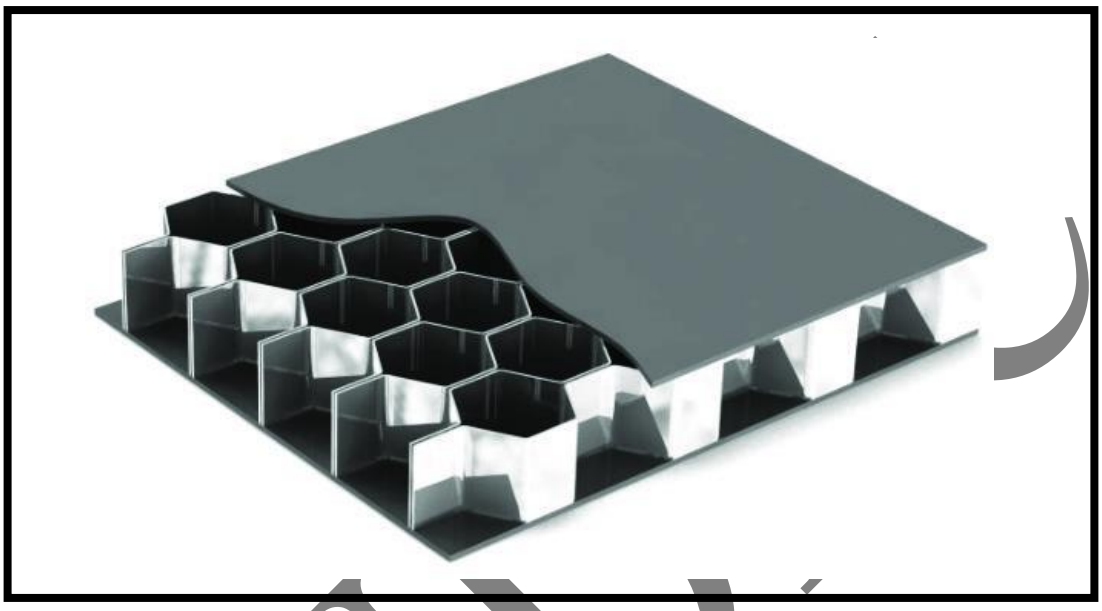
Module – 1

Emerging Materials

Honeycomb Structure

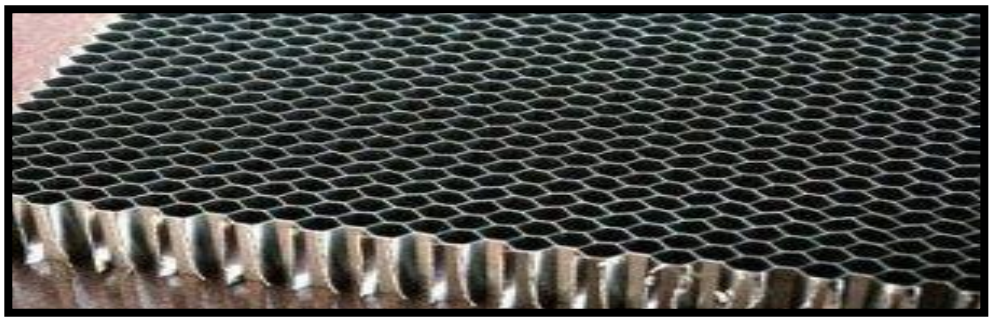
Honeycomb structure are natural or manmade structures that have the geometry of a honeycomb to allow the minimization of the amount of used material to reach minimal weight and minimal material cost



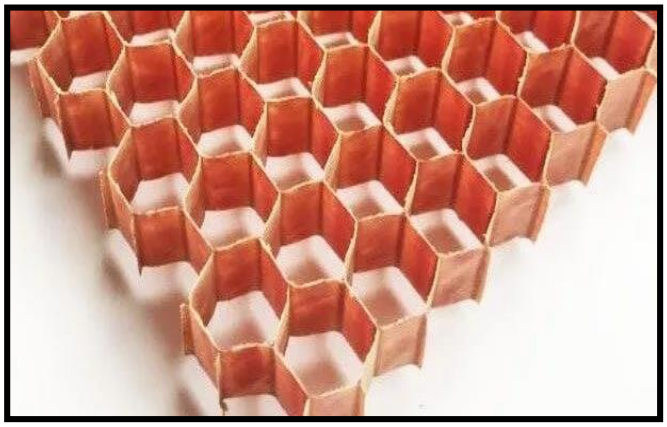
Types of honeycomb Structure

- Aluminum honeycombs
- Nomex honeycomb
- Thermoplastic honeycomb
- Stainless steel honeycomb

