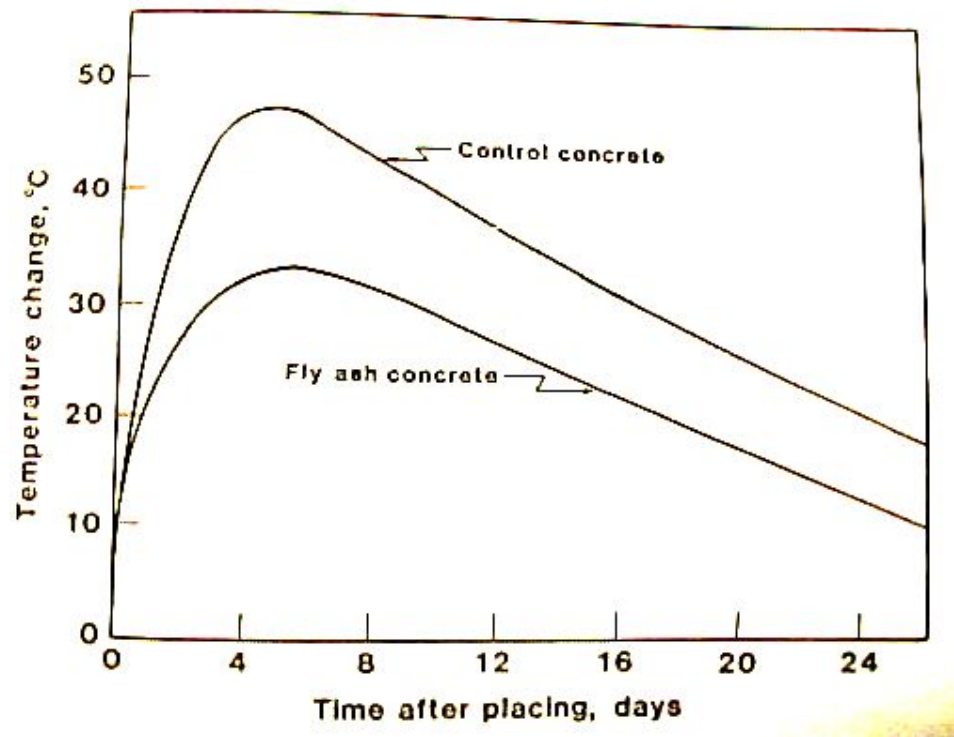
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- Class C: Containing more than 10% CaO (Normally produced from lignite or subbituminous coal. This class of fly ash, in addition to having pozzolanic properties, also has some cementitious properties.)
 - SiO₂, Al₂O₃, and CaO are the major constituents of most fly ashes. One of the important characteristics of fly ash is the spherical form of the particles, which can improve the concrete flowability.

