Unit 6

Special concretes

Introduction

- 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/m3.
- 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/m3.

- 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,
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- 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***

Groups of light weight concrete

Table 12.1. Groups of Light-weight Concrete

No-fines Concrete	*Light-weight aggregate concrete*	*Aerated Concrete*	
		Chemical aerating	*Foaming mixture*
(*a*) Gravel	(*a*) Clinker	(*a*) Aluminium powder method	(*a*) Preformed foam
(*b*) Crushed stone	(*b*) Foamed slag	(*b*) Hydrogen peroxide and bleaching powder method	(*b*) Air-entrained foam
(*c*) Coarse clinker	(*c*) Expanded clay		
(*d*) Sintered pulverised fuel ash	(*d*) Expanded shale		
(*e*) Expanded clay or shale	(*e*) Expanded slate		
(*f*) Expanded slate	(*f*) Sintered pulverised fuel ash		
(*g*) Foamed Slag	(*g*) Exfoliated vermiculite		
	(*h*) Expanded perlite		
	(*i*) Pumice		
	(*j*) Organic aggregate		

- 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.
- 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.
- 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 slate
(*f*) Rice husk	(*f*) Sintered fly ash
	(*g*) Exfoliated vermiculite
	(*h*) Expanded perlite
	(*i*) Thermocole beads.

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Table 12.2. Typical Properties of Common Light-weight Concretes

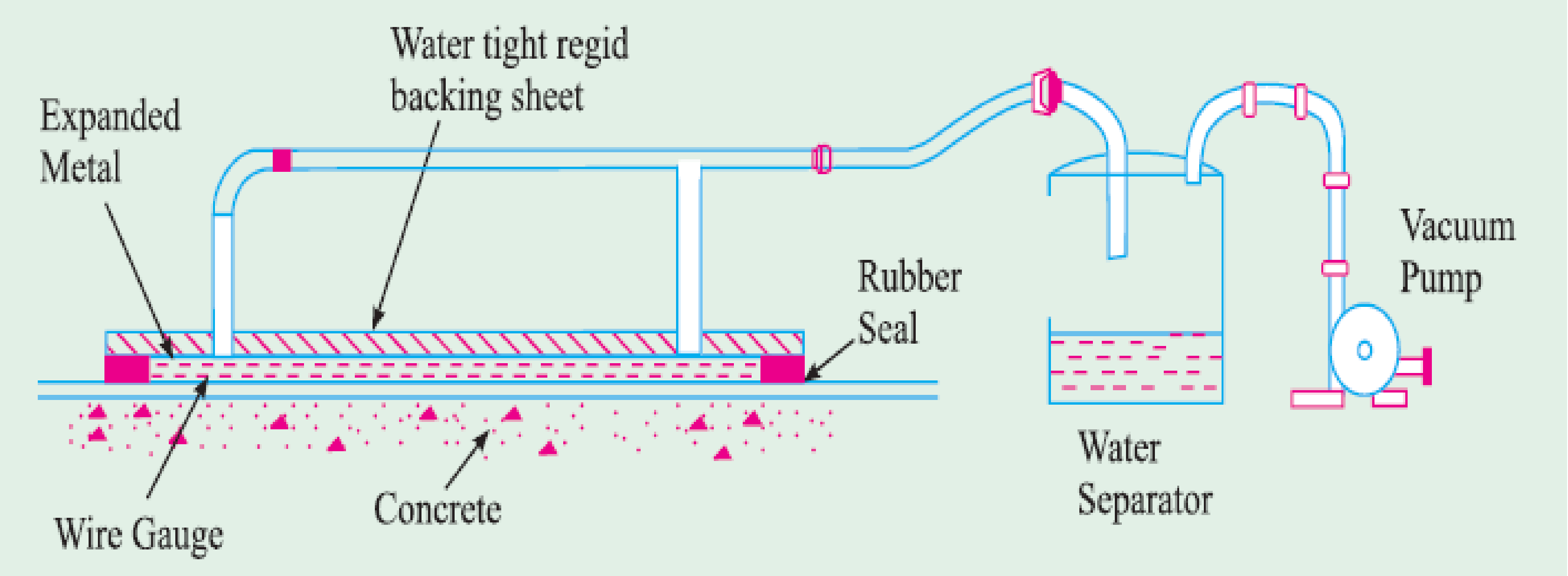
Sl. No.	Type of Concretes		Bulk density of aggregates kg/m³	Dry density of kg/m³	Compressive strength of 28 days	Drying Shrinkage 10^{-6}	Thermal conductivity Jm/m² 5°C
1.	Sintered fly ash						
		Fine	1050	1500	25	300	–
		Coarse	800	1540	30	350	–
2.	Sintered fly ash with natural sand						
		Coarse	800	1700	25	300	–
3.	Pumice		500–800	1200	15	1200	0.14
4.	Perlite		40–200	400–500	1.2–3.0	2000	0.05
5.	Vermiculite		60–200	300–700	0.3–3.0	3000	0.10
6.	Cellular (Fly ash)		950	750	3.0	700	0.19
		Sand	1600	900	6.0	–	0.22
7.	Autoelaved aerated		–	800	4.0	800	0.25

