CONCRETE TECHNOLOGY (IV sem)

UNIT-1

(Part-4 Concrete, Classification, Properties, Grades, Advantages and Disadvantages)

Introduction of Concrete:

Concrete is mostly widely used man-made construction material in the world. Concrete is a construction material composed of cement, fine aggregates (sand) and coarse aggregates mixed with water which hardens with time.

It is an important construction material used extensively in buildings, bridges, roads and dams. Its uses range from structural applications, to paviours, kerbs, pipes and drains.

Concrete used in construction may also contain reinforcing bars, welded wire fabric (wire mesh), and various reinforcing fibres. The tensile strength of concrete is much lower than its compressive strength

Classification of Concrete:

1. Based on the State of Concrete-

- **Fresh Concrete-** Fresh concrete is that stage of concrete in which concrete can be moulded and it is in plastic state. Sometimes it is also known as ***Green concrete***. Fresh concrete means the wet mix of concrete before being set.
- **Hardened Concrete-** The term hardened concrete is the stage where the concrete is completely set and enough strong to carry the self-load and structural load.

2. Based of Cement quantity

- **Lean Concrete-** A lean mixture is a mixture of concrete or mortar with a relatively low cement content.
- **Rich Concrete-** A rich mixture contains a high proportion of cement.

3. Based on Performance-oriented specifications

- **Normal Mix Concrete-**

  Nominal mix specifies the proportion of the cement, sand and aggregates without making special effort to know their individual properties. Nominal mix has Volumetric batching.

  The proportions of materials for nominal mix shall be in accordance Grade Proportions

C: FA: CA

- **Design Mix Concrete-**

  From M30 onwards we need to design the concrete mix.

  The concrete mix produced under quality control keeping in view the strength, durability, and workability is called the design Mix.

  • Others factors like compaction equipment's available, curing method adopted, type of cement, quality of fine and coarse aggregate etc. have to be kept in mind before arriving at the mix proportion.

  • The design mix or controlled mix is being used more and more in variety of important structures, because of better strength, reduced variability, leaner mixed with consequent economy, as well as greater assurance of the resultant quality.

4. Based on Special functions-

Based on special purpose requirements.

- **Light Weight Concrete**
- **Vacuum Concrete**
- **Mass Concrete**
- **Recycled Concrete**
- **Ferrocement**
- **Fibre-Reinforced Concrete**
- **Polymer Concrete**
- **High-Density Concrete**
- **Nuclear Concrete**
- **Refractory Concrete**
- **Ready-Mix Concrete**
- **Shotcrete**
- **Guniting**

Properties of Concrete:

Different properties of concrete are:

1. Grades (M20, M25, M30 etc.)
2. Compressive strength
3. Characteristic Strength
4. Tensile strength

5. Durability
6. Creep
7. Shrinkage
8. Unit weight
9. Modular Ratio
10. Poisson's ratio

1. Grades of concrete

Concrete is known by its grade which is designated as M15, M20 etc. in which letter M refers to concrete mix and number 15, 20 denotes the specified compressive strength (f_{ck}) of 150mm cube at 28 days, expressed in N/mm2.

Thus, concrete is known by its compressive strength. M20 and M25 are the most common grades of concrete, and higher grades of concrete should be used for severe, very severe and extreme environments.

2. Compressive strength of concrete

The strength of the concrete is also a quality which varies considerably for the same concrete mix. Therefore, a single representative value, known as characteristic strength is used.

3. Characteristic strength of concrete

It is defined as the value of the strength below which not more than 5% of the test results are expected to fall (i.e. there is 95% probability of achieving this value only 5% of not achieving the same)

Characteristic strength of concrete in flexural member

The characteristic strength of concrete in flexural member is taken as 0.67 times the strength of concrete cube.

Design strength (f_d) and partial safety factor for material strength

The strength to be taken for the purpose of design is known is known as design strength and is given by

Design strength (f_d) = characteristic strength/ partial safety factor for material strength

The value of partial safety factor depends upon the type of material and upon the type of limit state. According to IS code, partial safety factor is taken as 1.5 for concrete and 1.15 for steel.

Design strength of concrete in member = 0.45 f_{ck}

4. Tensile strength of concrete

The estimate of flexural tensile strength or the modulus of rupture or the cracking strength of concrete from cube compressive strength is obtained by the relations

$f_{cr} = 0.7\ f_{ck}$ N/mm^2. The tensile strength of concrete in direct tension is obtained experimentally by split cylinder. It varies between 1/8 to 1/12 of cube compressive strength.

5. Creep in concrete

Creep is defined as the plastic deformation under sustained load. Creep strain depends primarily on the duration of sustained loading. According to the code, the value of the ultimate creep coefficient is taken as 1.6 at 28 days of loading.