Effect of fly ash on properties of fresh concrete



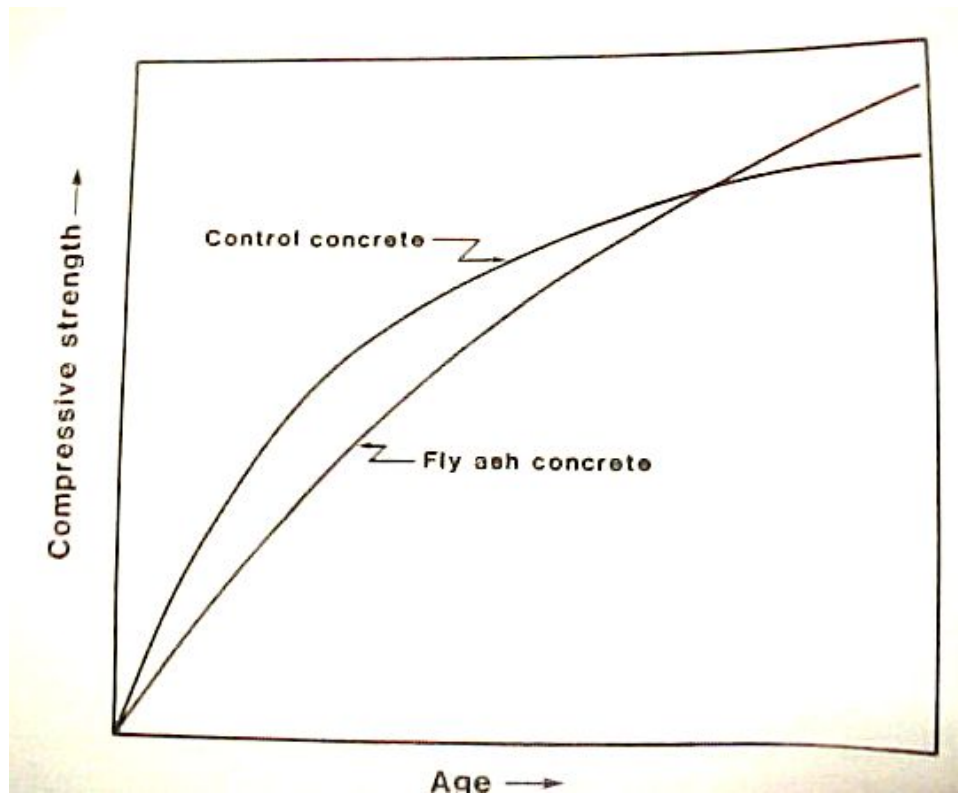
Concrete using fly ash is generally reported to show reduced segregation and bleeding and to be more satisfactory than plain concrete when placed by pumping.

Effect on Heat of Hydration



Replacement of cement by fly ash results in a reduction in the temperature rise in fresh Concrete. This is particular importance in mass concrete where cooling, following a large temperature rise, can lead to cracking.

Effect of fly ash on the structural properties of hardened concrete

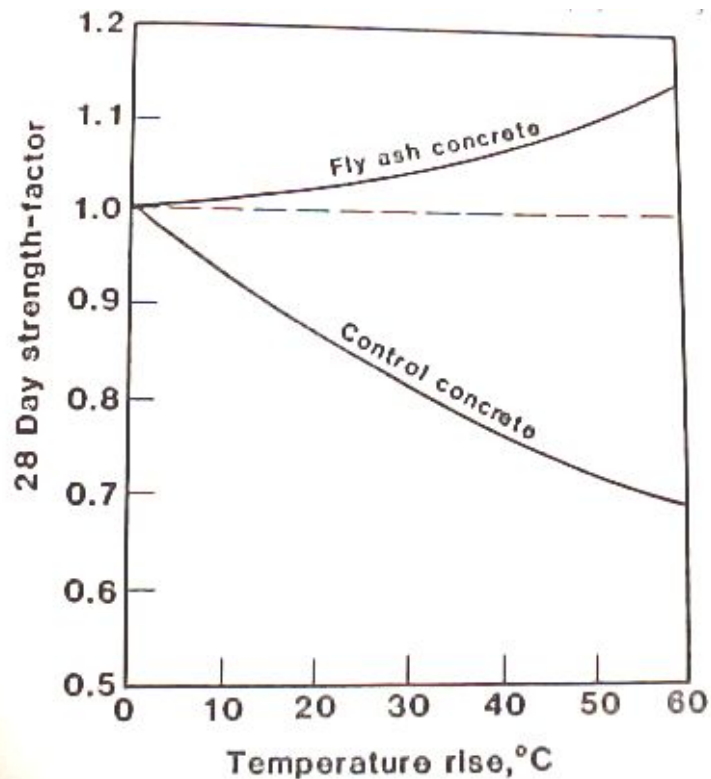


At early ages fly ash exhibits very little cementing value, at later ages cementing activity becomes apparent and a considerable Contribution to strength may results.

