UNIT-V

SPECIAL CONCRETE

1. What is the density of concrete?

The density of concrete varies between 2200 t0 2600 kg/m^3

2. Define light weight concrete.

The concrete is said to be light weight concrete whose density is between 300 to 1850 kg/m^3

3. Define High density concrete

The concrete is said to be High density concrete whose density is between 3360 to 3840 kg/m^3.

4. Name some of the natural light weight aggregate
   a. Pumice
   b. Diatiomite
   c. Scoria
   d. Volcanic cinders
   e. Saw dust
   f. Rice husk

5. Name some of the artificial light weight aggregate
   a. Brick bat
   b. Foamed slag
   c. Cinder, clinker
   d. Bloated clay
   e. Sintered fly ash
   f. Exfoliated vermiculite
   g. Expanded perlite

6. Where does high density concrete is applicable.

High density concrete is used as radiation shielding agent and it has satisfactory mechanical property .

7. Mention the applications of sulphur infiltrated concrete

a. Pre cast industry

b. Fencing post

c. Sewer pipes

d. Railway sleepers

8. Define Guniting or Shotcrete?

It is defined as a mortar conveyed through a hose and pneumatically projected at a high velocity on to a surface.

16 Mark Questions

1.Explain the light-weight concrete in details?

One of the disadvantages of conventional concrete is the high self weight of concrete. Density of the normal concrete is in the order of 2200 to 2600 kg/m^3. This heavy self weight will make it to some extent an uneconomical structural material. Attempts have been made in the past to reduce the self weight of concrete to increase the efficiency of concrete as a structural material. The light-weight concrete as we call is a concrete whose density varies from 300 to 1850 kg/m^3.

There are many advantages of having low density. It helps in reduction of dead load, increases the progress of building, and lowers haulage and handling costs. The weight of a building on the foundation is an important factor in design, particularly in the case of weak soil and tall structures. In framed structures, the beams and columns have to carry load of floors and walls. If floors and walls are made up of light-weight concrete it will result in considerable economy. Another most important characteristic of light-weight concrete is the relatively low thermal conductivity, a property which improves with decreasing density. In extreme climatic conditions and also in case of buildings where air-conditioning is to be installed, the use of light-weight concrete with low thermal conductivity will be of considerable advantage from the point of view of thermal comforts and lower power consumption. The adoption of light-weight concrete gives an outlet for industrial wastes such as clinker, fly ash, slag etc. which otherwise create problem for disposal.

Basically there is only one method for making concrete light *i.e.*, by the inclusion of air in concrete. This is achieved in actual practice by three different ways.

(a) By replacing the usual mineral aggregate by cellular porous or light-weight aggregate.

(b) By introducing gas or air bubbles in mortar. This is known as aerated concrete.

(c) By omitting sand fraction from the aggregate. This is called 'no-fines' concrete.

The Table 12.1 shows the whole ranges of light-weight concrete under three main groups.

Groups of Light-weight Concrete **Groups of Light-weight Concrete**

No-fines Concrete	Light-weight aggregate	Aerated Concrete	
		Chemical	Foaming mixture

(a) Gravel (b) Crushed stone (c) Coarse clinker (*d*) Sintered pulverised fuel ash (*e*) Expanded clay or shale (*f*) Expanded slate	(a) Clinker (b) Foamed slag (c) Expanded clay (d) Expanded shale (e) Expanded slate (f) Sintered pulverised fuel ash (g) Exfoliated	(a) Aluminium powder method (b) Hydrogen peroxide and bleaching powder method	(a) Preformed foam (b) Air-entrained foam