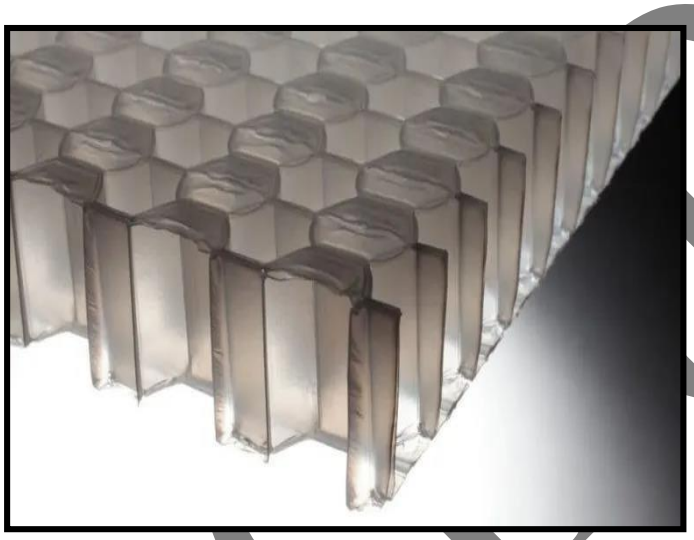
1. Aluminum honeycombs

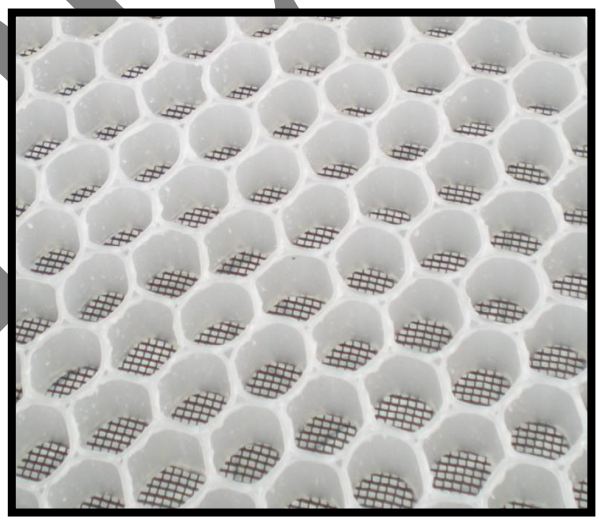


2. Nomex honeycomb

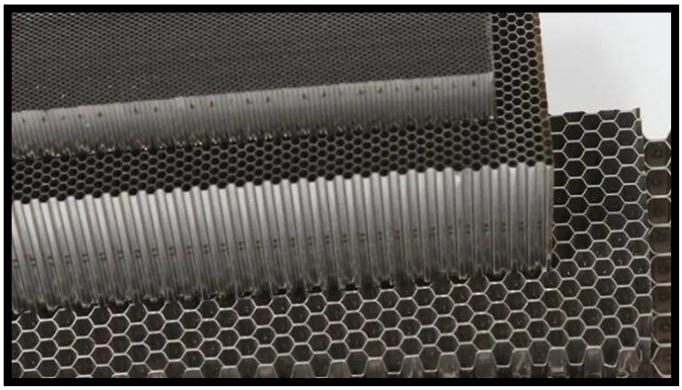


3. Thermo plastic honeycomb



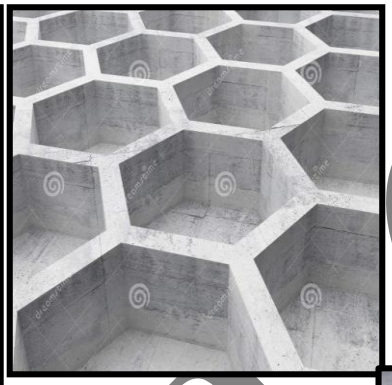


4. Stainless steel honeycomb



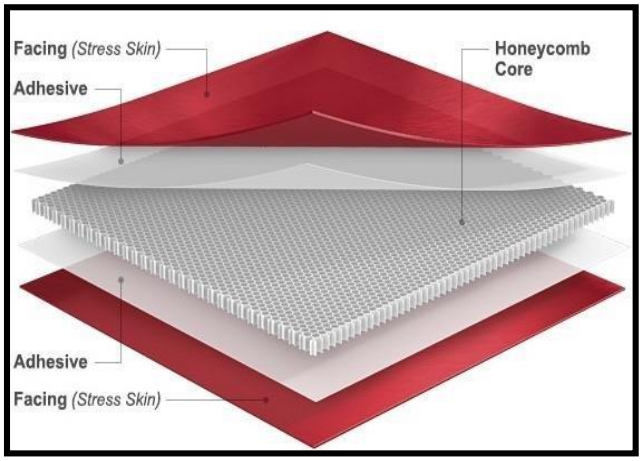
Application of honeycomb

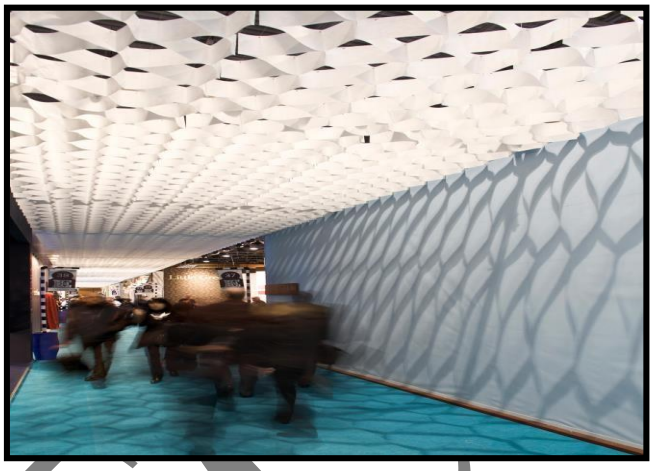
