**UNIT-5**

**SPECIAL CONCRETE**

**1.What is fibre reinforced concrete? What are its properties?**

**FIBER REINFORCED CONCRETE**

* Concrete containing cement, water , aggregate, and discontinuous, uniformly dispersed or discrete fibers is called fiber reinforced concrete.
* It is a composite obtained by adding a single type or a blend of fibers to the conventional concrete mix.
* Fibers can be in form of steel fibers, glass fibers, natural fibers , synthetic fibers, etc.
* Main role of fibers is to bridge the cracks that develop in concrete and increase the ductility of concrete elements.
* There is considerable improvement in the post-cracking behavior of concrete containing fibers due to both plastic shrinkage and drying shrinkage.
* They also reduce the permeability of concrete and thus reduce bleeding of water.
* Some types of fibers produce greater abrasion and shatter resistance in concrete.
* Imparts more resistance to Impact load.
* Toughness is ability of a material to absorb energy and plastically deform without fracturing.
* It can also be defined as resistance to fracture of a material when stressed.



**TYPES OF FIBERS:**

* Steel fibre
* Glass Fibre
* Carbon fibre
* Polypropylene fibre
* Nylon fibre
* Coir fibre
* Sisal fibre

**Steel fibers:**

* Aspect ratios of 30 to 250.
* Diameters vary from 0.25 mm to 0.75 mm.
* High structural strength.
* Reduced crack widths and control the crack widths tightly, thus improving durability.
* Improve impact and abrasion resistance.
* Used in precast and structural applications, highway and airport pavements, refractory and canal linings, industrial flooring, bridge decks, etc.

**Glass Fibers:**

* High tensile strength, 1020 to 4080 N/mm2
* Generally, fibers of length 25mm are used.
* Improvement in impact strength.
* Increased flexural strength, ductility and resistance to thermal shock.
* Used in formwork, swimming pools, ducts and roofs, sewer lining etc.

**Synthetic fibers**

* Man- made fibers from petrochemical and textile industries.
* Cheap, abundantly available.
* High chemical resistance.
* High melting point.
* Low modulus of elasticity.
* It’s types are acrylic, aramid, carbon, nylon, polyester, polyethylene, polypropylene, etc. Applications in cladding panels and shotcrete

**Natural fibers:**

* Obtained at low cost and low level of energy using local manpower and technology.
* Jute, coir and bamboo are examples.
* They may undergo organic decay.
* Low modulus of elasticity, high impact strength.

**MECHANICAL PROPERTIES OF FRC:**

* *Compressive Strength*

The presence of fibers may alter the failure mode of cylinders, but the fiber effect will be minor on the improvement of compressive strength values (0 to 15 percent).

* *Modulus* of *Elasticity*

Modulus of elasticity of FRC increases slightly with an increase in the fibers content. It was found that for each 1 percent increase in fiber content by volume, there is an increase of 3 percent in the modulus of elasticity.

* *Flexure*

The flexural strength was reported to be increased by 2.5 times using 4 percent fibers.

* *Splitting Tensile Strength*

The presence of 3 percent fiber by volume was reported to increase the splitting tensile strength of mortar about 2.5 times that of the unreinforced one.

* *Toughness*

For FRC, toughness is about 10 to 40 times that of plain concrete.

* *Fatigue Strength*

The addition of fibers increases fatigue strength of about 90 percent.

* *Impact Resistance*

The impact strength for fibrous concrete is generally 5 to 10 times that of plain concrete depending on the volume of fiber.

**STRUCTURAL BEHAVIOUR OF FRC:**

* *Flexure*

The use of fibers in reinforced concrete flexure members increases ductility, tensile strength, moment capacity, and stiffness. The fibers improve crack control and preserve post cracking structural integrity of members.

* *Torsion*

The use of fibers eliminate the sudden failure characteristic of plain concrete beams. It increases stiffness, torsional strength, ductility, rotational capacity, and the number of cracks with less crack width.

* *High Strength Concrete*

Fibers increases the ductility of high strength concrete. Fiber addition will help in controlling cracks and deflections.

* *Shear*

Addition of fibers increases shear capacity of reinforced concrete beams up to 100 percent. Addition of randomly distributed fibers increases shear-friction strength and ultimate strength.

* *Column*

The increase of fiber content slightly increases the ductility of axially loaded specimen. The use of fibers helps in reducing the explosive type failure for columns.

* *Cracking* and *Deflection*

Tests have shown that fiber reinforcement effectively controls cracking and deflection, in addition to strength improvement. In conventionally reinforced concrete beams, fiber addition increases stiffness, and reduces deflection.

**FACTORS AFFECTING THE PROPERTIES OF FRC:**

* Volume of fibers
* Aspect ratio of fiber
* Orientation of fiber
* Relative fiber matrix stiffness

**Volume of fiber**

1. Low volume fraction(less than 1%)
	* Used in slab and pavement that have large exposed surface leading to high shrinkage cracking.
2. Moderate volume fraction(between 1 and 2 percent)
	* Used in Construction method such as Shortcrete & in Structures which requires improved capacity against delamination, spalling & fatigue.
3. High volume fraction(greater than 2%)
	* Used in making high performance fiber reinforced composites.