Important variables influence strength development:

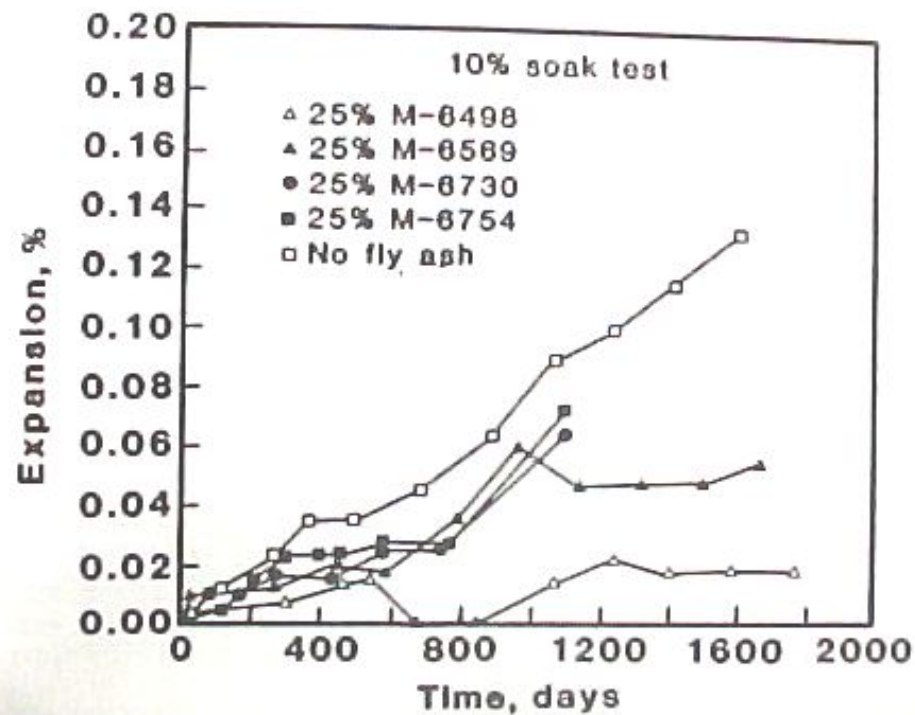
- properties of fly ash
- chemical composition
- particle size
- reactivity
- the temperature and other curing conditions

Advantage in high temperature



In contrast to the loss of strength that occurs with ordinary portland cement, fly ash concrete show strength gains as a consequence of heating.

Effect of fly ash on the durability of concrete



Fly ash greatly improved sulphate resistance.

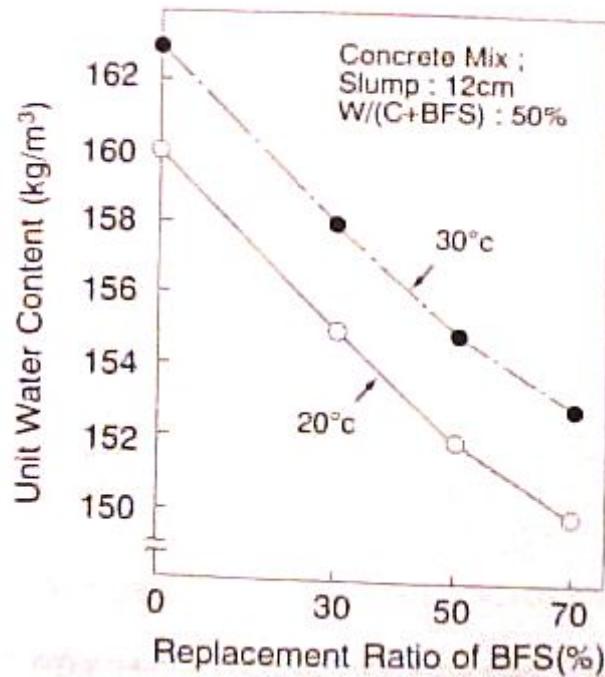
Sulphate expansion of concretes containing low-calcium fly ash

Blast-Furnace Slag

- Blast furnace slag is a by-product of pig iron manufacture. When quenched rapidly with water or air to a glassy state and finely ground, it develops the property of latent hydraulicity.
- Blast furnace slag has chemical component similar to that of Portland cement. Due to hydraulicity, therefore, its use contributes not only to improvement in concrete performance, but also to resource and energy savings.

Performance of concrete containing blast furnace slag

- Fresh concrete



The unit water content necessary to obtain the same slump decreases with the increase in the slag content.