6. Shrinkage of Concrete

The property of diminishing in volume during the process of drying and hardening is termed Shrinkage. It depends mainly on the duration of exposure. If this strain is prevented, it produces tensile stress in the concrete and hence concrete develops cracks.

7. Modular ratio

Short term modular ratio is the modulus of elasticity of steel to the modulus of elasticity of concrete.

Short term modular ratio = E_s / E_c

E_s = modulus of elasticity of steel (2 x 10^5 N/mm^2)

E_c = modulus of elasticity of concrete (5000 x $\sqrt{f_{ck}}$ N/mm^2)

As the modulus of elasticity of concrete changes with time, age at loading etc the modular ratio also changes accordingly. Taking into account the effects of creep and shrinkage partially IS code gives the following expression for the long-term modular ratio.

Long term modular ratio (m) = 280/ ($3f_{cbc}$)

Where, f_{cbc} = permissible compressive stress due to bending in concrete in N/mm^2.

8. Poisson's ratio

Poisson's ratio varies between 0.1 for high strength concrete and 0.2 for weak mixes. It is normally taken as 0.15 for strength design and 0.2 for serviceability criteria.

9. Durability of concrete

Durability of concrete is its ability to resist its disintegration and decay. One of the chief characteristics influencing durability of concrete is its permeability to increase of water and other potentially deleterious materials.

10. Unit weight of concrete

The unit weight of concrete depends on percentage of reinforcement, type of aggregate, amount of voids and varies from 23 to 26 kN/m^2. The unit weight of plain and reinforced concrete as specified by IS:456 are 24 and 25 KN/m^3 respectively.

The desired low permeability in concrete is achieved by having adequate cement, sufficient low water/cement ratio, by ensuring full compaction of concrete and by adequate curing.

Grades of Concrete:

The grade designation gives characteristic compressive strength requirements of the concrete.

Concrete mix ratios are the proportions of concrete components such as cement, sand, aggregates and water. These mix ratios are decided based on type of construction and mix designs. However, building codes provides nominal and standard concrete mix ratios for various construction works based on experience and testing.

In the classification of concrete mix, the letter **M** denote **Mix design,** and the **Numbers** represent the predetermined works **cube strength** of 15 cm cube after curing of **28 days** in N/mm^2.

The works cubes strength refers to the strength archived by concrete after 28 days curing.

Group	Grade Designation	Specified Characteristic Compressive Strength of 150 mm Cube at 28 Days in N/mm^2
(1)	(2)	(3)
Ordinary Concrete	M 10	10
	M 15	15
	M 20	20
Standard Concrete	M 25	25
	M 30	30
	M 35	35
	M 40	40
	M 45	45
	M 50	50
	M 55	55
High Strength Concrete	M 60	60
	M 65	65
	M 70	70
	M 75	75
	M 80	80

Designation	Mix Proportion	Characteristic Compressive Strength in N/mm^2	Group (as per IS : 456 - 2000)
M5	1 : 5 : 10	5	Lean Mix
M7.5	1 : 4 : 8	7.5	
M10	1 : 3 : 6	10	Ordinary Concrete
M15	1 : 2 : 4	15	
M20	1 : 1½ : 3	20	
M25	1 : 1 : 2	25	Standard Concrete
M30	Designed	30	
M35		35	
M40		40	
M45		45	
M50		50	
M55		55	
M60		60	High Strength Concrete

Advantages of Concrete:

1. Concrete is economical, as it can be made from locally available coarse and fine aggregates.

2. It possesses high Compressive strength.

3. In its fresh or green state it can be easily handled and moulded into any shape and size according to the specifications.

4. Concrete is good in compressive strength but has unlimited structural applications in combination with steel. Concrete and Steel have approximately equal coefficients of thermal expansion.

5. Concrete can be sprayed on and filled into fine cracks for repairs by the guniting process.

6. Concrete can be pumped and can be laid in difficult positions.

7. It is durable and is less affected by the weathering effects of environmental conditions.

8. It is fire-resistant.

9. It has long life and requires very little maintenance.

Disadvantages of Concrete:

1. Concrete has low Tensile strength hence develops cracks.

2. Fresh concrete shrinks on drying and hardened concrete expands on wetting.

3. Concrete expands or contracts with the temperature change.

4. Concrete undergoes Creep under sustained loading.

5. Concrete is not entirely impervious to moisture and soluble salts which may cause effloresence.

6. It is liable to disintegrate by alkali and sulphate attacks.

7. The lack of ductility in concrete is disadvantageous with respect to earthquake resistant design.