CHAPTER-1
CONCRETE AS A CONSTRUCTION MATERIAL

- **TOPICS TO BE COVERED:-**
- GRADES OF CONCRETE
- ADVANTAGES & DISADVANTAGES OF CONCRETE

Concrete:-

Concrete is produced by mixing cement, fine aggregate ,& coarse aggregate & water and mixed with water in a definite proportion.

Among different building materials , concrete is the best material come to beam.

Concrete is composed of inorganic material called aggregate, gravel, sand etc. Cementing together with some water .

Concrete is very strong in compression & weak in tension

Advantages Of Using Concrete :-

- It has a very high compressive strength. The strength of concrete can be increased or decreased by using suitable proportion of its ingredients.
- It is free from corrosion & weathering effects and hence superior to other building materials like wood, steel, etc. In compare to steel it is generally economical.
- It acts as a good fire proofing material.
- It binds with steel ,so that concrete can be reinforced with steel to form reinforced concrete
- The structures made out of reinforced concrete are very rigid & have a low maintenance cost.
- It has long service life.

Disadvantages of concrete:-

- It is weak in tension & cracks easily when subjected to tensile stress.
- It requires the form work to be kept for many days. The cost of form work varies from 30 to 40 %of total cost.
- It is not completely impervious.
- It shrinks and set up shrinkage stress.
- **Grades Of Concrete :-**

Designation of grade of concrete.	**Proportion**	**Applications**	**Specified characteristics compressive strength of 28days in N/mm^2 (f_{ck})**	**Permissible stress in compression in N/mm^2 (bending σ_{cbc})**
M_5	1:5:10	Ordinary	-	-

		concrete		
$M_{7.5}$	1:4:8	Ordinary concrete foundation	-	-
M_{10}	1:3:6	Lean concrete foundation	10	3
M_{15}	1:2:4	General purposes, flooring , base foundation	15	5
M_{20}	1:1.66:3.33 or 1:1.5:3	RCC beam, column, footing, slab	20	7
M_{25}	1:1:2	Water tank, u/s face dam	25	8.5
M_{30}	-	-	30	10
M_{35}	-	-	35	11.5

*******The End*******

CHAPTER-2
CEMENT

- **TOPICS TO BE COVERED:-**
- **Composition of cement**
- **Hydration of cement**
- **Water cement ratio**
- **Compressive strength**
- **Fineness of cement**
- **Set5ting time**
- **Soundness**
- **Types of cement**

Cement:-

The natural cement is obtained by burning & crushing the stones containing clay, carbonate of lime & some amount of carbonate of magnesia.

- ➔ The clay content in such stones is about 20 to 40 %.
- ➔ The colour of natural cement is brown.

Composition of ordinary cement:-

Following are the composition of ordinary cement.

Ingredient	per cent	Range
Lime (CaO)	62	62 to 67
Silica (SiO2)	22	17 to 25
Alumina (Al2O3)	5	3 t0 8
Calcium sulphate (CaSO4)	4	3 to 4
Iron oxide (Fe2O3)	3	3 to 4
Magnesia (MgO)	2	0.1 to 3
Sulphur (S)	1	1 to 3
Alkalise	1	0.2 to 1

Function of cement ingredient:-

Following are the function of ingredient of cement.

a) Lime (CaO)
b) Silica (SiO_2)
c) Alumina (Al_2O_3)
d) Calcium sulphate($CaSO_4$)
e) Iron oxide(Fe_2O_3)
f) Magnesia (MgO)
g) Sulphur (S)

h) Alkalies

a) **lime (CaO):-**

- This is the most important ingredient of cement.
- The excess lime makes the cement unsound & causes the cement to expand & disintegrate.
- If lime is in deficiency, the strength of cement is decreased & it causes cement to set quickly.

b) Silica (SiO_2):-

- This is also an important ingredient of cement & it gives strength to the cement.
- If silica is present in excess the strength of cement is increased, but at the same time its setting time is prolonged.

c) Alumina (Al_2O_3):-

- This ingredient gives quick setting property to the cement.
- If it is present in excess, it weakens the cement.

d) Calcium sulphate($CaSO_4$):-

- This ingredient is in the form of gypsum.
- Its function is to increase the initial setting property.

e) Iron oxide(Fe_2O_3):-

- This ingredient gives colour, hard ness & strength to the cement.

f) Magnesia (MgO):-

- If magnesia is present in small quantity, it gives colour & hardness to the cement.
- If it is present in excess, it makes the cement unsound.

g) Sulphur (S):-

- A very small amount of sulphur is useful for making sound cement.
- If it is in excess, it causes the cement unsound.

h) **Alkalies** :-

- If alkali is present in excess, they cause a no. of troubles such as efflorescence.