**Aspect Ratio of fiber:**

* It is defined as ratio of length of fiber to it’s diameter (L/d).
* Increase in the aspect ratio upto 75, there is increase in relative strength and toughness.
* Beyond 75 of aspect ratio, there is decrease in aspect ratio and toughness.

**Orientation of fibers:**

* Aligned in the direction of load
* Aligned in the direction perpendicular to load
* Randomly distribution of fibers
* It is observed that fibers aligned parallel to applied load offered more tensile strength and toughness than randomly distributed or perpendicular fibers.

  

 Parallel Perpendicular Random

**Advantages of FRC:**

* High modulus of elasticity for effective long-term reinforcement, even in the hardened concrete.
* Does not rust nor corrode and requires no minimum cover.
* Ideal aspect ratio (i.e. relationship between Fiber diameter and length) which makes them excellent for early-age performance.
* Easily placed, Cast, Sprayed and less labour intensive than placing rebar.
* Greater retained toughness in conventional concrete mixes.
* Higher flexural strength, depending on addition rate.
* Can be made into thin sheets or irregular shapes.
* FRC possesses enough plasticity to go under large deformation once the peak load has been reached.

**Disadvantages of FRC:**

* Greater reduction of workability.
* High cost of materials.
* Generally fibers do not increase the flexural strength of concrete, and so cannot replace moment resisting or structural steel reinforcement.

**APPLICATIONS OF FRC:**

* *Runway, Aircraft Parking,* and Pavements.

For the same wheel load FRC slabs could be about one half the thickness of plain concrete slab. FRC pavements offers good resistance even in severe and mild environments.

It can be used in runways, taxiways, aprons, seawalls, dock areas, parking and loading ramps.

* *Tunnel Lining* and *Slope Stabilization*

Steel fiber reinforced concrete are being used to line underground openings and rock slope stabilization. It eliminates the need for mesh reinforcement and scaffolding.

* Dams and *Hydraulic* Structure

FRC is being used for the construction and repair of dams and other hydraulic structures to provide resistance to cavitation and severe erosion caused by the impact of large debris.

* *Thin Shell, Walls,* Pipes, and *Manholes*

Fibrous concrete permits the use of thinner flat and curved structural elements. Steel fibrous shortcrete is used in the construction of hemispherical domes.

* Agriculture

It is used in animal storage structures, walls, silos, paving, etc.

* Precast Concrete and Products

It is used in architectural panels, tilt-up construction, walls, fencing, septic tanks, grease trap structures, vaults and sculptures.

* Commercial

It is used for exterior and interior floors, slabs and parking areas, roadways, etc.

* Warehouse / Industrial

It is used in light to heavy duty loaded floors.

* Residential

It includes application in driveways, sidewalks, pool construction, basements, colored concrete, foundations, drainage, etc.

**2.How is light weight concrete is produced? What are its properties and applications?**

**LIGHT WEIGHT CONCRETE:**

* Light weight concrete is a special concrete which weighs lighter than conventional concrete.
* Density of this concrete is considerably low (300 kg/m3 to 1850 kg/m3) when compared to normal concrete (2200kg/m3 to 2600kg/m3).
* Three types of LWC :
	+ - Light weight aggregate concrete
		- Aerated concrete
		- No – fines concrete
* Light weight aggregate concrete - UK, France & USA
* Aerated concrete - Scandinavian countries
* No – fines concrete is less popular

The basic principle behind the making of light weight concrete is by inducing the air in concrete.

 To achieve the above principle practically, there are 3 different ways.

* By replacing the conventional mineral aggregates by cellular porous aggregates (Light weight agg. Concrete).
* By incorporating the air or gas bubbles in concrete (Aerated concrete).
* By omitting the sand from the concrete (No- fines concrete).

**1.LIGHT WEIGHT AGGREGATE CONCRETE:**

* Basically two types of light weight aggregates
	+ - Natural aggregates
		- Artificial aggregates
		- Natural light weight aggregates are less preferred over artificial aggregates.
* Important natural aggregates – Pumice & Scoria
* Artificial aggregates are usually produced by expanding the rocks such as Shale, Slate, Perlite, Vermiculite, etc.,
* Type of aggregates decides the density of concrete.
* Density of concrete as low as 300 kg/m3 can be achieved.
* Compressive strength varies from 0.3Mpa to 40Mpa.