- Most of the light-weight aggregates have a high and rapid absorption quality. This is one of the important difficulties in applying the normal mix design procedure to the light-weight concrete.
- But it is possible to water-proof the light-weight aggregate by coating it with Bitumen or such other materials by using a special process.
- The coating of aggregate by Bitumen may reduce the bond strength between aggregate and paste.
- Coating of aggregate by silicon compounds does not impair the bond characteristics but at the same time makes it non absorbant.

- Light-weight concrete being comparatively porous, when used for reinforced concrete, reinforcement may become prone to corrosion.
- Either the reinforcement must be coated with anticorrosive compound or the concrete must be plastered at the surface by normal mortar to inhibit the penetration of air and moisture inside.

Vacuum Concrete

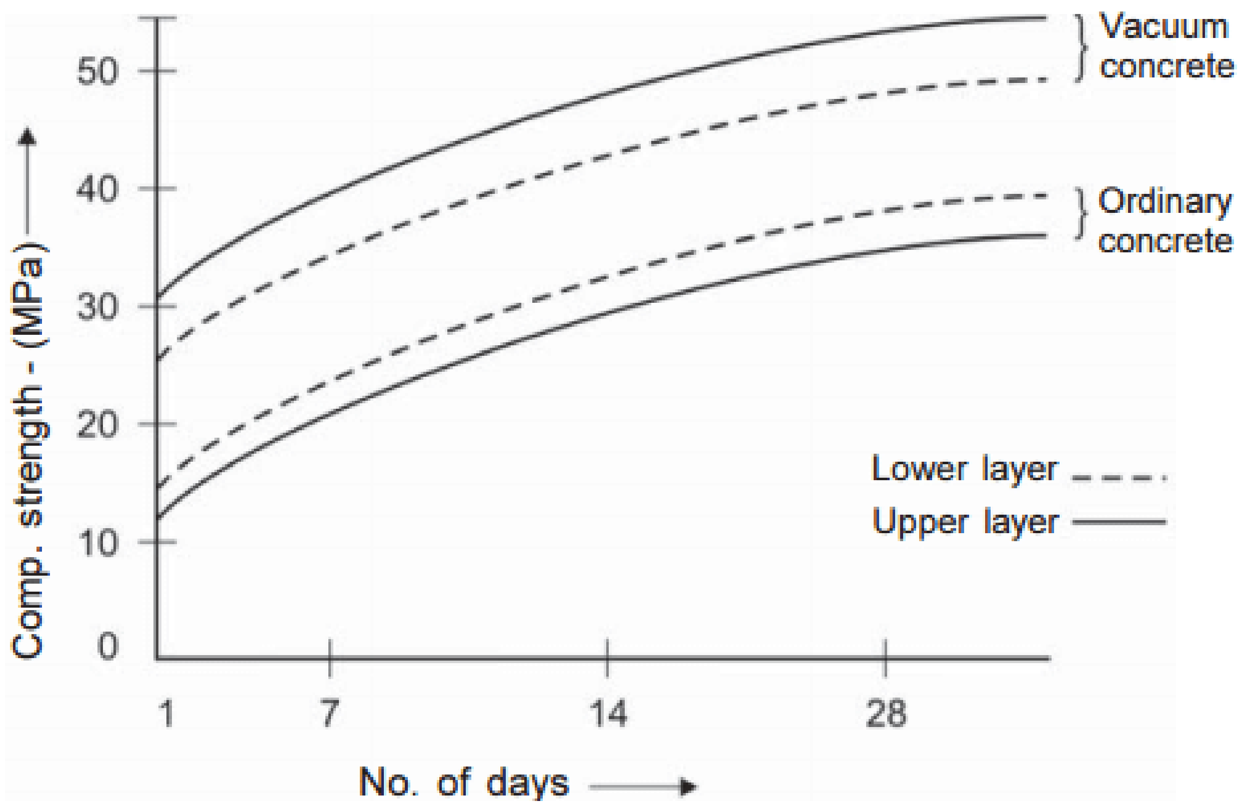
- It has been amply brought out in the earlier discussion that high water/cement ratio is harmful to the overall quality of concrete, whereas low water/cement ratio does not give enough workability for concrete to be compacted hundred per cent.
- Generally, higher workability and higher strength or very low workability and higher strength do not go hand in hand.
- Vacuum process of concreting enables to meet this conflicting demand. This process helps a high workable concrete to get high strength.
- In this process, excess water used for higher workability, not required for hydration, and harmful in many ways to the hardened concrete is withdrawn by means of vacuum pump, subsequent to the placing of the concrete.



