Module # 3

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1. Micro Structure

Micro Structure

- The type, amount, size, shape, and distribution of phases present in a solid creates its microstructure.
- The gross elements of the microstructure of a material can readily be seen from a cross section of the material, whereas the finer elements are usually resolved with the help of a microscope.
- The term macrostructure is generally used for the gross microstructure visible to the human eye.

Micro Structure Continued

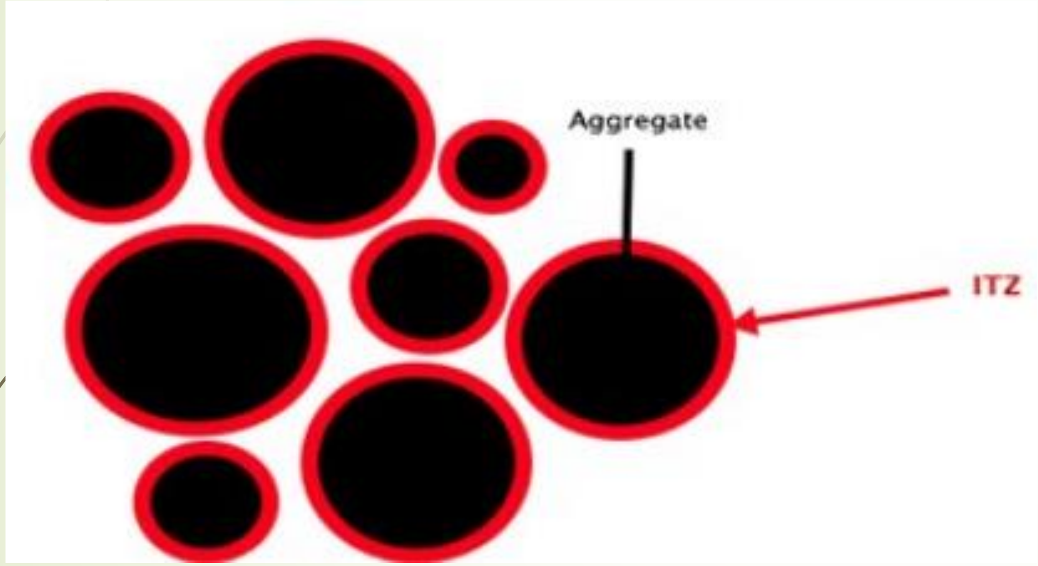
- The term microstructure is used for the microscopically magnified portion of a macrostructure.
- The magnification capability of modern electron microscopes is of the order of 10 raise to five times.
- Therefore, scanning electron microscopy techniques has made it possible to resolve the microstructure of materials.

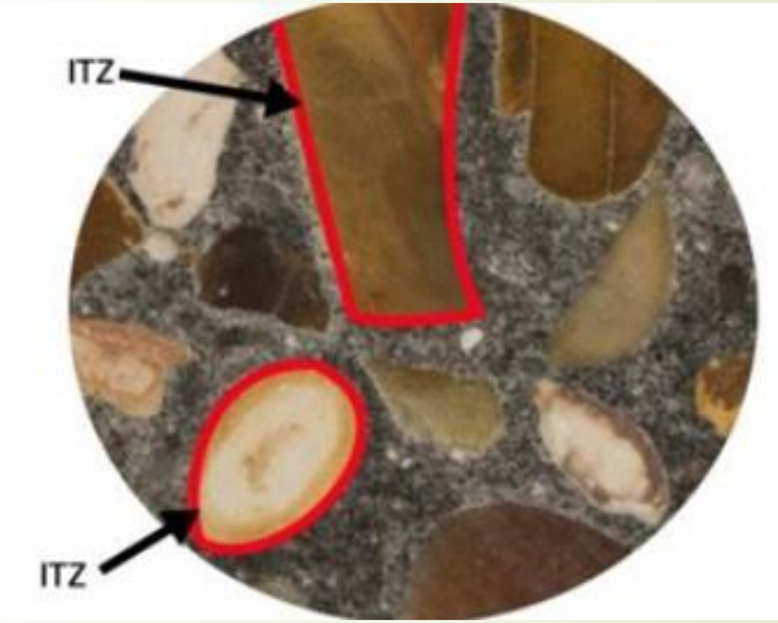
2. Interfacial transition zone in concrete (ITZ)