**PROPERTIES OF LIGHT WEIGHT AGGREGATES:**

* Pumice and Scoria are volcanic rocks having densities between 500kg/m3 to 900kg/m3.
* Natural aggregates have good insulating properties but subjected to high absorption and shrinkage.
* Among artificial aggregates, Perlite & Exfoliated Vermiculite gives lowest possible dense concrete. (Perlite – 30kg/m3 to 240 kg/m3 and Vermiculite 60kg/m3 to 130kg/m3).
* Light weight aggregates have higher apparent specific gravity than conventional aggregates.
* Properties of artificial aggregates are less variable than natural aggregates.
* Light weight aggregates have a tendency to absorb more water than conventional aggregates.
* Semi – light weight concrete with normal fine aggregates and lighter coarse aggregates is better than all light weight aggregates.
* In case of RCC structures, increase the cover by 10mm extra, to avoid corrosion steel.
* Light weight aggregates have harsh surface. Add pozzolanic materials to improve workability.
* Concrete which is light weight and has sufficient compressive strength.
* 28 days compressive strength of more than 17Mpa and 28 days dry density not exceeding 1850 kg/m3.
* Generally has normal fine aggregates and lighter coarse aggregates.
* Workability is less due to water absorption by the aggregates.
* Drying shrinkage is more and less thermal expansion than normal concrete.
* Is good in sound proofing, sound absorption & thermal insulation.
* Economical when compared to normal weight concrete.
* Has good fire resistance property than conventional concrete.

**2.AERATED CONCRETE:**

* Produced by introducing air into the concrete.
* It is also called cellular concrete having voids between 0.1mm to 1mm size.
* Two ways are there to induce the air in concrete.
	+ - Gas concrete
		- Foamed concrete
		- Gas concrete is produced by chemical reaction in which gas is produced in the concrete.
* Finely divided aluminum powder is generally used as gas producing agent.
* Its quantity is about 0.2% of weight of cement.
* Aluminum powder reacts with Ca(OH)2 to liberate hydrogen bubbles.
* Powdered zinc, aluminum alloy or hydrogen peroxide can also be used as gas producing agents.
* Foamed concrete is produced by adding foaming agent, usually hydrolyzed protein or resin soaps, during mixing
* In some cases, stable preformed foam is also added during mixing.
* Concrete of densities 300kg/m3 to 1100kg/m3 can be obtained.
* Compressive strength varies from 12Mpa to 14Mpa for a concrete of density 500kg/m3.
* Generally autoclaved aerated concrete is used.
* Aerated concrete has higher thermal movement, higher shrinkage and higher moisture movement compared to light weight aggregate concrete of same strength.

**3.NO – FINES CONCRETE:**

* It is a type of light weight concrete produced by omitting the fine aggregates from conventional concrete.
* This concrete has only cement, coarse aggregate and water.
* Due to absence of fine aggregates, concrete will have large voids, resulting in light weight.
* Even though there is reduction in strength, there is no capillary movement of water, resulting in low permeability and consequently more durable.
* Density of concrete will be less if coarse aggregates are of single size ranging from 10mm to 20mm rather than well graded aggregates.
* No – fines concrete with lighter coarse aggregates, we can get density as low as 640 kg/m3.



* In this concrete, strength criteria depends on cement content in the concrete than water – cement ratio.
* Drying shrinkage is comparatively less. But shrinkage takes place rapidly than conventional concrete.
* Thermal conductivity is also comparatively less.
* No – fines concrete has better architectural appearance.

**3.Describe about the ferrocement.**

**FERROCEMENT:**

* Ferro cement is a type of thin wall reinforced concrete, commonly constructed of hydraulic cement mortar, reinforced with closely spaced layers of continuous and relatively small size wire mesh. The mesh may be made of metallic or other suitable materials.”
* Mortar provides the mass and wire mesh imparts tensile strength and ductility.
* When building Ferro-cement structures the sand/cement mortar is applied to the reinforcing wire with a trowel, never poured like common concrete work. Often a form is used to provide the desired shape.
* Ferrocement is a super reinforced concrete. It differs from conventional concrete in that there is a higher ratio of steel to cement mortar. By altering the cement/steel ratio to make ferrocement we actually produce a material, which exhibits properties, superior to either steel or cement separately. Ferrocement has many of the properties of steel and yet it will not rust. Although it looks and feels like concrete it can flex without cracking.

****

**TECHNIQUES OF MANUFACTURES**

* Hand plastering
* semi-mechanised process
* Centrifuging and Guniting

**MATERIALS USED IN FERRO CEMENT**

* Cement mortar mix
* Skeleton steel
* Steel mesh reinforcement or Fibre-reinforced polymeric meshes

**CEMENT MORTAR MIX**

* ordinary Portland cement and fine aggregate matrix is used
* The matrix constitutes 95% cement mortar & 5% wire mesh of the composite.
* FA (sand), occupies 60 to 75% of the volume of the mortar
* Plasticizers and other admixtures are used

**MIX PROPORTIONS**

* Sand: cement ratio (by mass)  1.5 to 2.5
* Water: cement ratio (by mass)  0.35 to 0.60

**SAND**

* confirming to zone-I or Zone-II
* free from impurities

**WATER**

* Free from salts and organic impurities
* Minimum to achieve desired workability
* pH equal or greater than 7

**SKELETON STEEL**

* It support the steel wire mesh
* 3 to 8 mm steel rods are used
* Thickness varies from 6-20mm according to loading condition
	+ Generally mild steel or Fe 415 or Fe 500 bars are used
	+ Spacing 7.5cm to 12m
* Used to impart structural strength in case of boats, barges etc.
* Reinforcement should be free from dust, rust and other impurities.