The equipment is shown in Figure . It essentially consists of a vacuum pump, water
separator and filtering mat. The filtering consists of a backing piece with a rubber seal all round the periphery. A sheet of expanded metal and then a sheet of wire gauge also forms part of the filtering mat.

- The top of the suction mat is connected to the vacuum pump. When the
- vacuum pump operates, suction is created within the boundary of the suction mat and the excess of water is sucked from the concrete through the fine wire gauge or muslin cloth.
- At least one face of the concrete must be open to the atmosphere to create difference of pressure.The contraction of concrete caused by loss of water must be vibrated.
- The vacuum processing can be carried out either from the top surface or from the side surface. There will be only nominal difference in the efficiency of top processing or sideprocessing.
- It has been seen that the size of the mat should not be less than 90 cm x 60 cm. Smaller mat was not found to be effective.

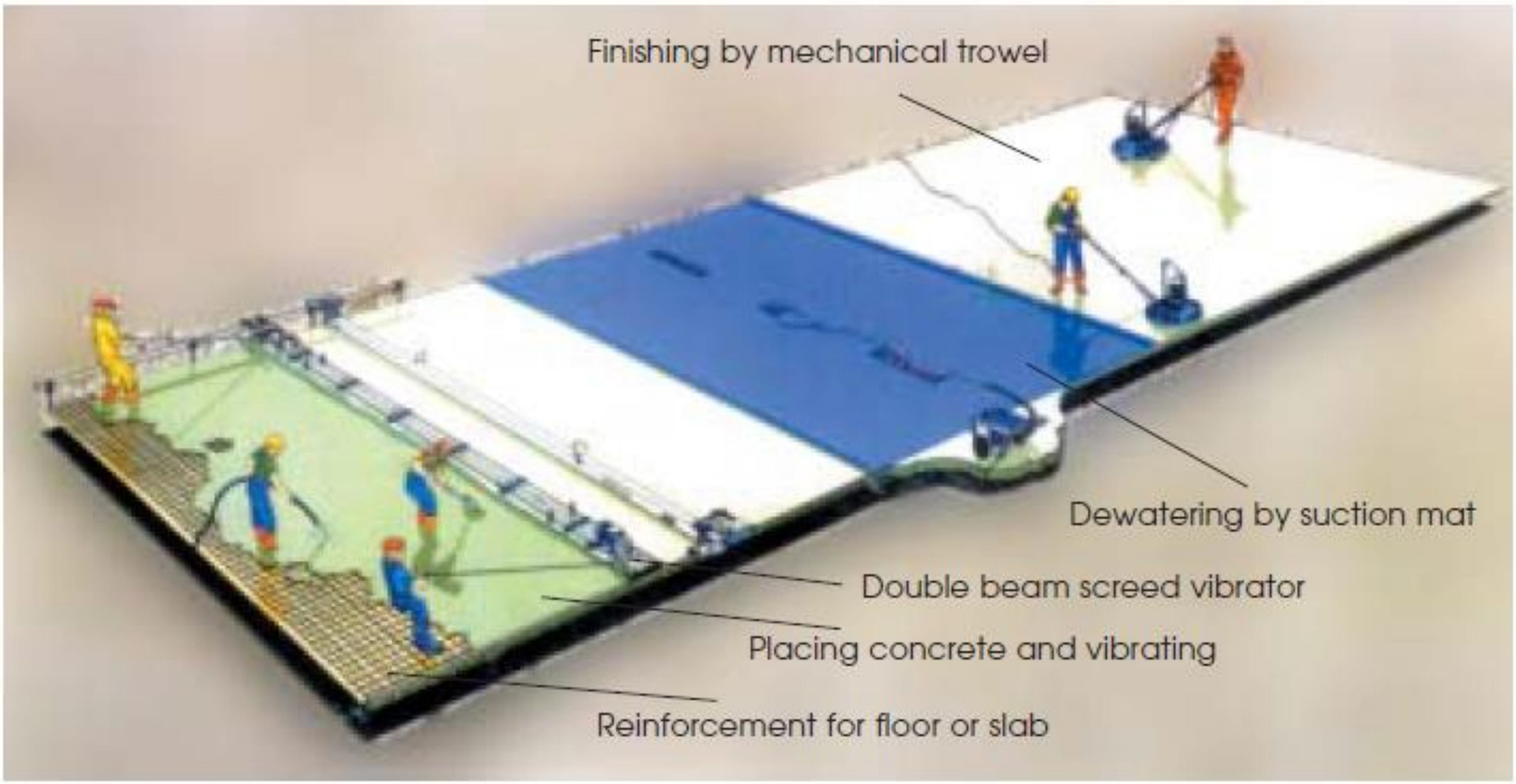
Fig: Effect of vacuum dewatering of concrete