Types of cement:-

Following are the different types of cement

i. Acid resistance cement
ii. Blast furnace cement
iii. Coloured cement
iv. Expanding cement
v. High alumina cement
vi. Hydrophobic cement

vii. Low heat cement
viii. Hydrophobic cement
ix. Quick setting cement
x. Rapid hardening cement
xi. Sulphate resisting cement
xii. White cement

i. <u>Acid resistance cement:-</u>

➔ An Acid resistance cement is composed of acid resistance aggregate such as quartzite, additive such as sodium flu silicate, aqueous solution of soluble gas.

➔ The binding material of acid resistance cement is soluble gas.

➔ This cement is used acid resistance & heat resistance coatings of installation of chemical industry.

ii. **<u>Blast furnace cement</u>**:-

➔ In this cement, the slag obtained from blast furnace is used.

➔ The slag is a waste product in the manufacture of pig iron & it contains basic elements of cement namely lime, silica, alumina.

➔ It proves economical as slag, which is a waste product.

➔ This cement is durable but it is not suitable for use in dry area.

iii. <u>Coloured cement:-</u>

➔ The cement of desired colour is obtained by intimately mixing mineral pigment with ordinary cement.

➔ The amount of colouring material may vary from 5 to 10 %.if this per cent exceeds 10 % the strength of cement is affected.

➔ The chromium oxide gives green colour, cobalt oxide gives blue colour, and iron

oxide in different proportion gives brown, red, yellow colour. The manganese dioxide gives black or brown colour cement.

➔ The colour cement is used for finishing of floors.

iv. <u>Expanding cement:-</u>

➔ This type of cement is produced by adding expanding medium like sulpho-aluminate, & a stabilising agent to the ordinary cement.

➔ This cement is used for construction for repairing the damaged concrete surface.

v. <u>High alumina cement:-</u>

➔ This type of cement is produced by grinding clinkers formed by calcing bauxite & lime.

➔ It is costly. It cannot be used for mass construction as it evolves great heat and it sets quickly.

vi. <u>Hydrophobic cement:-</u>

➔ This type of cement contains admixture which decreases the wetting ability of cement grains.

➔ The usual hydrophobic admixtures are acidol, petrolatum etc.

➔ This cement is used for construction of concrete structures.

vii. **<u>Low heat cement</u>**:-

➔ The considerable heat is produced during the setting action of cement.

➔ In order to reduce the amount of heat, this type of cement is used.

➔ It is mainly used for mass concrete work.

viii. <u>Pozzuolana cement:-</u>

➔ The pozzuolana is volcanic powder. The percentage of pozzuolana should be between 10 to 30.

➔ It is cheap.

➔ It is used in sewage works & for laying concrete under water.

ix. <u>Quick setting cement:-</u>

➔ This cement is produced by adding a small percentage of aluminium sulphate & by finely grinding the cement.

➔ This cement is used to lay concrete under static or running water.

x. **<u>Rapid hardening cement</u>**:-

➔ The initial & final setting time of cement is same as ordinary cement.

➔ It is light in weight.

➔ This cement requires short period of curing.

Xi <u>Sulphate resisting cement:-</u>

➔ In this cement the percentage of tri calcium aluminate is kept below 5% & it results in the increase in resisting power against sulphate.

➔ This cement is used for structures which are likely to be damaged by severe alkaline condition such as canal lining, culvert etc.

xii . **<u>White cement</u>**:-

➔ This type of cement is prepared from such raw materials which are practically free from colouring oxides of iron, manganese, or chromium.

➔ It is more costly than ordinary cement.

➔ White cements are used for fixing of marbles.

<u>Properties of cement</u>:-

Following are the properties of cement.

❖ It gives strength to the masonry.

❖ It is an excellent binding material.

❖ It is easily workable.

❖ It possesses a good plasticity.

❖ It stiffens or hardens early.

Testing of quality of cement:-

Following are the standard test for cement.

A. Fine ness test.
B. Compressive strength test.
C. Tensile strength test.
D. Consistency test.
E. Setting time test.
F. Sound ness test.

A. Fine ness test:-

This test is carried out to check proper grinding of cement. The fineness of cement particles are determined by sieve test.

Procedure:-

- In this test, first 100 gm. of cement is taken.
- Then it is continuously passed for 15 minutes through standard BIS 90 micron sieve.
- The residue is then weighed & this weight should not be more than 10 % of the original weight.