1. **Doors, Floors, Absorber/Bumpers, Furniture in rail industry.**


2. **Architectural curtain wall panels**

3. Ceiling and Flooring panels

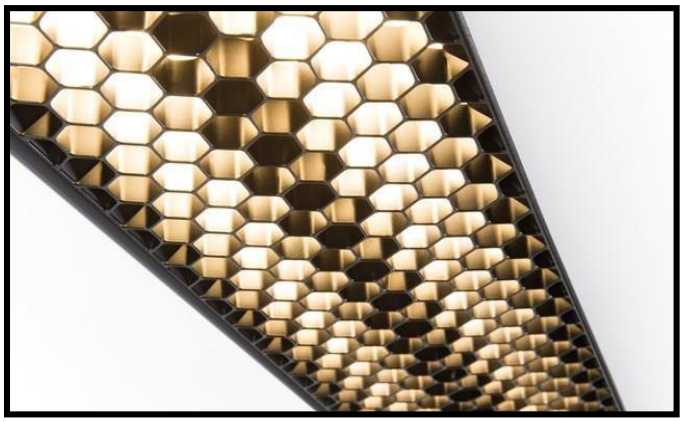




4. Clean room

5. Ventilators

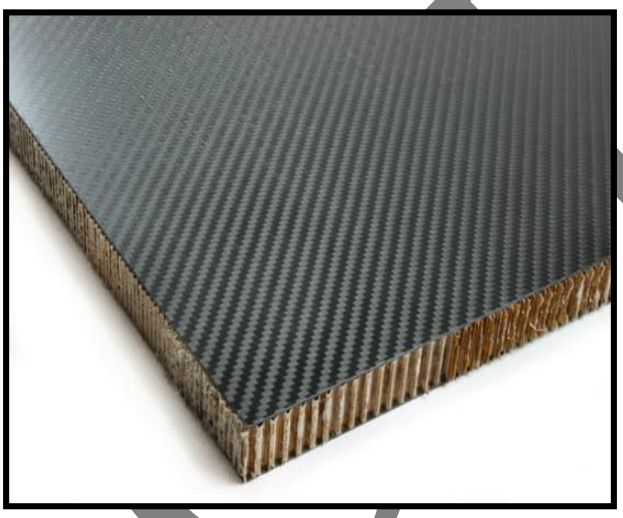
6. Light diffusers



7. Rotor blade of wind turbine

Carbon Composite

Composite materials composed of carbon fibers and matrix phases (Mixing activated carbon and polymer)