Light-weight concrete has become more popular in recent years owing to the tremendous advantages it offers over the conventional concrete. Modern technology and a better understanding of the concrete has also helped much in the promotion and use of light-weight concrete. A particular type of light-weight concrete called structural light-weight concrete is the one which is comparatively lighter than conventional concrete but at the same time strong enough to be used for structural purposes. It, therefore, combines the advantages of normal normal weight concrete and discards the disadvantages of normal weight concrete. Perhaps this type of concrete will have great future in the years to-come. Out of the three main groups of light-weight concrete, the light-weight aggregate concrete and aerated concrete are more often used than the 'no-fines' concrete. Light-weight concrete can also be classified on the purpose for which it is used, such as structural light weight concrete, non-load bearing concrete and insulating concrete. The aerated concrete which was mainly used for insulating purposes is now being used for structural purposes sometimes in conjunction with steel reinforcement. The aerated concrete is more widely manufactured and used in the Scandinavian countries; whereas in U.K., France, Germany and U.S.A. owing to the production of large scale artificial industrial light-weight aggregate, light-weight aggregates concrete is widely used. In some countries the natural dense graded aggregate are either in short supply or they are available at a considerable distance from the industrial cities. In such cases the use of locally produced light-weight aggregates in the city area offers more economical solutions. These factors have led to the development and widespread use of considerable varieties of industrial light-weight aggregates of varying quality by trade names such as Leca (expanded clay), Aglite (expanded shale), Lytag (sintered pulverised fuel ash), Haydite (expanded shale).

Light Weight Aggregates

Light-weight aggregates can be classified into two categories namely natural light-weight aggregates and artificial light-weight aggregates.

Natural light-weight aggregate	*Artificial light-weight aggregate*
(*a*) Pumice	(a) Artificial cinders
(*b*) Diatomite	(*b*) Coke breeze
(*c*) Scoria	(*c*) Foamed slag
(*d*) Volcanic cinders	(*d*) Bloated clay
(*e*) Sawdust	(*e*) Expanded shales and
(*f*) Rice husk	(*f*) Sintered fly ash
	(*g*) Exfoliated vermiculite
	(*h*) Expanded perlite
	(*i*) Thermocole beads.

Natural Aggregates

Natural light-weight aggregates are not found in many places and they are also not of uniform quality. As such they are not used very widely in making light-weight concrete. Out of the natural light-weight aggregates pumice is the only one which is used rather widely.

Pumice

These are rocks of volcanic origin which occur in many parts of the world. They are light enough and yet strong enough to be used as light-weight aggregate. Their lightness is due to the escaping of gas from the molten lava when erupted from deep beneath the earth's crest. Pumice is usually light coloured or nearly white and has a fairly even texture of interconnected cells.

Pumice is one of the oldest kinds of light-weight aggregates which has been even used in Roman structures. Pumice is mined, washed and then used. Pumice may be sintered to the point of incipient fusion when a much stronger aggregate is required. The density and other properties of pumice concrete can be seen from Table 12.3.

Diatomite

This is a hydrated amorphous silica derived from the remains of microscopic aquatic plants called diatoms. It is also known a Kieselguhr. The deposits of this aquatic plants are formed beneath the deep ocean bed. Subsequently when the ocean bed is raised and becomes continent, the diatomaceous earth become available on land. In pure form diatomite has an average weight of 450 kg/m^3. But due to impurities, the naturally available diatomite may weight more than 450 kg/m^3. It has been pointed out earlier that diatomite is used as a workability agent and also as one of the good pozzolanic material. Diatomite or diatomaceous earth can also be sintered in rotary kilns to make artificial light-weight aggregates.

Scoria

Scoria is also light-weight aggregate of volcanic origin which is usually dark in colour and contains larger and irregularly shaped cells unconnected with each other. Therefore, it is slightly weaker than pumice.

Volcanic Cinders

These are also loose volcanic product resembling artificial cinder.

Saw Dust

Sometimes saw dust is used as a light-weight aggregate in flooring and in the manufacture of precast products. A few difficulties have been experienced for its wide-spread use. Saw dust affect adversely the setting and hardening of Portland cement owing to the content of tannins and soluble carbohydrates. With saw dust manufactured from soft wood, the addition of lime to the mix in an amount equal to about 1/3 to 1/2 the volume of cement will counteract this. But the above method *i.e.*, addition of lime is not found effective when the saw dust is made from some of the hard woods. Others methods such as boiling in water and ferrous sulphate solutions also have been tried to remove the effect of tannins, but the cost of the process limits its application. To offset the delay in setting and hardening, addition of calcium chloride to the extent of about 5 per cent by weight of cement has been found to be successful.