**STEEL MESH REINFORCEMENT**

* Consists of galvanized steel wires of diameter 0.5 to 1.5 mm, spaced at 6 to 20mm centre to centre
* Welded wire mesh has hexagonal or rectangular openings
* Expanded-metal lath is also used Made from carbon, glass etc.

**CHEMICAL ADMIXTURES IN FERROCEMENT:**

* water reduction, with strength and reduces permeability.
* Air entrainment, which increases resistance to freezing and thawing;

suppression of reaction between galvanized reinforcement and cement

**PROPERTIES OF FERRO CEMENT**

* It is very durable, cheap and versatile material.
* Low w/c ratio produces impermeable structures.
* Less shrinkage, and low weight.
* High tensile strength and stiffness.
* Better impact and punching shear resistance.
* Undergo large deformation before cracking or high deflection.

**ADVANTAGES OF FERRO-CEMENT**

* It is highly versatile and can be formed into almost any shape for a wide range of uses
* 20% savings on materials and cost
* Suitability for pre-casting
* Flexibility in cutting, drilling and jointing
* Very appropriate for developing countries; labor intensive
* Good fire resistance
* Good impermeability
* Low maintenance costs
* Thin elements and light structures, reduction in self weight   & Its simple techniques require a minimum of skilled labor
* Reduction in expensive form work so economy & speed can be achieved
* Only a few simple hand tools are needed to build any structures
* Structures are highly waterproof  & Higher strength to weight ratio than R.C.C

**DISADVANTAGES OF FERRO-CEMENT**

* Low shear strength
* Low ductility
* Susceptibility to stress rupture failure
* It can be punctured by collision with pointed objects.
* Corrosion of the reinforcing material due to the incomplete coverage of metal by mortar.
* It is difficult to fasten to ferrocement with bolt, screw, welding and nail etc.
* Large no of labours required
* Tying rods and mesh together is especially tedious and time consuming.

**APPLICATIONS OF FERRO CEMENT**

1. Marine Applications

* Boats, fishing vessels, barges, cargo tugs, flotation buoys
* Key criteria for marine applications: light weight, impact resistance, thickness and water tightness

2. Water supply and sanitation

* Water tanks, sedimentation tanks, swimming pool linings, well casings, septic tanks etc.

3. Agricultural

* Grain storage bins, silos, canal linings, pipes, shells for fish and poultry farms

4. Residential Buildings

* Houses, community centers, precast housing elements, corrugated roofing sheets, wall panels etc.

5. Rural Energy

* Biogas digesters, biogas holders, incinerators, panels for solar energy collectors etc.

6. Miscellaneous uses

* Mobile homes
* Kiosks
* Wind tunnel
* Silos and bins
* Bus shelters
* pedestrian bridges
* soil stabilization
* chemical resistant treatment
* Precast ferrocement structures
* Boats, fishing vessels, barges, cargo tugs

**4.How is HPC produced?what are its uses?**

**HIGH PERFORMANCE CONCRETE:**

* High performance concrete is a concrete mixture, which possess high durability and high strength when compared to conventional concrete. This concrete contains one or more of cementious materials such as fly ash, Silica fume or ground granulated blast furnace slag and usually a super plasticizer. . The use of some mineral and chemical admixtures like Silica fume and Super plasticizer enhance the strength, durability and workability qualities to a very high extent.
* Any concrete which satisfies certain criteria proposed to overcome limitations of conventional concrete may be called as high performance concrete .
* It may include concrete which provides either substantially improved resistance to environmental influences OR substantially increased structural capacity while maintaining adequate durability.
* Concrete may be regarded as high performance for several reasons
* High strength
* High workability
* High durability
* Also improve visual appearance

**PROPERTIES OF HIGH PERFORMANCE CONCRETE**

* Ease of placement
* Compaction without segregation
* Early age strength
* Long term mechanical properties
* Permeability
* Density
* Toughness
* Volume stability
* Long life in severe environments
* Concrete is the most widely used building material. any improvement in the design of this material e.g. cost, durability, or strength ripples through the economy. HPC is a specialized series of concretes designed to provide several benefits in construction of concrete structure.
* Setting time can vary depending on the application and the presence of set modifying admixtures and percentage of the paste composed of Portland cement. The use of large quantities of water reducing admixtures can significantly extend setting time
* The most important property which distinguish HPC from conventional concrete.
* This is due to the refinement of pore structure of microstructure of the cement concrete to achieve a very compact material with very low permeability to ingress of water, air, oxygen, chlorides, sulphates and other deleterious agents.
* High Performance Concrete can be used in severe exposure conditions where there is a danger to concrete by chlorides or sulphates or other aggressive agents as they ensure very low permeability.