Properties of carbon composite

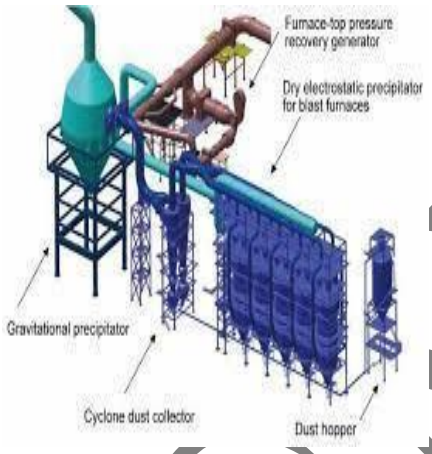
- Low density
- High mechanical strength
- High thermo stability
- High electrical conductivity

- High thermal conductivity
- Low CTE(Co-efficient of thermal expansion)
- Excellent fracture toughness

Emerging sustainable by products

FLYASH

Fly ash is finely divided residue resulting from the combustion of powdered coal and transported by the flue gases and collected by electrostatic precipitator. Fly ash is the most widely used pozzolanic material all over the world.



The importance and use of fly ash in concrete has grown so much that it has almost become a common ingredient in concrete, particularly for making high strength and high performance concrete.

The use of fly ash as concrete admixture not only extends technical advantages to the properties of concrete but also contributes to the environmental pollution control.

In India alone, we produce more than about 100 million tons of fly ash per years, the disposal of which has become a serious environmental problem.

Production of every tone of cement emits carbon dioxide to the tune of about 0.87 ton. Because of the significant contribution to the environmental pollution and to the high consumption of natural resources like limestone etc., we cannot go on producing more and more cement. So one of the practical solutions to economies cement is to replace cement with supplementary cementitious materials like fly ash and slag.

The total production of fly ash is more than 100 million tons. But utilization of fly ash is only about 20% of the production. Therefore, the use of fly ash must be popularized for more than one reason.

FLYASH: Advantages

- Fly ash use in concrete improves the workability (how easily freshly mixed concrete can be mixed, placed, consolidated, and finished with minimal loss of homogeneity) of plastic concrete, and the strength and durability of hardened concrete.
- Increases strength and durability of hardened concrete
- Reduces permeability at a low cost
- It is also used as material to make bricks, ceramic tiles and plasters filler in metal and plastic composites and in paints and adhesives.
- It is also used to neutralize soil acidity.

FLYASH: Disadvantages

- The quality of fly ash can affect the quality and strength of Cement concrete.
- Poor quality fly ash can increase the permeability of the concrete and cause damage to the building.
- Slower strength gain.
- Seasonal limitation.
- Increased need for air-entraining admixtures.
- Increase in salt scaling produced by higher proportions of fly ash.

GGBS (Ground Granulated Blast Furnace Slag)

- Ground granulated blast-furnace slag is a nonmetallic product consisting essentially of silicates and aluminates of calcium and other bases. The molten slag is rapidly chilled by quenching in water to form a glassy sand like granulated material.
- ThechemicalcompositionofBlastFurnaceSlag(BFS)issimilartothatofcement
    - clinker(CaO–60-67%,SiO2–17-25%,Al2O3–3-8%,Fe2O3–0.5-6%,MgO–
    - 0.1-4%, Specific gravity–3.15).
- In India, we produce about 7.8million tons of blast furnace slag. All the blast furnace slags are granulated by quenching the molten slag by high power water jet, making 100% glassy slag granules of 0.4 mm size.

Performance of GGBS in concrete

Fresh Concrete:

- There placement of cement with GGBS will reduce the unit water content necessary to obtain the same slump (How fluid the concrete mix is).
- ThisreductionofunitwatercontentwillbemorepronouncedwithincreaseinSlag content and also on the fineness of slag**.**

Hardened concrete:

- Reduced heat of hydration(The heat generated when water reacts in contact With the cement powder).

Performance of GGBS in concrete

- Reduced permeability to the external agencies.
- Increased resistance to chemical attack.
- Improved resistance to corrosion of steel reinforcement.
- High ultimate strength.
- Improved workability.
- Saving cement in concrete mix**.**

Construction chemicals

- Plasticizers(Water reducers)
- Super plasticizers (High Range Water Reducers)
- Retarders
- Accelerators

Requirement of right workability is the essence of good concrete. Concrete in different situations require different degree of workability (**how easily freshly mixed concrete can be mixed, placed, consolidated, and finished with**

minimal loss of homogeneity).A high degree of workability is required in situations like deep beams, thin walls of water retaining structures with high percentage of steel reinforcement, column and beam junctions, hot weather concreting, for concrete to be conveyed for considerable distance and in ready mixed concrete industries etc.