The shrinkage and moisture movement of saw dust is also high. The practical mix is of the ratio of 1 : 2 to 1 : 3 *i.e.*, cement to saw dust by volume.

Saw dust concrete has been used in the manufacture of precast concrete products, jointless flooring ad roofing tiles. It is also used in concrete block for holding the nail well. Wood aggregate also has been tried for making concrete. The wood wool concrete is made by mixing wood shavings with Portland cement or gypsum for the manufacture of precast blocks. This has been used as wall panels for acoustic purposes.

Rice Husk

Limited use of the rice husk, groundnut husk and bagasse have been used as light-weight aggregate for the manufacture of light-weight concrete for special purposes.

Artificial Aggregates Brick

Bats

Brick bats are one of the types of aggregates used in certain places where natural aggregates are not available or costly. The brick bat aggregates cannot be really brought under light-weight aggregates because the concrete made with this aggregate will not come under the category of light-weight concrete. However since the weight of such concrete will be less than the weight of normal concrete it is included here. Wherever brick bat aggregates are used, the aggregates are made from slightly overburnt bricks, which will be hard and absorb less water. Brick bat aggregates are also sometimes used in conjunction with high alumina cement for the manufacture of heat resistant concrete.

Cinder, Clinker and Breeze

The term clinker, breeze and cinder are used to cover the material partly fused or sintered particles arising from the combustion of coal. These days the use of these materials as light-weight aggregate in the form of coarse or fine aggregate is getting abated owing to the wider use of pulverised coal rather than lumps of coal. Cinder aggregates undergo high drying shrinkage and moisture movement. Cinder aggregates have been also used for making building blocks for partition walls, for making screeding over flat roofs and for plastering purposes.

The unsoundness of clinker or cinder aggregates is often due to the presence of excessive unburnt coal particles. Sometimes unburnt particles may be present as much as 15 to 25%. This high proportion of coal expand on wetting and contract on drying which is responsible for the unsoundness of concrete made with such aggregate.

Foamed Slag

Foamed slag is one of the most important types of light-weight aggregates. It is made by rapidly quenching blast furnace slag, a by-product, produced in the manufacture of pig iron. If the cooling of the slag is done with a large excess of water, granulated slag is formed which is used in the manufacture of blast furnace slag cement. If the cooling done with a limited amount of water, in such a way as to trip steam in mass, it produces a porous, honeycombed material which resembles pumice. Sometimes, the molten slag is rapidly agitated with a limited amount of water and the steam and gas produced are made to get entrapped in the mass. Such a product is also called foamed slag or expanded slag.

The texture and strength of foamed slag depends upon the chemical composition and the method of production. But in general, the structure is similar to that of natural pumice. The foamed slag must be

(a) Free from contamination of heavy impurities

(b) Free from volatile impurities such as coke or coal.

(c) Free from excess of sulphate.

In India foamed slag is manufactured in many steel mills. In Mysore. Iron and Steel Works at Bhadravati large quantity of foamed slag is being manufactured. Industries have come up near the steel mills to manufacture ready-made building blocks and partition wall pnels. Such prefabricated items being lighter in weight, could be transported at comparatively low cost. Foamed slag is also used for the manufacture of precast RCC lintels and other small structural numbers. By controlling the density, foamed slag can be used for load bearing walls and also for the production of structural light-weight concrete.

Bloated Clay

When certain glass and shales are heated to the point of incipient fusion, they expand or what is termed as bloat to many times their original volume on account of the formation of gas within the mass at the fusion temperatures. The cellular structure so formed is retained on cooling and the product is used as light-weight aggregate. “Haydite”, “Rocklite”, “Gravelite”, “Leca”, “Aglite”, “Kermazite” are some of the patent names given to bloated clay or shale manufactured in various western countries adopting different techniques.