Interfacial Transition zone in concrete

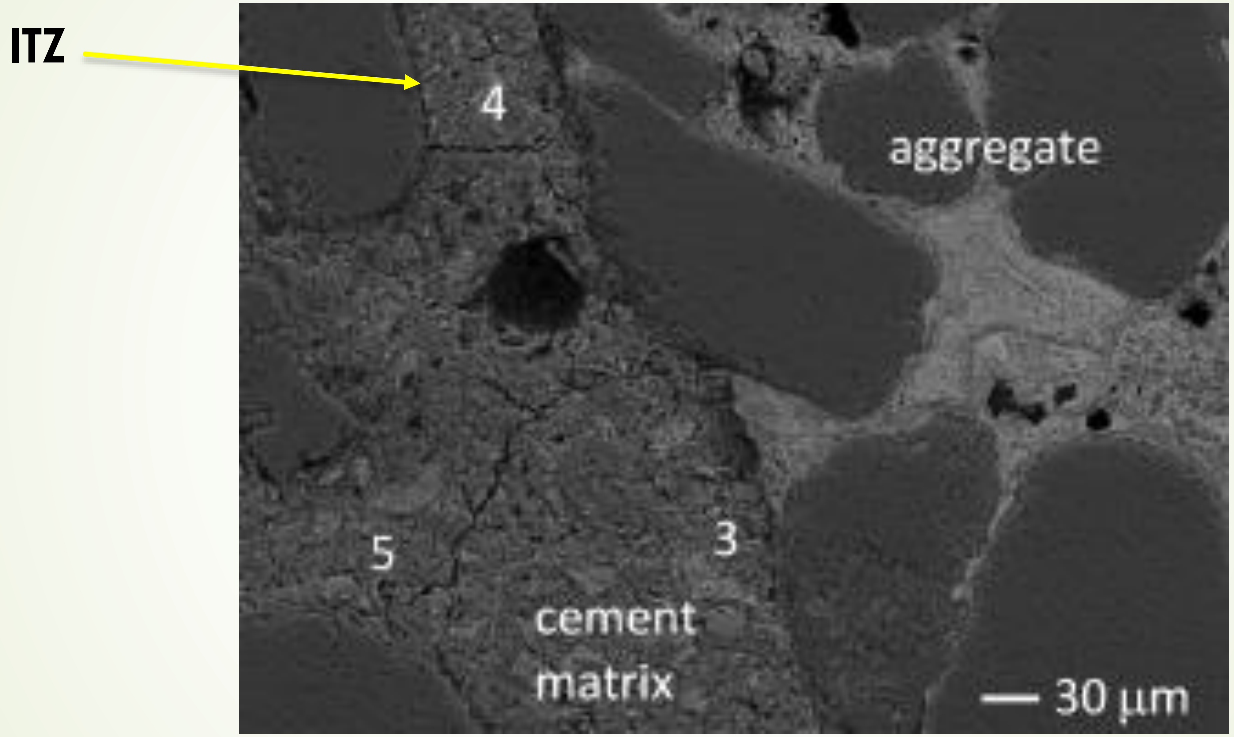
- Concrete is considered to be two phase material:
  1. Paste phase
  2. Aggregate phase
- At microscopic level, the concrete have complexities, particularly in the area of large aggregate particles.
- This area is considered as a third phase called the transit zone, which represents, the inter facial region zone between the particles of coarse aggregate and hardened paste.
- This transition zone is a plane of weakness and therefore has great influence on mechanical behavior (strength) of concrete.