**PERFORMANCE BENEFITS**

* Ease of placement and consolidation without affecting strength
* Long term mechanical properties
* Early high strength
* Toughness
* Volume stability
* Longer life in severe environments

**COST& OTHER BENEFITS**

* Less material
* Fewer beams
* Reduced maintenance
* Extended life cycle

**TYPES OF HIGH PERFORMANCE CONCRETE:**

1. Toproc CR – Chemical Resistant concrete
2. Toproc ED – Early Drying concrete
3. Toproc UW – Ultra Water resistant concrete
4. Toproc HR – Heat Resistant concrete
5. Toproc SY – Impact and abrasion resistance

**LIMITATIONS:**

* Concrete can be damaged at very high temperature.
* High Performance Concrete has to be manufactured much more carefully than normal concrete.
* An extended quality control is required
* In concrete plant and at delivery site, additional tests are required. This increases the cost
* Some special constituents are required which may not be available in the ready mix concrete plants.
* HPC become a crucial element of the viability of tall buildings in the region
* High strength to reduce the size of sections
* High durability makes it much important
* It enhance visual effect
* It can bear severe environments

**5.Explain detail about the polymer concrete.**

**POLYMER CONCRETE:**

* Continuous research by concrete technologists to understand, improve and develop the properties of concrete has resulted in a new type of concrete known as, “Polymer Concrete”.
* It is referred time and again in the earlier chapters that the concrete is porous. The porosity is due to air-voids, water voids or due to the inherent porosity of gel structure itself.
* On account of the porosity, the strength of concrete is naturally reduced. It is conceived by many research workers that reduction of porosity results in increase of strength of concrete.
* Therefore, process like vibration, pressure application spinning etc., have been practised mainly to reduce porosity.
* All these methods have been found to be helpful to a great extent, but none of these methods could really help to reduce the water voids and the inherent porosity of gel, which is estimated to be about 28%. The impregnation of monomer and subsequent polymerisation is the latest technique adopted to reduce the inherent porosity of the concrete, to improve the strength and other properties of concrete.
* The pioneering work for the development of polymer concrete was taken up by United States Bureau of Reclamation (USBR). The initial exploratory works carried out at the Brookhaven National Laboratory (BNL) in cooperation with USBR and US in Atomic Energy Commission (AEC) revealed great improvement in compressive strength, permeability, impact resistance and abrasion resistance.
* The development of concrete-polymer composite material is directed at producing a new material by combining the ancient technology of cement concrete with the modern technology of polymer chemistry.

**TYPE OF POLYMER CONCRETE**

* Four types of polymer concrete materials are being developed presently. They are:

(a) Polymer Impregnated Concrete (PIC).

(b) Polymer Cement Concrete (PCC).

(c) Polymer Concrete (PC).

(d) Partially Impregnated and surface coated polymer concrete.

**POLYMER IMPREGNATED CONCRETE (PIC):**

* Polymer impregnated concrete is one of the widely used polymer composite. It is nothing but a precast conventional concrete, cured and dried in oven, or by dielectric heating from which the air in the open cell is removed by vacuum. Then a low viscosity monomer is diffuse through the open cell and polymerised by using radiation, application of heat or by chemical initiation.
* Mainly the following types of monomer are used:

(a) Methylmethacrylate (MMA),

(b) Styrene,

(c) Acrylonitrile,

(d) t-butyl styrene,

(e) Other thermoplastic monomers.

* The amount of monomer that can be loaded into a concrete specimen is limited by the amount of water and air that has occupied the total void space. It is necessary to know the concentration of water and air void in the system to determine the rate of monomer penetration. However, the main research effort has been towards obtaining a maximum monomer loading in concrete by the removal of water and air from the concrete by vacuum or thermal drying, the latter being more practicable for water removal because of its rapidity.
* Another parameter to consider is evacuation of the specimen prior to soaking in monomer. This eliminates the entrapment of air towards the centre of the specimen during soaking which might otherwise prevent total or maximum monomer loading. The applicationof pressure is another technique to reduce monomer loading time.

**POLYMER CEMENT CONCRETE (PCC)**

Polymer cement concrete is made by mixing cement, aggregates, water and monomer.

Such plastic mixture is cast in moulds, cured, dried and polymerised. The monomers that are

used in PCC are:

* + - * (a) Polyster-styrene.
			* (b) Epoxy-styrene.
			* (c) Furans.
			* (d) Vinylidene Chloride.
* However, the results obtained by the production of PCC in this way have been disappointing and have shown relatively modest improvement of strength and durability. Inmany cases, materials poorer than ordinary concrete are obtained. This behaviour is explained by the fact that organic materials (monomers) are incompatible with aqueous systems and sometimes interfere with the alkaline cement hydration process.
* Recently Russian authors have reported the production of a superior Polymer cement concrete by the incorporation of furfuryl alcohol and aniline hydrochloride in the wet mix. Thmaterial is claimed to be specially dense and non-shrinking and to have high corrosion resistance, low permeability and high resistance to vibrations and axial extension.

Washington State University in cooperation with Bureau of Reclamation tested the

* incorporation of several monomers into wet concrete for preparing PCC for fabrication of distillation units for water disalination plants. However, it is reported that only epoxy resin produced a concrete that showed some superior characteristics over ordinary concrete.