Sintered Fly Ash (Pulverised Fuel Ash)

Fly ash is finely divided residue, comprising of spherical glassy particles, resulting from the combustion of powdered coal. By heat treatment these small particles can be made to combine, thus forming porous pellets or nodules which have considerable strength.

The fly ash is mixed with limited amount of water and is first made into pellets and then sintered at a temperature of 1000° to 1200°C. The sintering process is nearly similar to that used in the manufacture of Portland cement. The fly ash may contain some unburnt coal which may vary from 2 to 15 per cent or more depending upon the efficiency of burning. The aim is always to make use of the fuel present in the fly ash and to avoid the use of extra fuel which incidentally improves the quality of sintered fly ash.

Expanded Perlite

Perlite is one of the natural volcanic glasses like pumice. This when crushed and heated to the point of incipient fusion at a temperature of about 900 to 1100°C it expands to form a light cellular material with density of about 30 to 240 kg/m^3. This light material is crushed carefully to various sizes and used in concrete. Due to its very low density this is also used for insulation grade concrete.

2.Explain the Aerated Concrete in details?

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 at 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/m^3 to about 800 kg/m^3. 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

No-fines Concrete

The third method of producing light concrete is to omit the fines from conventional concrete.

No-fines concrete as the term implies, is a kind of concrete from which the fine aggregate fraction has been omitted. This concrete is made up of only coarse aggregate, cement and water. Very often only single sized coarse aggregate, of size passing through 20 mm retained on 10 mm is used. No-fines concrete is becoming popular because of some of the advantages it possesses over the conventional concrete.

The single sized aggregates make a good no-fines concrete, which in addition to having large voids and hence light in weight, also offers architecturally attractive look.

Drying Shrinkage

The drying shrinkage of no-fines concrete is considerably lower than that of conventional concrete. No-fines concrete made with river gravel, may show a drying shrinkage of the order of 200×10^{-6} which is only about 50% of the conventional concrete. Since there is only a very thin layer of paste existing between aggregates and aggregates, and since the aggregate are having point to point contact, the value of drying shrinkage becomes low. However, the rate of drying shrinkage is generally much higher than conventional concrete. For no-fines concrete 50 to 80% of the total drying shrinkage takes place within about 10 days. The corresponding value for conventional concrete in 10 days is 20 to 30%. Further all the drying shrinkage will get completed in just over a month.

Compressive Strength of No-fines Concrete Made with Different Grading of Crushed Limestone

Water cement ratio by weigh	Aggregate grading	Aggregate cement ratio by weight	Cement content kg/m^3	Unit weight of fresh concrete	Compressive strength of 150 x 300 mm	
					7 days MPa	28 days MPa
0.36	A	8 : 1	35	1910	7.1	8.4
			36	1871	4.8	6.7
			36	1858	5.5	7.5
			36	1813	6.0	5.6
0.36	B	9 : 1	368	1884	4.7	7.1
			360	1820	4.0	5.7
			364	1801	4.4	5.1
0.36	C	7 : 1	36	1877	7.4	8.8
			36	1851	5.4	7.1
			36	1826	5.6	6.9
			36	1826	6.5	6.5

3.Explain the Sulphur-Infiltrated Concrete in details?

New types of composites have been produced by the recently developed techniques of impregnating porous materials like concrete with sulphur. Sulphur impregnation has shown great improvement in strength. Physical properties have been found to improve by several hundred per cent and large improvements in water impermeability and resistance to corrosion have also been achieved.

In the past, some attempts have been made to use sulphur as a binding material instead of cement. Sulphur is heated to bring it into molten condition to which coarse and fine aggregates are poured and mixed together. On cooling, this mixture gave fairly good strength, exhibited acid resistance and also other chemical resistance, but it proved to be costlier than ordinary cement concrete.