Vacuum Dewatered Concrete

It has been stressed time and again that adoption of low water cement ratio will give alround improvement in the quality of concrete, but satisfactory workability is the essential requirement for placing concrete. One solution to this problem is the use of superplasticizer and the other solution is the adoption of vacuum dewatering of concrete. For the last about ten years vacuum dewatering technique is fairly widely used in the construction of factory floors. The techniques have been adopted in a big way for the construction of DCM Daewoo Motors at Delhi, Whirpool factory construction near Pune, Tata Cummins at Jamshedpur, Fiat Ltd. etc. amongst hundreds of other factory floors.

The process is equipment oriented. It requires formwork in the form of channels, internal vibrators, double beam screed board vibrator for the full width, bull float, filter pads, vacuum pump, disc floater, and power trowel.



Schematic sketch showing method of vacuum dewatering system.

- First, concrete with relatively higher w/c to facilitate full compaction with needle vibrator, is poured. Then the concrete is further compacted by double beam screed vibrator.
- This makes the surface smooth. Filter mat is placed and it is pressed on all the four sides and effectively sealed. Within about 30 minutes, the vacuum pump is started which sucks the unwanted water, what could be termed as “water of workability” from the concrete and is thrown out.
- After vacuum dewatering, it gives the ideal condition for application of surface hardners in powder form. With the combined effect of vacuum dewatering and application of floor hardners a very good abrasion resistant factory floor may be constructed.

Roller Compacted Concrete

- Roller-compacted concrete (RCC), which takes its name from the construction method used to build it, is a concrete of zero-slump consistency in its unhardened state. It is defined as concrete compacted by roller, as per ACI 207.5R.
- This would ensure an effective consolidation which is crucial for achieving satisfactory density, strength (compressive strength can be more than 60MPa), smoothness, and surface texture. The roller compacted concrete is constructed without joints, formwork, finishing, steel reinforcement, or dowels.
- These characteristics make roller-compacted concrete simple, fast, and economical. Roller compacted concrete owes much of its economy to high-volume, high-speed construction methods

