

Chapter one: Introduction to Concrete Technology



1.1 Background

Concrete has been the most common building material for many years. It is expected to remain so in the coming decades. Concreting is widely used in domestic, rural, commercial, recreational and educational constructions. Communities around the world rely on concrete as a safe, strong and simple building material.

Concrete, in the broadest sense, is any product or mass made by the use of a cementing medium. Generally, this medium is the product of reaction between hydraulic cement and water.

Concrete and steel are the two most commonly used structural materials. They sometimes complement one another, and sometimes compete with one another. Steel is manufactured under carefully controlled conditions; its properties are determined in a laboratory and described in a manufacturer's certificate. Thus, the designer need only specify the steel as complying with a relevant standard, and the site engineer's supervision is limited to the workmanship of the connections between the individual steel members.

On a concrete building site, the situation is totally different. It is true that the quality of cement is guaranteed by the manufacturer in a manner similar to that of steel. But it is concrete, and not cement, that is the building material and its quality is almost exclusively dependent on the workmanship of concrete making and placing. Therefore, the importance of the control of the quality of concrete work on the site is clear and apparent.

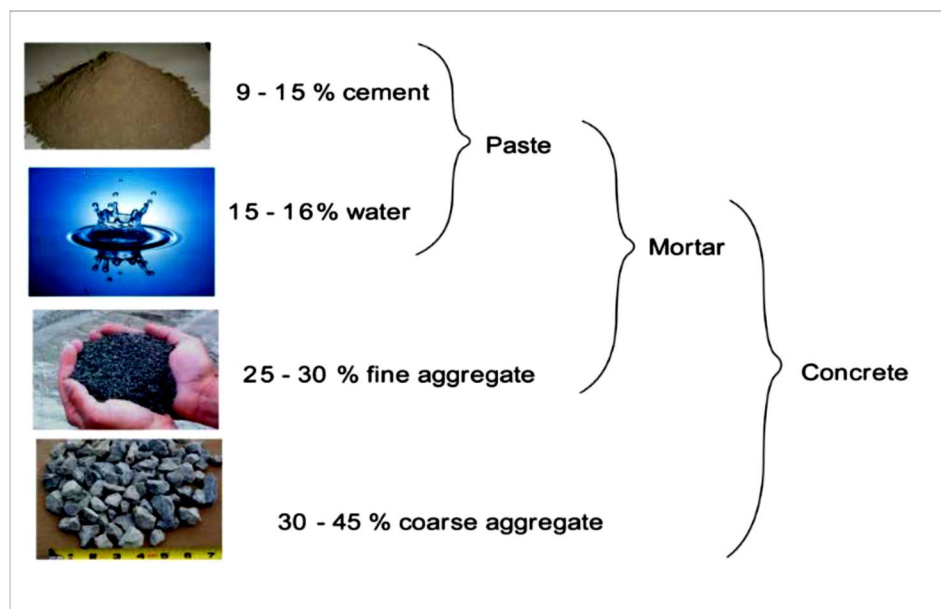
What is good concrete? The concrete has to be satisfactory in its **hardened state**, and also in its **fresh state** while being transported from the mixer and placed in the formwork. The primary requirements of a good concrete in its hardened state are a satisfactory compressive strength and an adequate durability.

1.2 Definition of Concrete

Concrete is an engineering material that simulates the properties of rock being a combination of particles closely bound together. It is simply a blend of **aggregates** bound together by a **hydraulic binder** e.g. Portland cement, activated by **water**, to form a dense semi homogenous mass.

There are four basic ingredients within the concrete mix:

- Binding materials like cement or lime
- Aggregates or Inert Materials
 - Fine aggregate (sand)
 - Coarse aggregate (stone chips, brick chips)
- Water
- Admixtures (e.g. Pozzolana)



1.3 Common Terms

Cement → Powder material

Cement + Water → Cement Paste

Cement Paste + Fine Aggregate (FA) → Mortar

Mortar + Coarse Aggregate (CA) → Concrete

1.4 Concrete Ingredient

Brief description of the concrete ingredients is given below.

1.4.1 Binding Materials

Binding material is the main element of a concrete mix. Cement is the most commonly used binding material. Lime could also be used. When water is mixed with the cement, a paste is created that coats the aggregates within the mix. The paste hardens, binds the aggregates and form a stone-like substance.

1.4.2 Aggregates

Sand is the fine aggregates. Gravel or crushed stone is the coarse aggregates in most mixes. They represent about 65% to 75% of the concrete.

1.4.3 Water

Water is required to activate the reaction of cement (hydration) and to supply workability with the concrete. The amount of water compared with the amount of cement in concrete is named the water/cement ratio. The lower the w/c quantitative relation, the stronger the concrete. (Higher strength, less permeability).