Recently, use of sulphur was made to impregnate lean porous concrete to improve its strength and other useful properties considerably. In this method, the quantity of sulphur used is also comparatively less and thereby the processes is made economical. It is reported that compressive strength of about 100 MPa could be achieved in about 2 day's time. The following procedures have been reported in making sulphur-infiltrated concrete.[12.6]

A coarse aggregate of size 10 mm and below, natural, well graded, fine aggregate and commercial sulphur of purity 99.9 per cent are used. A large number of trial mixes are made to determine the best mix proportions. A water/cement ratio of 0.7 or over has been adopted in all the trials. A number of 5 cm cubes, 7.5 cm x 15 cm cylinders and also 10 cm x 20 cylinders are cast from each batch of concrete. These samples are stored under wet cover for

24 hours, after which they are removed from moulds and the densities determined. Control specimens are moist cured at 24°C for 26 hours.

Two procedures are adopted. In procedure “A” after 24 hours of moist curing, the specimen is dried in heating cabinet for 24 hours at 121°C. Then the dried specimen are placed in a container of molten sulphur at 121°C for 3 hours. Specimens are removed from the container, wiped clean of sulphur and cooled to room temperature for one hour and weighed to determine the weight of sulphur infiltrated concrete.

In procedure “B”, the dried concrete specimen is placed in an airtight container and subjected to vacuum pressure of 2 mm mercury for two hours. After removing the vacuum, the specimens are soaked in the molten sulphur at atmospheric pressure for another half an hour. The specimen is taken out, wiped clean and cooled to room temperature in about one hour. The specimen is weighed and the weight of sulphur-impregnated concrete is determined.

The specimens made adopting procedure A and B are tested by compression and splitting tension tests. It is seen that the compression strength of sulphur-infiltrated cubes and cylinders are enormously greater than the strength of plain moist cured specimen. It is found that when water/cement ratio of 0.7 is adopted an achievement of about 7 fold increase in the strength of the test cube when procedure B is adopted and five-fold increase in strength when procedure A is adopted was obtained. When water/cement ratio of 0.8 is adopted, procedure B gave about a tenfold increase in strength.

Similarly, the sulphur-infiltrated concrete showed more than four times increase in splitting tensile strength when procedure B was adopted.

It was also found that the elastic properties of sulphur-infiltrated concrete has been generally improved 100 per cent and also sulphur-infiltrated specimen showed a very high resistance to freezing and thawing. When the moist cured concrete was disintegrated after about 40 cycles, the sulphur impregnated concrete was found to be in fairly good condition, even after 1230 cycles, when procedure B was adopted and the sample deteriorated after 480 cycles when the sample was made by procedure A. Table 12.8 and Table 12.9, show the typical values of strength test conducted.

The improvement in strength test attributed to the fact that porous bodies having randomly distributed pores have regions of stress concentration when loaded externally. The impregnation of a porous body by some material would modify these stress concentrations. The extent of modification will depend on how well the impregnant has penetrated the smaller pores.

Application of Sulphur-infiltrated Concrete

The sulphur-infiltration can be employed in the precast industry. This method of achieving high strength can be used in the manufacture of pre-cast roofing elements, fencing posts, sewer pipes, and railway sleepers, Sulphur-infiltrated concrete should find considerable use in industrial situations, where high corrosion resistant concrete is required. This method cannot be conveniently applied to cast-in place concrete.

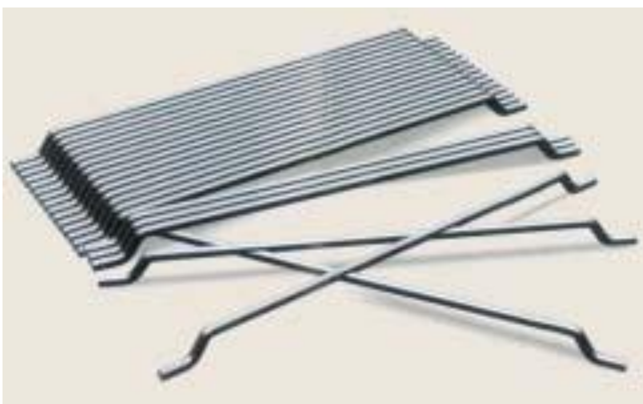
Preliminary studies have indicated that sulphur-infiltrated precast concrete units is cheaper than commercial concrete. The added cost of sulphur and process should be offset by considerable savings in concrete.