Fig. 4: Roller Compacted Concrete for Road Construction

Fig. 3: Dam Construction Using Roller Compacted Concrete

- Roller Compacted Concrete (RCC) is a recent development particularly in the field of dam construction.
- Roller compacted concrete is a lean no slump, almost dry concrete that is compacted by Vibratory Roller. A mixture of aggregates, cement and water are mixed in a conventional batch mixer or in other suitable mixers. Supplementary cementing material, such as fly ash can also be used. In some cases high volume fly ash to the extent of 60% by weight of cement has been used. The cement content ranges from 60 to 360 kg/m3.
- Roller compacted concrete is placed in layers thin enough to allow complete compaction.The optimum layer thickness ranges from 20 to 30 cm.
- To ensure adequate bonding between the new and old layer or at cold joint, segregation must be prevented and a high plasticity bedding mix must be used at the start of the placement.
- A compressive strength of about 7 MPa to 30 MPa have been obtained.

Characteristics & Advantages of RCC

- **Tough**
- **Durable**
- **Strong**
- **Sustainable**
- **Versatile**
- **Resist freezing and thawing**
- The main advantage is reduced cost and time for construction (cost effective and Fast construction). so, it can achieve high quality in terms of strength, durability, and surface finish at relatively low device and personnel costs

- Resistance to shoving and pushing
- Minimal maintenance required
- No rutting
- No pot holes
- Resistance to oil spills, fuels and/or hydraulic fluids
- Formwork costs are minimized or eliminated because of the layer placement method.
- Rebar is not required
- High Volume Placement

- It does not deform under heavy, concentrated loads
- Span soft localized subgrades
- Can withstand high temperatures
- Reduce cement consumption as the leaner concrete mix can be used.
- No concerns about high heat release while the concrete is drying.
- The cost of transporting, placement, and compaction of concrete are minimized because concrete can be hauled by dump trucks; spread by bulldozers and compacted by vibratory rollers.

Disadvantages

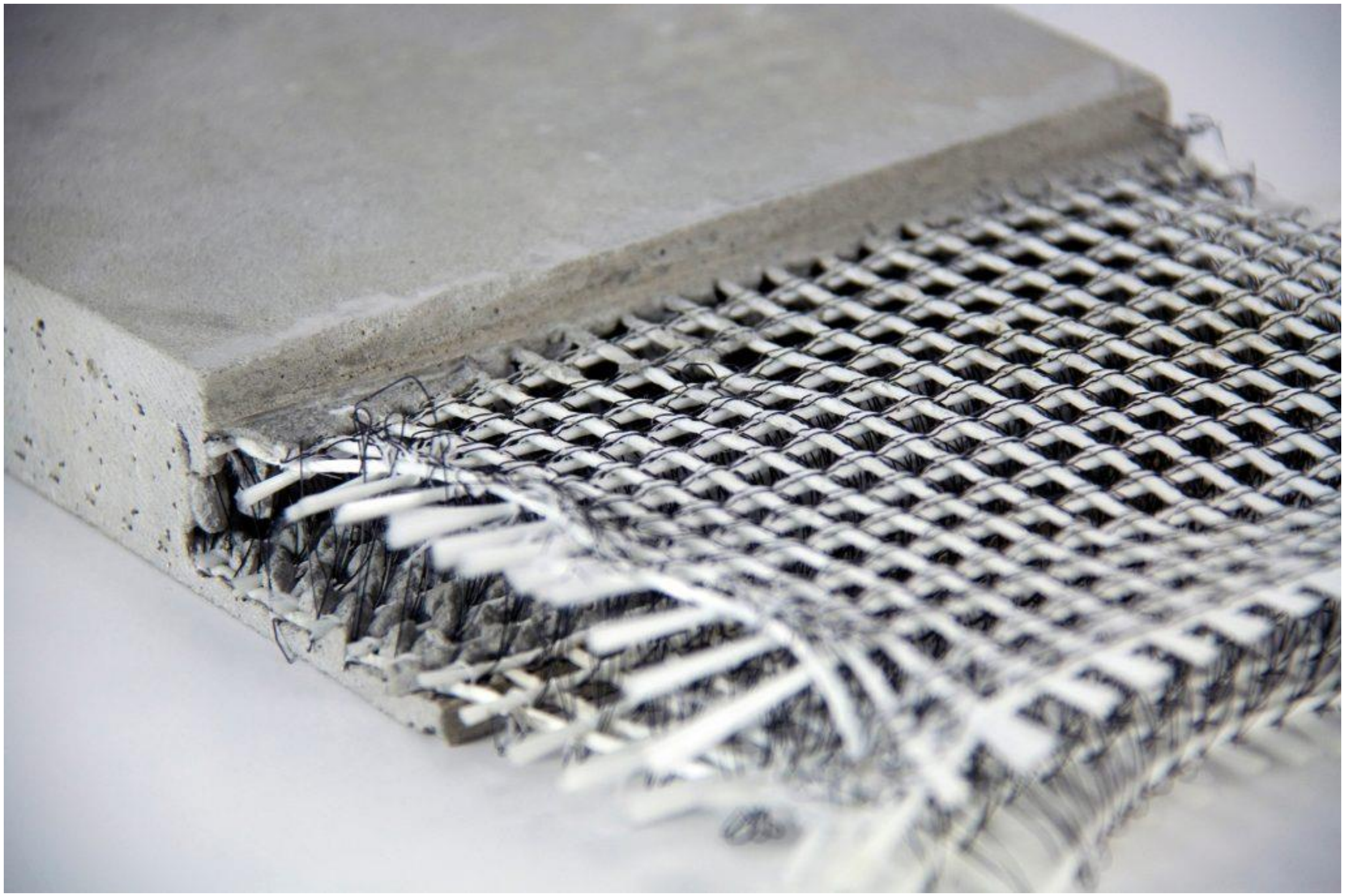
- Although it is used to efficiently design RCC dams to be the least cost alternate when compared to other types of dams, there are conditions that may make RCC more costly.
- Situations where RCC may not be appropriate is when aggregate material is not reasonably available, the foundation rock is of poor quality or not close to the surface, or where foundation conditions can lead to excessive differential settlement.
- Dams repaired or constructed with roller compacted concrete may suffer from water seepage. That is why water stoppage layers shall be considered.