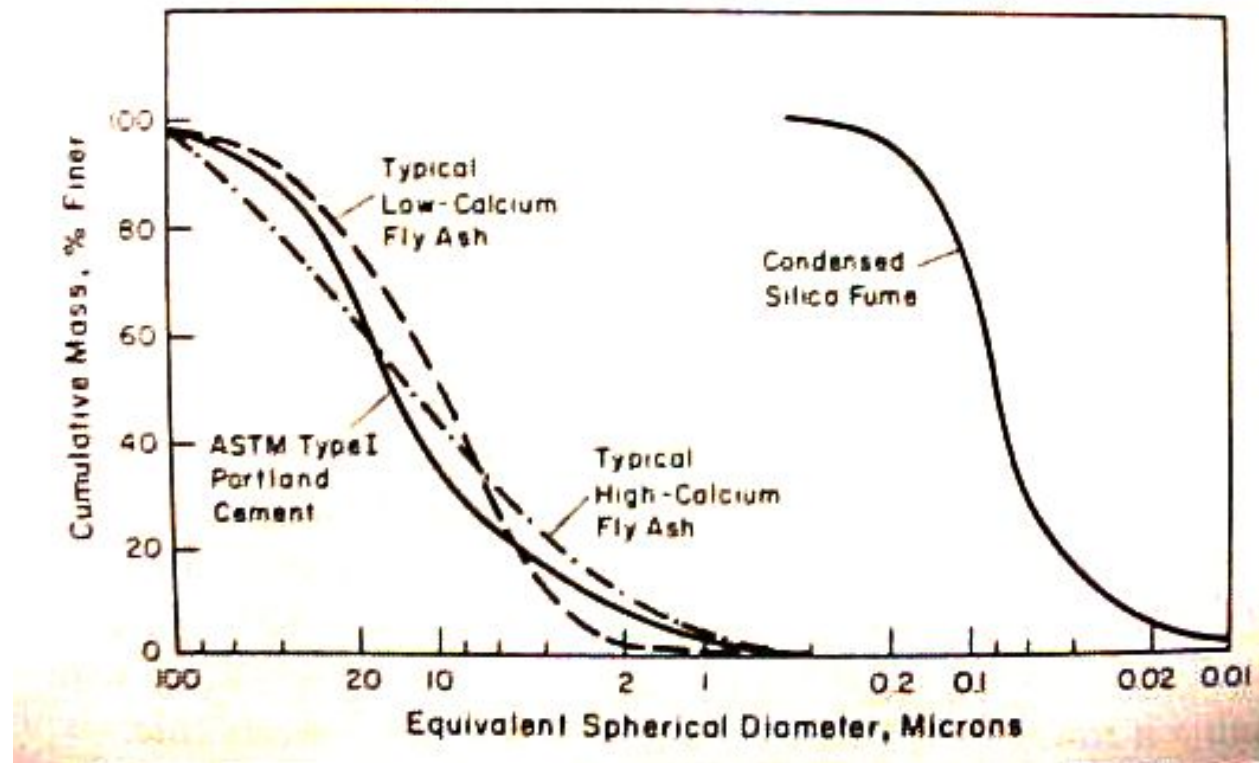
Hardened concrete

- The strength development is greatly affected by the quality and replacement ratio of blast furnace slag, and curing condition.
- Heat of hydration of concrete containing slag powder decreases with the increase in the slag powder content.
- Concrete containing slag as a mineral admixture generally offers better chemical resistance due to improved watertightness, since the concrete texture becomes dense.