The techniques are simple, effective and inexpensive. The tremendous strength gained in pressure application, wherein immersion accompanied by evacuation may also offset the extra cost. The attainment of strength in about two days time makes this process all the more attractive.

4.Explain the fibre reinforced concrete in details?

Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal microcracks are inherently present in the concrete and its poor tensile strength is due to the propagation of such microcracks, eventually leading to brittle fracture of the concrete.

In the past, attempts have been made to impart improvement in tensile properties of concrete members by way of using conventional reinforced steel bars and also by applying



restraining techniques. Although both these methods provide tensile strength to the concrete members, they however, do not increase the inherent tensile strength of concrete itself.

In plain concrete and similar brittle materials, structural cracks (micro-cracks) develop even before loading, particularly due to drying shrinkage or other causes of volume change. The width of these initial cracks seldom exceeds a few microns, but their other two dimensions may be of higher magnitude.

When loaded, the micro cracks propagate and open up, and owing to the effect of stress concentration, additional cracks form in places of minor defects. The structural cracks proceed slowly or by tiny jumps because they are retarded by various obstacles, changes of direction in bypassing the more resistant grains in matrix. The development of such microcracks is the main cause of inelastic deformations in concrete.

It has been recognised that the addition of small, closely spaced and uniformly dispersed fibres to concrete would act as crack arrester and would substantially improve its static and dynamic properties. This type of concrete is known as Fibre Reinforced Concrete.

Fibre reinforced concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibres. Continuous meshes, woven fabrics and long wires or rods are not considered to be discrete fibres.

Fibres Used

Fibre is a small piece of reinforcing material possessing certain characteristic properties. They can be circular or flat. The fibre is often described by a convenient parameter called "aspect ratio". The aspect ratio of the fibre is the ratio of its length to its diameter. Typical aspect ratio ranges from 30 to 150.

Steel fibre is one of the most commonly used fibre. Generally, round fibres are used. The diameter may vary from 0.25 to 0.75 mm. The steel fibre is likely to get rusted and lose some of its strengths. But investigations have shown that the rusting of the fibres takes place only at the surface. Use of steel fibre makes significant improvements in flexural, impact and fatigue strength of concrete, It has been extensively used in various types of structures, particularly for overlays of roads, airfield pavements and bridge decks. Thin shells and plates have also been constructed using steel fibres.

Factors Effecting Properties of Fibre Reinforced Concrete

Fibre reinforced concrete is the composite material containing fibres in the cement matrix in an orderly manner or randomly distributed manner. Its properties would obviously, depend upon the efficient transfer of stress between matrix and the fibres, which is largely dependent on the type of fibre, fibre geometry, fibre content, orientation and distribution of the fibres, mixing and compaction techniques of concrete, and size and shape of the aggregate. These factors are briefly discussed below:

Relative Fibre Matrix Stiffness

The modulus of elasticity of matrix must be much lower than that of fibre for efficient stress transfer. Low modulus of fibers such as nylons and polypropylene are, therefore, unlikely to give strength improvement, but they help in the absorption of large energy and, therefore, impart greater degree of toughness and resistance to impact. High modulus fibres such as steel, glass and carbon impart strength and stiffness to the composite.

Volume of Fibres

The strength of the composite largely depends on the quantity of fibres used in it. Fig. 12.5 and Fig. 12.6 show the effect of volume on the toughness and strength . It can be seen from Fig. 12.6 that the increase in the volume of fibres, increase approximately linearly, the tensile strength and toughness of the composite. Use of higher percentage of fibre is likely to cause segregation and harshness of concrete and mortar.