1.5 Advantages of Concrete

- Concrete has many environmental advantages, including durability, longevity, heat storage capability, and chemical inertness.
- Ability to be Cast.
- Fire resistant.
- On-site fabrication.
- Aesthetic properties.
- The raw materials used in cement production are widely available in great quantities.
- Needs little or no finish or final treatments.
- Chemically inert concrete doesn't require paint to achieve a given colour; natural - mineral pigments and coloring agents can be added at the mixing to provide a rainbow of options.
- Low maintenance.
- Can be **reused** or **recycled**.

- Concrete can be **reused** with bituminous asphalt as road base materials, can be recycled and reused by crushing into aggregates for new concrete or as fill material for road beds or site works.

1.6 Limitations of Concrete

- Low tensile strength.
- Low ductility.
- Volume instability.
- Low strength-to-weight ratio.

1.7 Types of Concrete Mixs

There are various types of concrete for different applications that are created by changing the proportions of the main ingredients. Such as:

1. Normal Strength Concrete
2. Plain or Ordinary Concrete
3. Reinforced Concrete
4. Prestressed Concrete
5. Precast Concrete
6. Light – Weight Concrete
7. High-Density Concrete
8. Air Entrained Concrete
9. Ready Mix Concrete
10. Polymer Concrete
11. High-Strength Concrete
12. High-Performance Concrete
13. Self – Consolidated Concrete
14. Shotcrete Concrete
15. Pervious Concrete
16. Vacuum Concrete
17. Pumped Concrete
18. Limecrete
19. Asphalt Concrete
20. Roller Compacted Concrete
21. Rapid Strength Concrete
22. Glass Concrete

1.7.1 Normal Strength Concrete

This concrete is obtained by mixing the basic ingredients cement, water and aggregate will give us normal strength concrete. The strength of these type of concrete will vary from 10 MPa to 40MPa. The normal strength concrete has an initial setting time of 30 to 90 minutes that is dependent on the cement properties and the weather conditions of the construction site.

1.7.2 Plain Concrete

The plain concrete will have no reinforcement in it. The main constituents are the cement, aggregates, and water. Most commonly used mix design is 1:2:4 which is the normal mix design. The density of the plain concrete will vary between 2200 and 2500 Kg/meter cube. The compressive strength is 200 to 500 kg/cm². These types of concrete are mainly used in the construction of the pavements and the buildings, especially in areas where there is less demand of high tensile strength.

1.7.3 Reinforced Concrete

The reinforced cement concrete is defined as the concrete to which reinforcement is introduced to bear the tensile strength. Plain concrete is weak in tension and good in compression. Hence the placement of reinforcement will take up the responsibility of bearing the tensile stresses.

The steel reinforcement used in the concrete can be in the form of rods, bars or in the form of meshes. Now fibers are also developed as reinforcement.

Fiber reinforced concrete are concrete that use fibers (steel fibers) as reinforcement for the concrete. Whatever be the type of reinforcement used in concrete, it is very necessary to ensure proper bond between the concrete and the reinforcement. This bond will control the strength and the durability factors of the concrete.

1.7.4 Prestressed Concrete

Most of the mega concrete projects are carried out through prestressed concrete units. This is a special technique in which the bars or the tendons used in the concrete is stressed before the actual service load application.

During the mixing and the placing of the concrete, these tensioned bars placed firmly and held from each end of the structural unit. Once the concrete sets and harden, the structural unit will be put in compression.

This phenomenon of prestressing will make the lower section of the concrete member to be stronger against the tension.

1.7.5 Precast Concrete

Various structural elements can be made and cast in the factory as per the specifications and bought to the site at the time of assembly. Such concrete units are called as the precast concrete.

The examples of precast concrete units are concrete blocks, the staircase units, precast walls and poles, concrete lintels and many other elements. These units have the advantage of acquiring speedy construction as only assemblage is necessary. As the manufacturing is done at site, quality is assured. The only precaution taken is for their transportation.

1.7.6 Lightweight Concrete

Concrete that have a density lesser than 1920kg/m^3 will be categorized as lightweight concrete. The use of lightweight aggregates in concrete design will give us lightweight aggregates.

Aggregates are the important element that contributes to the density of the concrete. The examples of light weight aggregates are the pumice, perlites, and scoria.

1.7.7 High-Density Concrete

The concretes that have densities ranging between 3000 to 4000 kg/m^3 can be called as the heavyweight concrete. Here heavy weight aggregates are used. The crushed rocks are used as the coarse aggregates. The most commonly used heavy weight aggregates is Barytes.

These types of aggregates are most commonly used in the construction of atomic power plants and for similar projects. The heavy weight aggregate will help the structure to resist all possible type of radiations.

1.7.8 Air Entrained Concrete

These are concrete types into which air is intentionally entrained for an amount of 3 to 6% of the concrete. The air entrainment in the concrete is achieved by the addition of foams or gas – foaming agents. Some examples of air entraining agents are resins, alcohols, and fatty acids.