Interfacial Transition zone in concrete



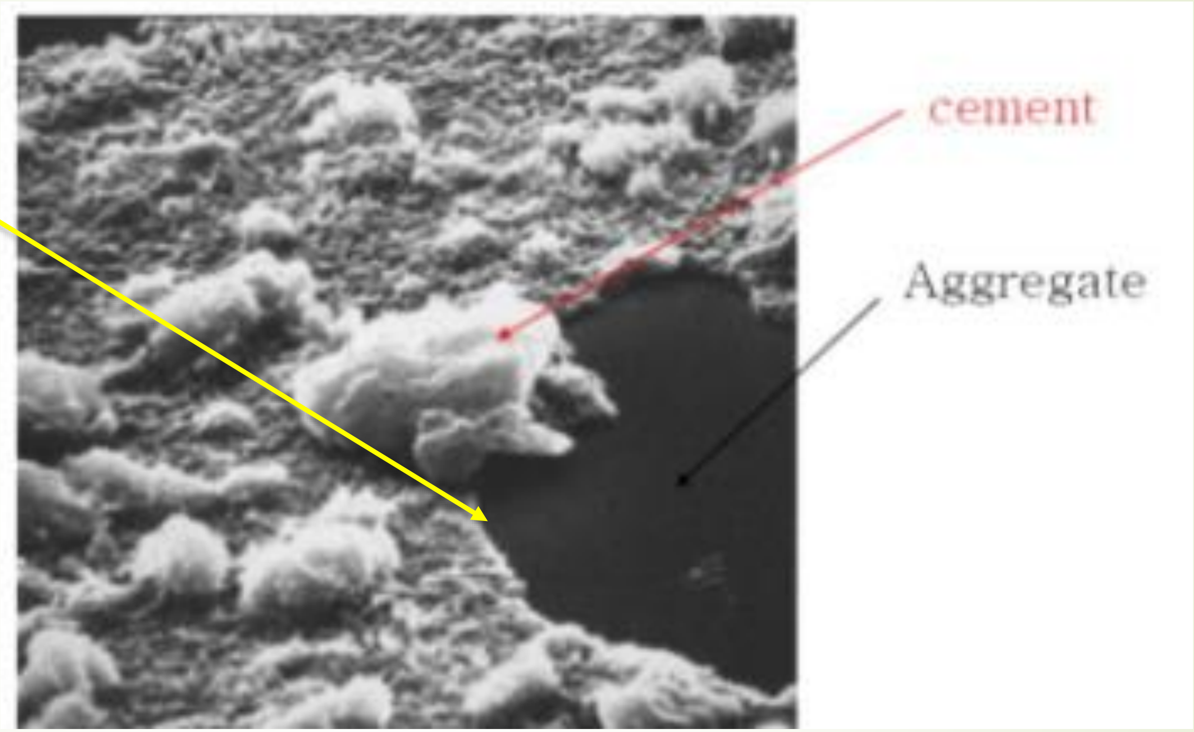


Interfacial Transition zone in concrete



Interfacial Transition zone in concrete

ITZ



3. Influence of interfacial transitional zone on properties of concrete

Influence of interfacial transitional zone on properties of concrete

Transition zone -Influence on concrete properties
Fraction of transition zone in size is much smaller than other two phases, its influence on concrete properties is far greater.