The conventional methods followed for obtaining high workability is by improving the gradation, or by the use of relatively higher percentage of fine aggregate or by increasing the cement content. There are difficulties and limitations to obtain high workability in the field for a given set of conditions.

1. Plasticizer (Water reducers)

These plasticizers can help the difficult conditions for obtaining higher workability without using excess of water. One must remember that addition of excess water, will only improve the fluidity or the consistency but not the workability of concrete. The excess water will not improve the inherent good qualities such as homogeneity and cohesiveness of the mix which reduces the tendency for segregation and bleeding. The organic substances or combinations of organic and inorganic substances, which allow a reduction in water content for the given workability, or give a higher workability at the same water content, are termed as plasticizing admixtures.

The basic products constituting plasticizers are as follows:

- Anionic surfactants such as lignosulphonates and their modifications and derivatives, salts of sulphonates hydrocarbons.
- Nonionic surfactants, such as polyglycol esters, acid of hydroxylated carboxylic acids and their modifications and derivatives.
- Other products, such as carbohydrates etc among these, calcium, sodium and ammonium lignosulphonates are the most used.

Advantages of Plasticizers in concrete

- Reduction of water in concrete without affecting its consistency
- Increase the slump without affecting the water content • Improved bond strength.
- Increased abrasion resistance.
- Decreased permeability.
- Reduced segregation and bleeding.
- Higher early and ultimate strength.

2. Super plasticizers (High water reducers)

Super plasticizers constitute improved version of plasticizer, they are chemically different from normal plasticiszers.

Use of super plasticizers permits the reduction of water to the extent up to 30 % without reducing workability.

The use of super plasticizer is practiced for production of flowing, self levelling, and self-compacting and for the production of high strength and high performance concrete.

The super plasticizers are more powerful as dispersing agents and they are high range water reducers

It is the use of super plasticizer which has made it possible to use w/c as low as 0.25 or even lower and yet to make flowing concrete to obtain strength of the order 120 Mpa or more

Effects of Superplasticizers on Fresh Concrete

- A mix with an initial slump of about 2 to 3 cm can only be fluidised by plasticizers or superplasticizers at nominal dosages. A high dosage is required to fluidify no slump concrete.
- Slump increases with increase in dosage. But there is no appreciable increase in slump beyond certain limit of dosage. As a matter of fact, the over dosage may sometime harm the concrete.

Factors Affecting the Workability

- Type of super plasticizers
- Dosage
- Mix composition
- Variability in cement composition and properties
- Mixing procedure
- Equipment's
- Other

Effect of Super plasticizers on the Properties of Hardened Concrete.

Plasticizers or super plasticizers do not participate in any chemical reactions with cement or blending material used in concrete. Their actions are only physical in fluidizing the mix, made even with low water content. Their fluid fying action lasts only as long as the mix is in plastic condition. Once the effect of adsorbed layer is lost, the hydration process continues normally. The use of right quality of plasticizers or super plasticizers when used in usual small dose (say up to 3% by weight of cement) there is no bad effect on the properties of hardened concrete. Only in case of bad quality it may result in air-entrainment, which reduces the strength of concrete.

3. Retarders

• A retarder is an admixture that slows down the chemical process of hydration so that concrete remains plastic and workable for a longer time than concrete without the retarder.

• Retarders are used to overcome the accelerating effect of high temperature on setting properties of concrete in hot weather concreting

. • The retarders are used in casting and consolidating large number of pours without the formation of cold joints

The most commonly known retarder is calcium sulphate. The appropriate amount of gypsum to be used must be determined carefully for the given job. Addition of

excess amount may cause undesirable expansion and indefinite delay in the setting of concrete.

• In addition to gypsum there are number of other materials found to be suitable for this purpose. They are: starches, cellulose products, sugars, acids or salts of acids. These chemicals may have variable action on different types of cement when used in different quantities.

Retarding admixtures are sometimes used to obtain exposed aggregate look in concrete. The retarder sprayed to the surface of the formwork, prevents the hardening of matrix at the interface of concrete and formwork, whereas the rest of the concrete gets hardened. On removing the formwork after one day or so, the unhardened matrix can be just washed off by a jet of water which will expose the aggregates.