1.7.9 Ready Mix Concrete

The concrete that mix in a central mixing plant is called as **ready-mix concrete**. The mixed concrete is brought to the site with the help of a truck-mounted transit mixer. This once reached in the site can be used directly without any further treatment.

The ready-mix concrete is very precise and specialty concrete can be developed based on the specification with utmost quality. The manufacture of these concrete will require a centralized mixing plant. These plants will be located at an adjustable distance from the construction site. If the transportation is too long then it will result in setting of concrete. Such issues of time delay are cope up with the use retarding agents that delays the setting.

1.7.10 Polymer Concrete

When compared with the conventional concrete, in polymer concrete the aggregates will be bound with the polymer instead of cement. The production of polymer concrete will help in the reduction of volume of voids in the aggregate. This will hence reduce the amount of polymer that is necessary to bind the aggregates used.

1.7.11 High-Strength Concrete

The concretes that have strength greater than 40MPa can be termed as high strength concrete. This increased strength is achieved by decreasing the water-cement ratio even lower than 0.35.

1.7.12 High-Performance Concrete

These concretes conform to a particular standard. Standards that conform to the high-performance concrete are enlisted below:

- 1- Strength gain in early age.
- 2- Easy placement of the concrete.
- 3- Permeability and density factors.
- 4- Heat of hydration.
- 5- Long life and durability.
- 6- Toughness and life term mechanical properties.
- 7- Environmental concerns.

1.7.13 Self – Consolidated (compacted) Concrete

The concrete mix when placed will compact by its own weight is regarded as self-consolidated concrete. No vibration must be provided for the same separately. This mix has a higher workability. The slump value will be between 650 and 750.

This concrete due to its higher workability is also called as flowing concrete. The areas where there is thick reinforcement, self – consolidating concrete works best.

1.7.14 Shotcrete Concrete

Here the concrete type differs in the way it is applied on the area to be cast. The concrete is shot into the frame or the prepared structural formwork with the help of a nozzle. As the shooting is carried out in a higher air pressure, the placing and the compaction process will be occurring at the same time.

1.7.15 Pervious Concrete

Pervious or permeable concrete are concrete that are designed such a way that it allows the water to pass through it. These types of concrete will have 15 to 20% voids of the volume of the concrete when they are designed.

The pervious concrete is created by unique mixing process, performance, application methods etc. These are used in the construction of pavements and driveways where storm water issues persist. The storm water will pass through these pervious concrete pavements and reach the groundwater. Hence most of the drainage issues is solved.

1.7.16 Vacuum Concrete

Concrete with water content more than required quantity is poured into the formwork. The excess water is then removed out with the help of a vacuum pump without waiting for the concrete to undergo setting.

Hence the concrete structure or the platform will be ready to use earlier when compared with normal construction technique.

These concretes will attain their 28 days compressive strength within a period of 10 days and the crushing strength of these structure is 25 % greater compared with the conventional concrete types.

1.7.17 Pumped Concrete

One of the main property of the concrete used in large mega construction especially for the high-rise construction is the conveyance of the concrete to heights. Hence one such property of concrete to easily pump will result in the design of pumpable concrete.

The concrete that is used for pumping must be of adequate workability so that it is easily conveyed through the pipe. The pipe used will be rigid or a flexible hose that will discharge the concrete to the desired area.

The concrete used must be fluid in nature with enough fine material as well as water to fill up the voids. The more the finer material used, greater will be control achieved on the mix. The grading of the coarse aggregate used must be continuous in nature.

1.7.18 Limecrete

This is a concrete type in which the cement is replaced by lime. The main application of this product is in floors, domes as well as vaults. These unlike cements have many environmental and health benefits. These products are renewable and easily cleaned.

1.7.19 Asphalt Concrete

Asphalt concrete is a composite material, mixture of aggregates and asphalts commonly used to surface roads, parking lots, airports, as well as the core of embankment dams. Asphalt concrete is also called as asphalt, blacktop or pavement in North America, and tarmac or bitumen macadam or rolled asphalt in the United Kingdom and the Republic of Ireland.

1.7.20 Roller Compacted Concrete

These are concrete that is placed and compacted with the help of earth moving equipment like heavy rollers. This concrete is mainly employed in excavation and filling needs.

These concretes have cement content in lesser amount and filled for the area necessary. After compaction, these concretes provide high density and finally cures into a strong monolithic block.

1.7.21 Rapid Strength Concrete

As the name implies these concretes will acquire strength with few hours after its manufacture. Hence the formwork removal is made easy and hence the building construction is covered fastly. These have a wide spread application in the road repairs as they can be reused after few hours.

1.7.22 Glass Concrete

The recycled glass can be used as aggregates in concrete. Thus, we get a concrete of modern times, the glass concrete. This concrete will increase the aesthetic appeal of the concrete. They also provide long-term strength and better thermal insulation also.