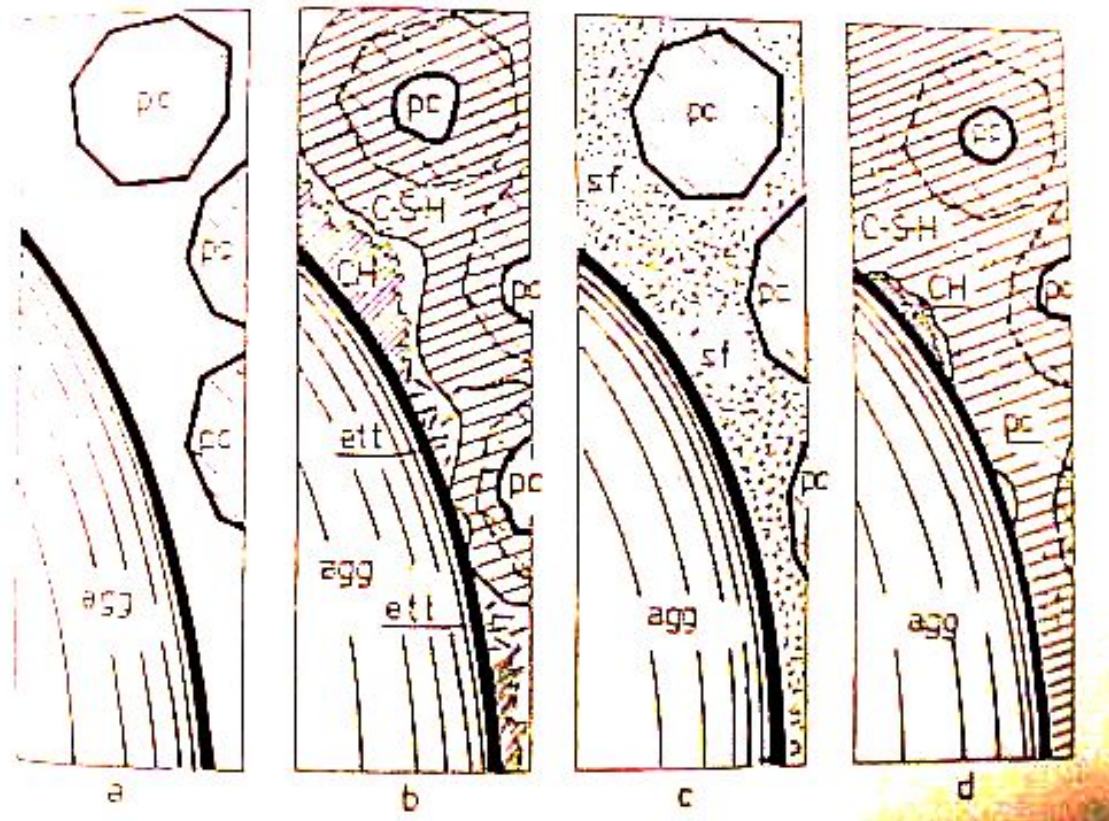
Silica Fume

- Silica fume is an industrial by-product consisting of ultrafine particle($0.01 \mu\text{m}$). It is recovered from electric furnace by means of dust collectors from the waste gas emitted during the production of ferro-silicon metal.
- Silica fume is a highly pozzolanic materials.
- **Difficult to handle so necessary to use (high-range) water-reducing admixture**

Comparison of particle size distributions of portland cement, fly ashes, and condensed silica fume