**POLYMER CONCRETE (PC)**

* Polymer concrete is an aggregate bound with a polymer binder instead of Portland
* cement as in conventional concrete.
* The main technique in producing PC is to minimise void volume in the aggregate mass so as to reduce the quantity of polymer needed for binding the aggregates. This is achieved by properly grading and mixing the aggregates to attain the maximum density and minimum void volume.
* The graded aggregates are prepacked and vibrated in a mould. Monomer is then diffused up through the aggregates and polymerisation is initiated by radiation or chemical means. A silane coupling agent is added to the monomer to improve the bond strength between the polymer and the aggregate. In case polyester resins are used no polymerisation is required.
* An important reason for the development of this material is the advantage it offers over conventional concrete where the alkaline Portland cement on curing, forms internal voids. Water can be entrapped in these voids which on freezing can readily crack the concrete.
* Also the alkaline Portland cement is easily attacked by chemically aggressive materials which results in rapid deterioration, whereas polymers can be made compact with minimum voids and are hydrophobic and resistant to chemical attack. The strength obtained with PC can be as high as 140 MPa with a short curing period.
* However, such polymer concretes tend to be brittle and it is reported that dispersion of fibre reinforcement would improve the toughness and tensile strength of the material. The use of fibrous polyester concrete (FPC) in the compressive region of reinforced concrete beams provides a high strength, ductile concrete at reasonable cost. Also polyester concretes are viscoelastic in nature and will fail under sustained compressive loading at stress levelsgreater than 50 per cent of the ultimate strength. Therefore, polyester concrete should be considered for structures with a high ratio of live load to dead load and for composite structures in which the polymer concrete may relax during long-term loading. Experiments conducted on FPC composite beams have indicated that they are performance effective when compared to reinforced concrete beam of equal steel reinforcement percentage. Such beams utilise steel in the region of high tensile stress, fibrous polyester concrete (FPC) with its favourable compressive behaviour, in the regions of high compressive stress and Portland cement concrete in the regions of relatively low flexural stress.

**APPLICATION OF POLYMER IMPREGNATED CONCRETE**

Keeping in view the numerous beneficial properties of the PIC, it is found useful in a large number of applications, some of which have been listed and discussed below:

(a ) Prefabricated structural elements.

(b) Prestressed concrete.

(c ) Marine works.

(d) Desalination plants.

(e ) Nuclear power plants.

(f ) Sewage works—pipe and disposal works.

(g) Ferrocement products.

(h) For water proofing of structures.

(i ) Industrial applications.

1. **Prefabricated Structural Elements:**
* For solving the tremendous problem of Urban housing shortage, maintaining quality, economy and speed, builders had to fall back on prefabricated techniques of construction. At present due to the low strength of conventional concrete, the prefabricated sections are large and heavy, resulting in costly handling and erection. These reasons have prevented wide adoption of prefabrication in many countries.
* At present, the technique of polymer impregnation is ideally suited for precast concrete. It will find unquestionable use in industrialisation of building components. Owing to higher strength, much thinner and lighter sections could be used which enables easy handling and erection. They can be even used in high rise building without much difficulties.
1. **Prestressed Concrete:**
* Further development in prestressed concrete is hindered by the inability to produce high strength concrete, compatible with the high tensile steel available for prestressing. Since PIC provides a high compressive strength of the order of 100 to 140 MPa, it will be possible to use it for larger spans and for heavier loads. Low creep properties of PIC will also make it a good material for prestressed concrete.
1. **Marine Works:**
* Aggressive nature of sea water, abrasive and leaching action of waves and inherent porosity, impair the durability of conventional concrete in marine works. PIC, possessing high surface hardness, very low permeability and greatly increased resistance to chemical attack, is a suitable material for marine works.
1. **Desalination Plants:**
* Desalination of sea water is being resorted to augment the shortage of surface and ground water in many countries. The material used in the construction of flash distillation vessels in such works has to withstand the corrosive effects of distilled water, brine and vapour at temperature upto 143°C. Carbon steel vessels which are currently in use are comparatively costly and deteriorate after prolonged use. Preliminary economic evaluation has indicated a savings in construction cost over that of conventional concrete by the use of PIC.
1. **Nuclear Power Plants:**
* To cope up with the growing power requirements for industrial purposes, many countries are resorting to nuclear power generation. The nuclear container vessel (pressure vessel) is a major element which is required to withstand high temperatures and provide shield against radiations. Another attendant problem of nuclear power generation is the containment of spent fuel rods which are radioactive over long period of time to avoid radiation hazards. At present heavy weight concrete is being used for this purpose, which is not very effective. PIC having high impermeability coupled with high strength and marked durability provide an answer to these problems.

**6.Discuss the merits and demerits of RMC**

**READY MIX CONCRETE**

Ready mix concrete is a tailor-made concrete which improves durability and sustainability. Instead of purchasing the raw materials by individuals and experimenting every time with handling and proportioning, it would be far better idea to entrust all these activities to some expert supplier who is having a professional acumen.