Aspect Ratio of the Fibre

Another important factor which influences the properties and behaviour of the composite is the aspect ratio of the fibre. It has been reported that upto aspect ratio of 75, increase in the aspect ratio increases the ultimate strength of the concrete linearly. Beyond 75, relative strength and toughness is reduced. Table 12.10 shows the effect of aspect ratio on strength and toughness.

Effect of Aspect Ratio on Strength and Toughness

Type of Concrete	Aspect Ratio	Relative strength	Relative toughness
Plain concrete	0	1.00	1.0
with	25	1.50	2.0
Randomly	50	1.60	8.0
dispersed fibres	75	1.70	10.5
	100	1.50	8.5

Workability and Compaction of Concrete

Incorporation of steel fibre decreases the workability considerably. This situation adversely affects the consolidation of fresh mix. Even prolonged external vibration fails to compact the concrete. The fibre volume at which this situation is reached depends on the length and diameter of the fibre.

Another consequence of poor workability is non-uniform distribution of the fibres. Generally, the workability and compaction standard of the mix is improved through increased water/cement ratio or by the use of some kind of water reducing admixtures.

Size of Coarse Aggregate

Several investigators recommended that the maximum size of the coarse aggregate should be restricted to 10 mm, to avoid appreciable reduction in strength of the composite. Fibres also in effect, act as aggregate. Although they have a simple geometry, their influence on the properties of fresh concrete is complex.

Applications

Fibre reinforced concrete is increasingly used on account of the advantages of increased static and dynamic tensile strength, energy absorbing characteristics and better fatigue strength. The uniform dispersion of fibres throughout the concrete provides isotropic properties not common to conventionally reinforced concrete. Fibre reinforced concrete has been tried on overlays of air-field, road pavements, industrial floorings, bridge decks, canal lining, explosive resistant structures, refractory linings etc. The fibre reinforced concrete can also be used for the fabrication of precast products like pipes, boats, beams, stair case steps, wall panels, roof panels, manhole covers etc... Fibre reinforced concrete sometimes called fibrous concrete, is manufactured under the trade name “Wirand Concrete”. After extensive research, the Wirand concrete is used very extensively in United States. Fibre reinforced concrete in also being tried for the manufacture of prefabricated formwork moulds of “U” shape for casting lintels and small beams.

5.Explain the Polymer Concrete in details?

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.difficulties and balling tendencies. A steel fibre content in excess of 2 per cent by volume and an aspect ratio of more than 100 are difficult to mix. The typical proportions for fibre reinforced concrete is given below:

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.

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 diffused 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.

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. In many 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.

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.

Partially Impregnated (or Coated in Depth CID) and Surface Coated (SC) Concrete

Partial impregnation may be sufficient in situations where the major requirement is surface resistance against chemical and mechanical attack in addition to strength increase. Even with only partial impregnation, significant increase in the strength of original concrete has been obtained. The partially impregnated concrete could be produced by initially soaking the dried specimens in liquid monomer like methyl methacrylate, then sealing them by keeping them under hot water at 70°C to prevent or minimise loss due to evaporation. The polymerisation can be done by using thermal catalytic method in which three per cent by weight of benzoyl peroxide is added to the monomer as a catalyst. It is seen that the depth of monomer penetration is dependent upon following:

(a) Pore structure of hardened and dried concrete.
(b) The duration of soaking, and
(c) The viscosity of the monomer.

The potential application of polymer impregnated concrete surface treatment (surface coated concrete, SC) is in improving the durability of concrete bridge decks. Bridge deck deterioration is a serious problem everywhere, particularly due to a abrasive wear, freeze-thaw deterioration, spalling and corrosion of reinforcement. Excellent penetration has been achieved by ponding the monomer on the concrete surface. Due care should be taken to prevent evaporation of monomer when ponded on concrete surface. A 5 cms thick slab, on being soaked by MMA for 25 hours produced a polymer surface coated depth of 2.5 cms. Significant increases in the tensile and compressive strengths, modulus of elasticity and resistance to acid attack have been achieved.

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.