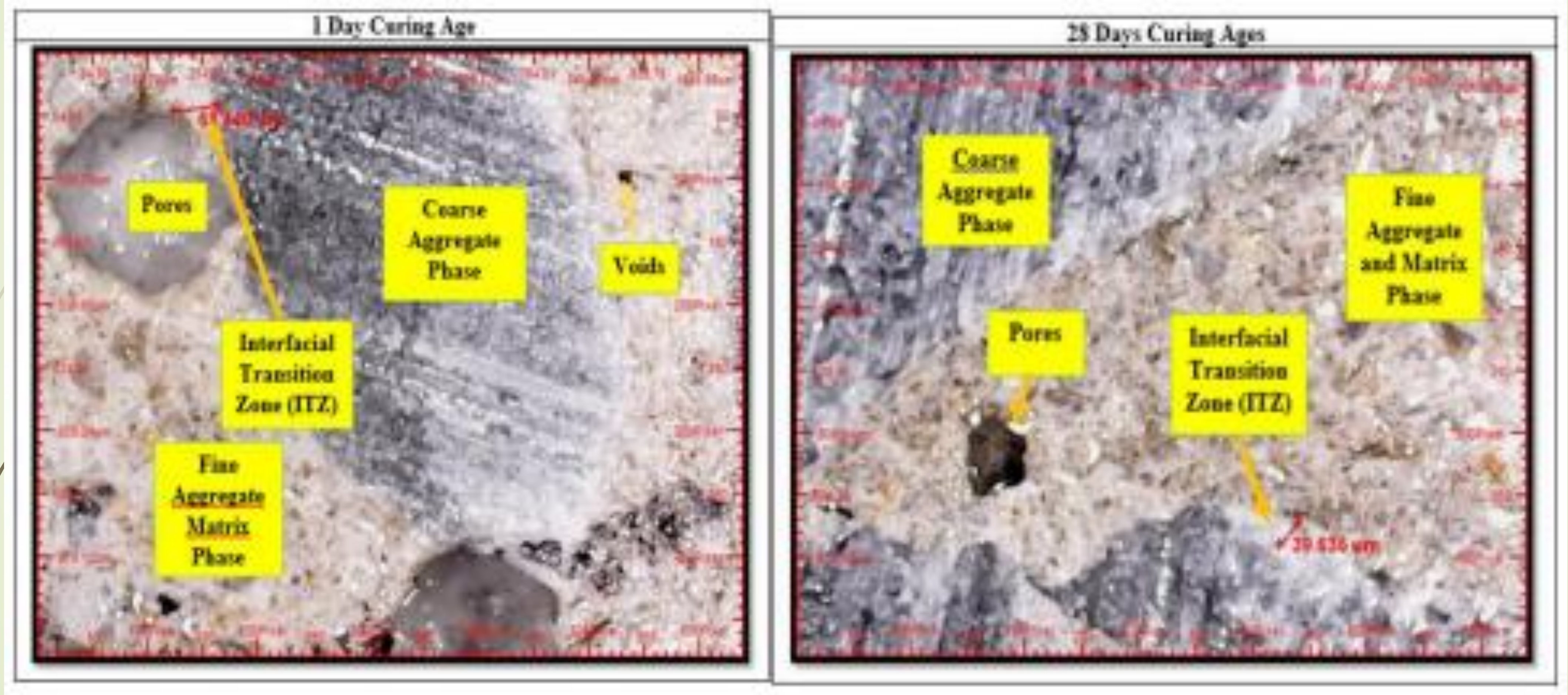
1. It lower the strength
2. It increase the permeability
3. It causes non-linear behavior of concrete
4. Crack formation

4. Micro Structure of Concrete

Micro Structure of concrete

- It can be observed that, the optical microstructure in normal concrete consisted of three distinct phases and boundaries.
- The three phases in concrete consisted of the aggregates phase, bulk cement paste and also the interfacial transition zone (ITZ).
- In addition, pores due to inefficient packing of concrete may also be observed using the optical microscope.
- The microstructural analysis images of concrete samples with water/cement ratio of 0.5 are shown in Figure in next slide.
- The ITZ is presence due to the potentially effect from the inefficient packing between the aggregate surface and cement particles. However, the thickness of the ITZ layer will decrease or even disappeared in respond to it increasing in curing ages.

Micro Structure of concrete



Micro Structure of concrete

- Figure in previous slide shows micro structure of concrete, having cement paste, aggregates and thickness of the interfacial transition zone (ITZ) against the curing age (1 and 28 Days) for the concrete samples with w/c ratio of 0.50.

4. Micro Structure of Hydrated cement Paste

Micro Structure of hydrated cement paste

- When Portland cement is dispersed in water, as a result of interaction between calcium, sulfate, aluminate, and hydroxyl ions within a few minutes of cement hydration, the needle-shaped crystals of **calcium tri-sulfo-aluminate** hydrate, called **ettringite**, first make their appearance having low surface area and volume.
- A few hours later, large hexagonal shaped crystals of **calcium hydroxide** also known as **Portlandite** and **calcium silicate hydrates (C-S-H gel)** having high surface area and volume begin to fill the empty space formerly occupied by water and the dissolving cement particles.
- After some days, depending on the alumina-to-sulfate ratio of the Portland cement, ettringite may become unstable and will decompose to form **mono-sulfo-aluminate** hydrate, which has a plane hexagonal in structure.