**Advantages of Ready Mixed Concrete:**

1. Quality assured concrete:- Concrete is produced under controlled conditions using consistent quality of raw material.
2. High speed of construction- Speed of construction can be vary fast in case RMC is used.
3. Reduction in cement consumption by 10 – 12 % due to better handling and proper mixing. Further reduction is possible if mineral admixtures or cementitious materials are used.
4. Versatility in uses and methods of placing: The mix design of the concrete can be tailor made to suit the placing methods of the contractor.
5. Since ready mixed concrete (RMC) uses bulk cement instead of bagged cement, dust pollution will be reduced and cement will be saved.
6. Conservation of energy and resources because of saving of cement.
7. Environment pollution is reduced due to less production of cement.
8. With better durability of structure, their overall service life increase and there is saving in life-cycle cost.
9. Eliminating or minimizing human error and reduction in dependency on labour.
10. Timely deliveries in large as well as small pours.
11. No need for space for storing the materials like coarse and fine aggregate, cement, water and admixtures.
12. No delay due to site based batching plant erection/ dismantling; no equipment to hire; no depreciation of costs.
13. Reduced noise and air pollution; less consumption of petrol and
diesel and less time loss to business.

**Limitations of Ready Mix Concrete:**

1. As the Ready Mixed Concrete is not available for placement immediately after preparation of concrete mix, loss of workability occurs. In addition, there are chances of setting of concrete if transit time involved is more. Therefore, generally admixture like plasticisers/ super plasticisers and retarders are used. Addition of retarders may delay the setting time substantially which may cause placement problems. In addition, it may also affect the strength of concrete. Therefore, it is necessary that the admixtures i.e. plasticisers and super plasticisers/ retarders used in Ready Mixed Concrete are properly tested for their suitability with the concrete. In case loss of strength is observed, the characteristic strength may have to be enhanced so that after loss of strength, required characteristic strength is available.
2. Because of large quantity of concrete available in short span, special placing and form work arrangement are required to be made in advance.

**7.Explain detail about the geopolymer concrete.**

**GEOPOLYMER CONCRETE:**

* Geopolymer concrete is an alternative of ordinary cement concrete.
* It is prepared by the geopolymer cement.
* Geopolymer cement is the different binder other than ordinary cement
* Alkaline solution induce silica & aluminum atoms to dissolve the fly ash.
* Gel formation started by applying heat.
* Gel binds the concrete contents to form the geopolymer concrete.
* The reduced CO2 emissions of Geopolymer cements make them a **good alternative** to Ordinary Portland Cement.
* Produces a substance that **is comparable to or better** than traditional cements with respect to most properties.
* Geopolymer concrete has excellent properties within both **acid and salt environments.**

**MATERIALS USED IN GEOPOLYMER CONCRETE:**

The following materials have been used in the experimental study

1.Fly Ash (Class C) collected form Raichur Thermal power plant having specific gravity 2.00.

2.Fine aggregate: Sand confirming to Zone having specific gravity 2.51 and fineness modulus of 2.70.

3.Coarse aggregate: Crushed granite metal having specific gravity 2.70 and fineness modulus of 5.85.

4.Water : Clean Potable water for mixing

5.Alkaline Media: Specific gravity of

a.Sodium Hydroxide (NaOH) = 1.16

b.Sodium Silicate (Na2SiO3)= 1.57

**MIXING, CASTING, COMPACTION AND CURING OF GEOPOLYMER CONCRETE**

* GPC can be manufactured by adopting the conventional techniques used in the manufacture of Portland cement concrete. In the laboratory, the fly ash and the aggregates were first mixed together dry on pan for about three minutes. The liquid component of the mixture is then added to the dry materials and the mixing continued usually for another four minutes. (Figure 1 and 2) In preparation of NaOH solution, NaOH pellets were dissolved in one litre of water in a volumetric flask for two different concentration of NaOH (8 and 12M). Alkaline activator with the combination of NaOH and Na2SiO3 was prepared just before the mixing with fly ash. The addition of sodium silicate is to enhance the process of geopolymerization
* . The ratio of fly ash/ alkaline activator and Na2SiO3/ NaOH used in the current study was 2.5 and 3.5 for all the mixes. The fly ash and alkaline activator were mixed together in the mixer until homogeneous paste was obtained. This mixing process can be handled within 5 minutes for each mixture with different molarity of NaOH. Fresh fly ash based geopolymer concrete was usually cohesive. The workability of the fresh concrete was measured by means of conventional slump test. Heat curing of GPC is generally recommended, both curing time and curing temperature influence the compressive strength of GPC
* After casting the specimens, they were kept in rest period for two days and then they were demoulded. The demoulded specimens were kept at 60°C for 24 hours in an oven

**PROPERTIES OF GEOPOLYMER CONCRETE:**

* High compressive strength.
* High tensile strength.
* Rapid strength gain.
* Low shrinkage.
* Sets on room temperature.
* Chemical resistance.
* Higher resistance to heat.

**COMPRESSIVE STRENGTH:**

* The compressive strength of geopolymer is **1.5 times** more than that of ordinary portland cement concrete.
* Workability of geopolymer concrete is better in comparison to ordinary concrete.
* The compressive strength of geopolymer concrete increases as increment in % of fly ash.

**ADVANTAGES:**

* Reduces CO2 emission.
* Utilization of byproducts.(Fly ash)
* Durable.
* Economically sustainable.
* Fire proof.
* Low permeability.
* Chemical resistance.
* High tensile and compression strength.