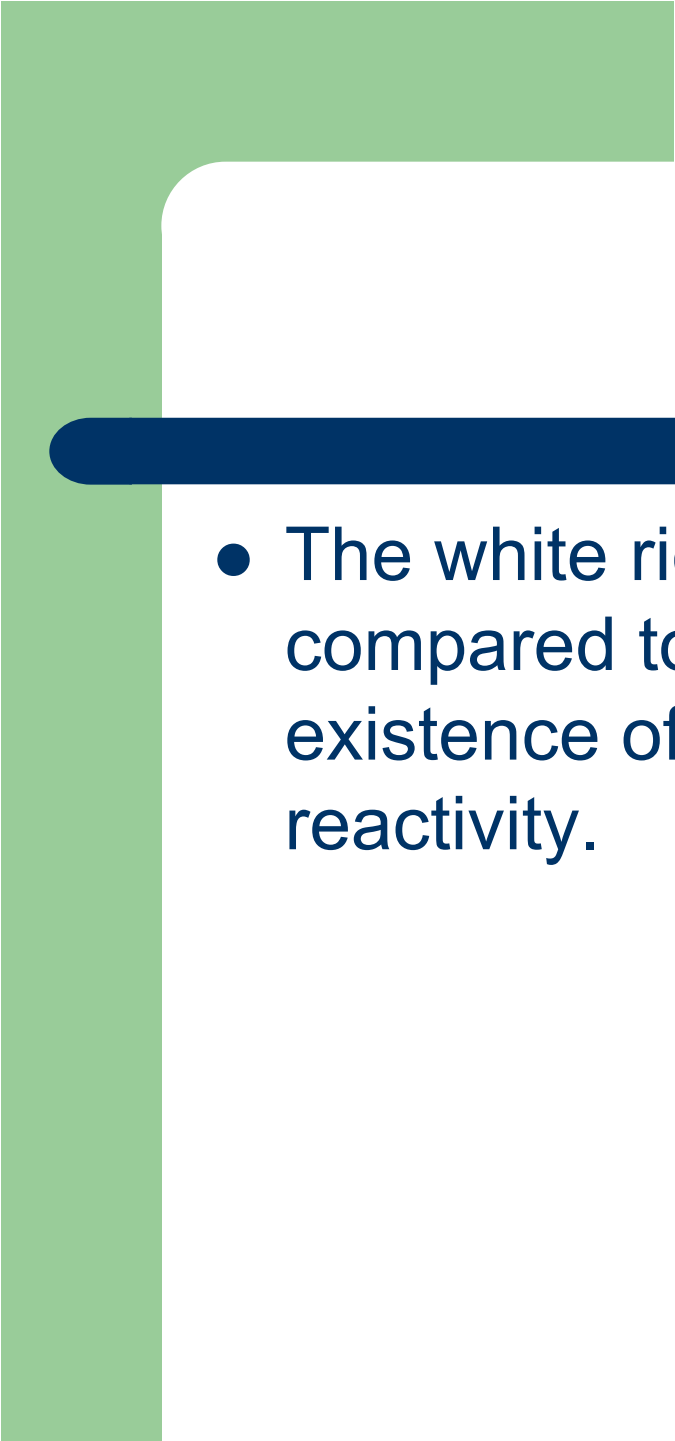



Schematic description of the mode and nature of formation of ITZ around aggregate



Rice Husk Ash

- Rice husk ash is obtained by burning rice husk.
- Highly pozzolanic characteristic.
- The properties are greatly affected by the burning conditions. The large amount of unburnt carbon due to the incomplete combustion exist and make the color of rice husk ash is black, whereas, the burning is done under enough air supply condition the rice husk ash become gray and white.

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- The white rice husk ash has better quality compared to the black rice husk ash due to the existence of carbon affecting adversely on the reactivity.

Multicomponent Blended Cement

- Is developed by mixing two or more kinds of mineral admixtures with the aim of further improving the performance of blended cement.
- This cement helps provide higher fluidity, higher strength, higher density, higher durability, lower heat evolution, and increase resistance to alkali aggregate reaction of concrete and is mainly used for massive structure including the foundation for piers of long, large bridges and dam.

Improved Concrete Quality with Combination of Fly Ash and Silica Fume

- Adding relatively small amount of **silica fume to fly ash concretes** with w/c of 0.40 to 0.45, results in concretes with satisfactory strength and very low permeability at 28 days.
- With concretes containing a combination of fly ash and silica fume, increasing the early curing temperature (up to 38 C) and duration of moist-curing reduces the chloride permeability, other conditions remaining the same.

Comment (1)

- The three important areas of concrete performance are strength, durability and fluidity and the materials affecting the physical properties of cement matrix are cement, mineral admixture and chemical admixture.
- The using only portland cement in concrete does not guarantee all performance of concrete.

Comment (2)

- The utilization of by-product mineral admixtures is the best alternative for nowadays since it not only makes the concrete accomplish the proper performance **but also reduce the concrete cost and environmental problems.**
- The user who can use by-product mineral admixture in large amount such as cement factory or ready mix concrete should be the main principal consuming by-product materials.