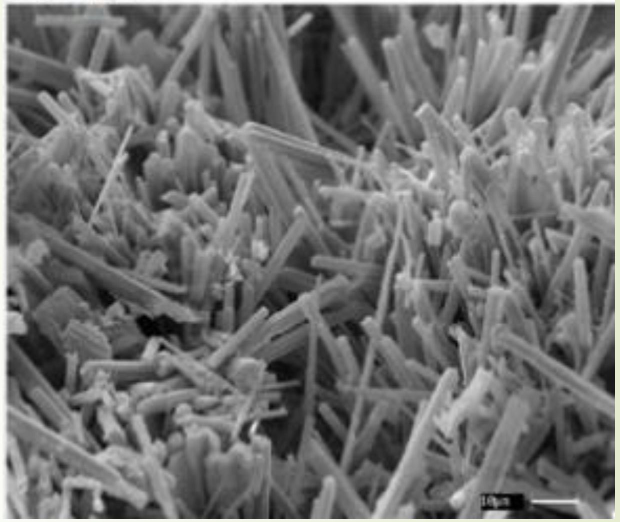
Micro Structure of hydrated cement paste

1. **Calcium sulfo-aluminates hydrates**

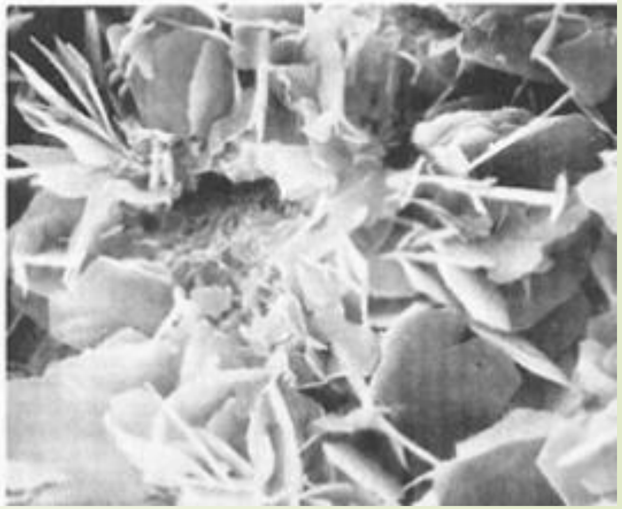
low surface area: 2 m2/g

- Calcium sulfo-aluminate hydrates occupy 15 to 20 percent of the solid volume in the hydrated paste and, therefore, play only a minor role in the microstructure-property relationships.
- In pastes of ordinary portland cement, ettringite eventually transforms to the monosulfate hydrate which forms plane hexagonal-plate crystals.
- The presence of the monosulfate hydrate in portland cement concrete makes the concrete weak to sulfate attack.

Ettringite



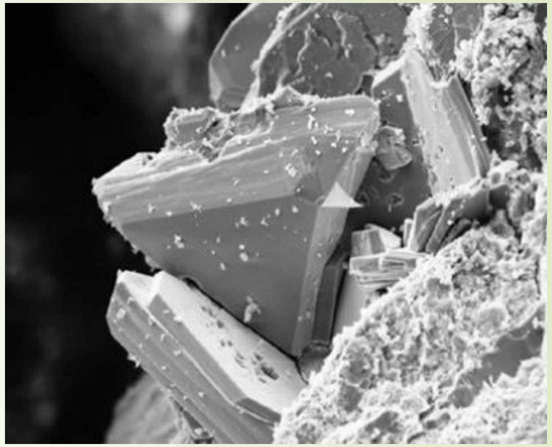
Monosulfoaluminate



Micro Structure of hydrated cement paste

Calcium Hydroxide or Portlandite

- Calcium hydroxide crystals (also called Portlandite) occupy 20 to 25 percent of the volume of solids in the hydrated paste.
- It tends to form large crystals with a hexagonal-prism shape. The shape is usually affected by the available space, temperature of hydration, and impurities.
- Calcium hydroxide have lower surface area (0.5 m2/g).