**DISADVANTAGES:**

* Source of materials: Requires different source materials. Like (Fly ash, Alumina and silica, Alkaline solution, Aggregates.)
* Difficult to create: Requires use of chemicals, such as sodium hydroxide, that can be harmful.
* Pre mix only: Sold only as pre mix/ pre cast material due to mixing is dangerous.

**APPLICATIONS:**

* Precast concrete products like railway sleepers, Parking tiles, geopolymer concrete blocks, etc
* In marine structures due to chemical attacks.
* Where the fire resistance material is required.
* In road construction.

**8.Explain detail about the aerated concrete**

**AERATED CONCRETE**

* Aerated concrete is made by introducing air or gas into a slurry composed of Portland cement or lime and finely crushed siliceous filler so that when the mix sets and hardens, a uniformly cellular structure is formed. Though it is called aerated concrete it is really not a concrete in the correct sense of the word. As described above, it is a mixture of water, cement and finely crushed sand.
* Aerated concrete is also referred to as gas concrete, foam concrete,cellular concrete. In India we have present a few factories manufacturing aerated concrete.
* A common product of aerated concrete in India is Siporex.There are several ways in which aerated concrete can be manufactured.

(a) By the formation of gas by chemical reaction within the mass during liquid or plastic state.

(b) By mixing preformed stable foam with the slurry.

(c) By using finely powdered metal (usually aluminium powder) with the slurry and made to react with the calcium hydroxide liberated during the hydration process, to give out large quantity of hydrogen gas. This hydrogen gas when contained in the slurry mix, gives the cellular structure.

* Powdered zinc may also be added in place of aluminum powder. Hydrogen peroxide and bleaching powder have also been used instead of metal powder. But this practice is not widely followed at present.
* In the second method preformed, stable foam is mixed with cement and crushed sand slurry thus causing the cellular structure when this gets set and hardened. As a minor modification some foam-giving agents are also mixed and thoroughly churned or beaten (in the same manner as that of preparing foam with the white of egg) to obtain foam effect in the concrete. In a similar way, air entrained agent in large quantity can also be used and mixed thoroughly to introduce cellular aerated structure in the concrete.
* However, this method cannot be employed for decreasing the density of the concrete beyond a certain point and as such, the use of air entrainment is not often practised for making aerated concrete.
* Gasification method is of the most widely adopted methods using aluminium powder or such other similar material. This method is adopted in the large scale manufacture of aerated concrete in the factory wherein the whole process is mechanised and the product is subjected to high pressure steam curing i.e., in other words, the products are autoclaved.
* Such products will suffer neither retrogression of strength nor dimensional instability.
* The practice of using preformed foam with slurry is limited to small scale production and in situ work where small change in the dimensional stability can be tolerated. But the advantage is that any density desired at site can be made in this method.

**PROPERTIES**

* Use of foam concrete has gained popularity not only because of the low density but also because of other properties mainly the thermal insulation property.
* Aerated concrete is made in the density range from 300 kg/m3 to about 800 kg/m3.
* Lower density grades are used for insulation purposes, while medium density grades are used for the manufacture of building blocks or load bearing walls and comparatively higher density grades are used in the manufacture of prefabricated structural members in conjunction with steel reinforcement.

**9.Expalin about High strength concrete.**

**HIGH STRENGTH CONCRETE**

* Using Type I Portland cement, gravel or crushed limestone coarse aggregate, sand from a local deposit, and for some mixes a water-reducing retarding admixture.
* Water-cement ratios ranged from 0.70 to 0.32
* Concrete strength of 90-120 MPa
* Uniaxial compressive strengths ranged from about 21 to 76 MPa.

* Pertaining to compressive strength, strength gain with age, specimen size effect, effects of drying, stress-strain curves, static modulus of elasticity, Poisson’s ratio, modulus of ruptuie, and split cylinder strength.

* Has to take care about mix proportioning, shape of aggregates, use of supplementary cementitious materials, silica fume and super plasticizers.

**Special methods of making high strength concrete**

* ***Seeding*:** This involves adding a small percentage of finely ground, fully hydrated Portland cement to the fresh concrete mix
* This method may not hold much promise.
* ***Revibration*:** Controlled revibration removes all the defects like bleeding, water accumulates , plastic shrinkage, continuous capillary channels and increases the strength of concrete.
* *High speed slurry mixing*: This process involves the advance preparation of cement - water mixture which is then blended with aggregate to produce concrete.
* ***Use of admixtures*:** Use of water reducing agents are known to produce increased compressive strength.
* *Inhibition of cracks*: If the propagation of cracks is inhibited, the strength will be higher.

 Concrete cubes made this way have yielded strength up to 105MPa.

* ***Sulphur Impregnation*:** Satisfactory high strength concrete have been produced by impregnating low strength porous concrete by sulphur.

 The sulphur infiltrated concrete has given strength up to 58MPa.

* ***Use of Cementitious aggregates*:** Cement fondu is kind of clinker.

 Using Alag as aggregate, strength up to 25MPa has been obtained with water cement ratio 0.32.