Applications

- Today, RCC is used when strength, speed of construction, durability, and economy are primary needs. It is a type of concrete pavement that is well suited for heavy industrial applications, as well as low-speed roads and arterial roads. The roller compacted concrete have been used to construct, repair, or maintenance of the following structures:
- Industrial and military facilities
- New dam construction
- Rehabilitation of existing dams
- Airports
- Storage
- Sub-base of roads and airfield pavements
- Ports
- Multi-modal yards
- Distribution centers
- Parking and storage facilities
- Streets & highways, intersections, shoulders, turn lanes, bike paths
- Manufacturing facilities, heavy haul roads, scrap yards

Fiber Reinforced Concrete

- Fiber Reinforced Concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers.
- Fiber is a small piece of reinforcing material possessing certain characteristics properties. They can be circular or flat. The fiber is often described by a convenient parameter called "aspect ratio". The aspect ratio of the fiber is the ratio of its length to its diameter. The typical aspect ratio ranges from 30 to 150.
- Continuous meshes, woven fabrics, and long wires or rods are **not** considered to be discrete fibers.



- Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers, and natural fibers.
- Within these different fibers, the character of fiber reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation, and densities.
- Fiber-reinforced normal concrete is mostly used for on-ground floors and pavements, but can be considered for a wide range of construction parts (beams, pliers, foundations, etc) either alone or with hand-tied rebars Concrete.

Effect of Fibers in Concrete

- Fibers are usually used in concrete to control plastic shrinkage cracking and drying shrinkage cracking. They also lower the permeability of concrete and thus reduce the bleeding of water.
- Some types of fibers produce greater impact, abrasion and shatter resistance in concrete. Generally, fibers do not increase the flexural strength of concrete, so it can not replace moment resisting or structural steel reinforcement.
- The amount of fibers added to a concrete mix is measured as a percentage of the total volume of the composite (concrete and fibers) termed volume fraction (V_f). V_f typically ranges from 0.1 to 3%.
- If the modulus of elasticity of the fiber is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material.

- However, fibers that are too long tend to "ball" in the mix and create workability problems.
- Some recent research indicated that using fibers in concrete has a limited effect on the impact resistance of concrete materials. This finding is very important since traditionally people think the ductility increases when concrete reinforced with fibers. The results also pointed out that the microfibres are better in impact resistance compared with the longer fibers.