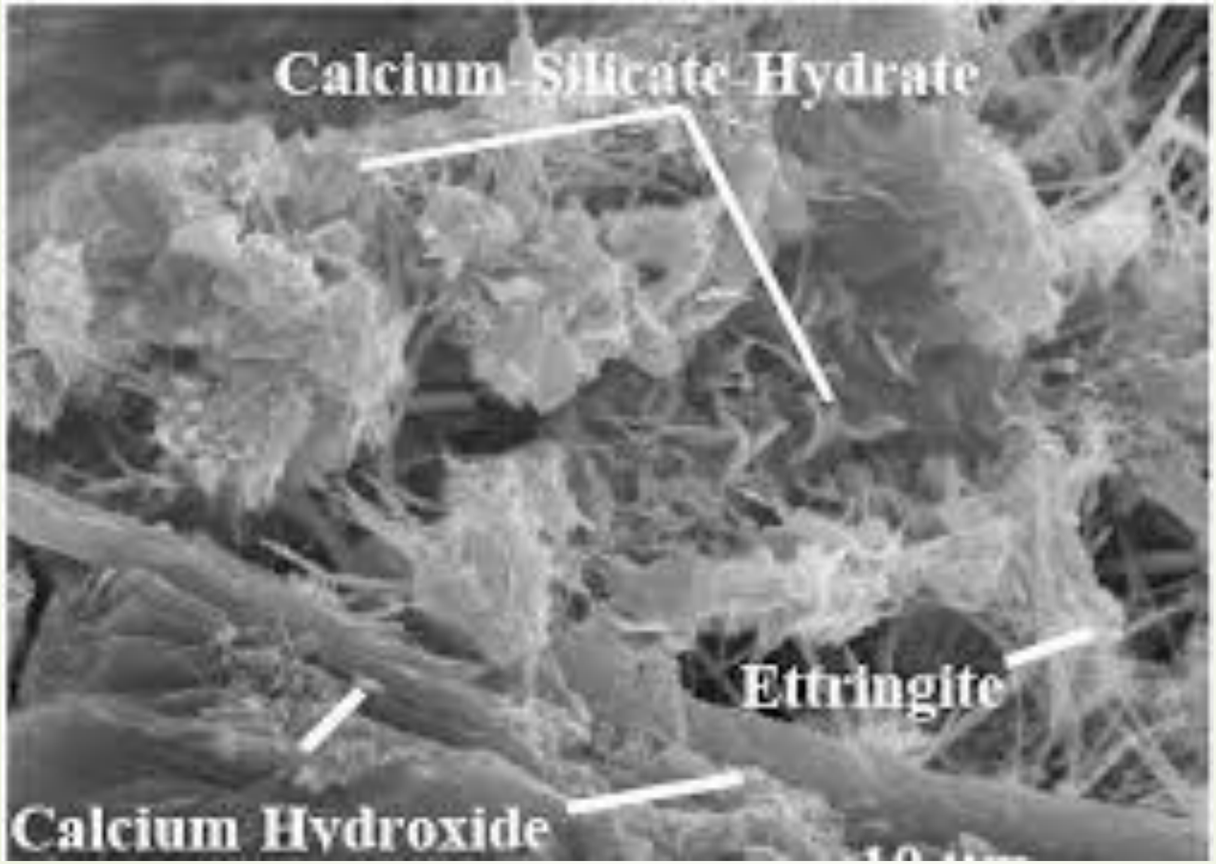


Micro Structure of hydrated cement paste

Calcium Silicate Hydrate or C-S-H gel

- The calcium silicate hydrate phase, abbreviated as C-S-H, makes up 50 to 60 percent of the volume of solids in a completely hydrated Portland cement paste and is, therefore, the most important phase determining the properties of the paste.
- Although the exact structure of C-S-H is not known, several models have been proposed to explain the structure and surface area.
- According to the **Powers-Brunauer model**, the material has a layer structure with a very high surface area. Depending on the measurement technique, surface areas on the order of 100 to 700 m2 /g have been proposed for C-S-H
- The **Feldman-Sereda** model visualizes the C-S-H structure as being composed of an irregular or linked array of layers which are randomly arranged of different shapes and sizes

Micro Structure of hydrated cement paste

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