Advantages of Retarders

- Retarders extend the setting time of the concrete.
- In large construction projects, a concrete retarder prevents the formation of cold joints

- . • Using retarders, you can compensate for the accelerated impact of high temperatures towards the initial setting time.

- Concrete retarder reduces isolation and bleeding.

4. Accelerators

Accelerating admixtures are added to concrete to increase the rate of early strength development in concrete to

- Permit earlier removal of formwork
- Reduce the required period of curing
- Advance the time that a structure can be placed in service
- Partially compensate for the retarding effect of low temperature during cold weather concreting
- In the emergency repair work

Accelerators

• In the past one of the commonly used materials as an accelerator was calcium chloride. But, now days it is not used. Instead, some of the soluble carbonates, silicates fluosilicates and some of the organic compounds such as triethenolamine are used.

• Some of the accelerators produced these days are so powerful that it is possible to make the cement set into stone hard in a matter of five minutes are less. With the availability of such powerful accelerator, the underwater concreting has become easy.

Advantages of accelerators

- Speeds the setting time and thus cure time starts earlier.
- Improve the strength of the concrete in the initial stage, increasing the rate of hydration.
- Increase the rate of hardening and early strength gain.

Engineered Polymers

Group of plastic materials that have improved mechanical and thermal properties that make them ideal for all types of engineering applications.

Usage of polymers in construction helps

• To resolve common defects in construction such as seepage, chemical and environmental erosion, corrosion, sagging etc.

• Production of energy efficient materials and components.

• Minimize the cost of construction.

• Make the building structure portable.

• Improve the thermal and sound insulation of the building.

Polymer concrete is a group of concretes that use polymers to supplement or replace cement as a binder.

Composite using polymer

1. Polymer concrete (PC) : When the binder is a polymer that replaces the cement paste.

2. Polymer modified concrete (PMC) : When the polymer is mixed along the cement.

3. Polymer impregnated concrete (PIC) : When the cement concrete is treated by soaking and polymerization.

4. Partially impregnated and surface coated polymer concrete.

1. Polymer Concrete

Polymer concrete is a composite material which results from the polymerization (Process in which relatively small molecules, called monomers, combine chemically to produce a very large chain-link or network molecule called a polymer) of a monomer (a molecule that can be bonded to other identical molecules to form a polymer) and aggregate mixture. The polymerized monomer acts as binder for the aggregates and the resulting composite is called polymer concrete.

Two techniques are used to mix monomer with aggregate

- Adding monomer to dry aggregate and stirring until a uniform blend is achieved.

- Placing the specimen mould and then gradually adding aggregate to the monomer. The mixture is consolidated by mechanical vibration. Monomer used in polymer concrete is Polyester resin, polyester etc.

Polymer Concrete Advantages

- Rapid curing at ambient temperature.
- Low permeability to water and aggressive solutions.
- Good resistance against corrosion.

Disadvantages

- It tends to be brittle in nature.
- High cost

2. Polymer Modified Concrete

It is also known as polymer cement concrete. It has low water absorption and permeability make it an effective material for use in hydraulic structures as well. It has the property of setting quickly

Advantages

- Ability to bond strongly with old concrete.
- To resist the entry of water and aggressive solutions.

Disadvantages

- Moderate improvement of strength and durability.

3. Polymer Impregnated Concrete (PIC)

PIC is generally a precast and hydrated Portland cement concrete, which has been cleaned, dried and impregnated with low viscosity monomer (eventually soaked under pressure) before being polymerized.

The unique feature of impregnating concrete is that a large part of the voids volume in the capillary pores is filled with the polymer and forms continuous

internal reinforcing structure which is thus responsible for the remarkable improvement in strength and durability.

Mainly the following types of monomer are used:

(a)Methylmethacrylate

(b)Styrene

(c)Acrylonitrile

4. Partially impregnated and surface coated polymer concrete

- The partially impregnated concrete can be easily produced by initially soaking the dried specimens in the liquid monomer, then sealing them by keeping them under hot water at 70º C to prevent or minimize loss due to evaporation.
- The depth of monomer penetration depends upon pore structure, duration of soaking, viscosity of the monomer.
- Partial impregnation may be sufficient in situations where the major requirement is surface resistance against chemical and mechanical attack in addition to increase the strength.