B. Compressive strength test:-

This test is carried out to determine the compressive strength of cement.

Procedure:-

❖ Take required quantity of cement & sand proportion 1:3, and then required quantity of water i.e. 40 % of cement is added to it for preparation of mortar.

❖ The mortar is placed in moulds in the form of cube of size 76 or 70.6 mm.

❖ Then it is compacted in vibrating machine for 2 minutes.

❖ Then the moulds are placed in damp cabin for 24 hours.

❖ The specimens are removed from the mould & they are submerged in clean water for curing.

❖ The cubes are then tested in compressive testing machine at the end of 3 days & 7 days.

❖ The compressive strength at the end of 3 days should not be less than 115 Kg/cm^2 or 11.50 N/mm^2 .And that at the end of 7 days should not be less than 175 Kg/cm^2 or 17.50 N/mm^2.

Setting time test:-

This test is carried out to detect the deterioration of cement due to storage. The test is carried out to determine the initial & final setting time of cement.

Initial setting time test:-

Procedure:

- First 300 gm. of cement is taken. Then it is mixed with percentage of water which is determined in the consistency test.
- The cement paste is filled with vicat mould.
- The square needle of cross section of 1 mm x 1 mm is attached to the moving rod of vicat apparatus.
- The needle is quickly released & it is allowed to penetrate the cement paste.
- In the beginning the needle penetrates completely.
- It is then taken out .the procedure is repeated at regular intervals till the needle does not penetrate completely.
- The needle should penetrate up to about 5 mm from the bottom.
- The initial setting time is the interval between the addition of water to cement & the stage when needle does not penetrate completely.
- The initial setting time period for ordinary cement should be 30 minutes.

Final setting time test:-

Procedure:-

- First 300 gm. of cement is taken. Then it is mixed with percentage of water which is determined in the consistency test.
- The cement paste is filled with vicat mould.
- Then the needle with annular collar is attached to the moving rod of vicat apparatus.
- The needle is gently released. The time at which the needle makes an impression on test block & the collar fails to do so is noted.
- The final setting time is the difference between the times at which water was added to cement.
- The final setting time period for ordinary cement should be about 10 hours.

F. Sound ness test:-

This test is carried out to detect the presence of combined lime in cement.

Procedure:-

- This test is carried out with the help of Le chatelier apparatus. It is consists of a brass mould of diameter 30 mm &height 30 mm. There is a split in mould & it does not exceed 0.5 mm.
- Two indicators with pointed ends are provided with the spilt.
- The cement paste is prepared .the percentage of water is taken as determined in the consistency test.
- The mould is placed on a glass plate & it is filled by cement paste.
- At top another glass plate is covered .A small weight is placed at top & then submerged in water for 24 hours & a temperature between 24° C to 35° C.

- The distance between the points of indicator is noted.
- The mould is again placed in water and heat is applied for 30 minutes.
- The mould is removed from water & it is allowed to cool down.
- The distance between the points of indicator is again measured.
- The difference between the two readings indicates the expansion of cement & it should not exceed 10 mm.

Water- cement ratio:-

The ratio of the amount of water to the amount of cement by weight is known as water cement ratio.

➔ The strength & quality of concrete of primarily depends upon this ratio.

➔ The quantity of water is usually expressed in litres per bag of cement.

➔ And hence the water cement ratio reduces to the quantity of water required in litres per kg of cement as 1 litre of water weighs 1 kg.

➔ It is found that the water required is about 0.5 to 0.6 times the weight of cement.

The important points to be observed in connection with the water cement ratio are:-

➔ The minimum quantity of water should be used to have reasonable degree of workability. The excess water occupies space in concrete & on evaporation; the voids are created in concrete. Thus the excess water affects considerably the strength & durability of concrete. In other wards the strength of concrete is inversely proportional to the water cement ratio.

➔ The water cement ratio for structures which are exposed to weather should be carefully d4ecided. For structures which are regularly wetting & drying, the water cement ratio by weight should be 0.45 & 0.55 for thin sections & mass concrete respectively. For structures which are continuously in water, the water cement ratio by weight should be 0.55 & 0.65 for thin sections & mass concrete respectively.

➔ Weight of water in concrete= 28 % of the weight of the cement + 4 % of the weight of total aggregate.

Or weight of water in concrete = 30 % of the weight of the cement + 5 % of the weight of total aggregate.

CHAPTER-3
AGGREGATE

TOPICS TO BE COVERED:-

- **Classification & characteristics of aggregate**
- **Deleterious substances in aggregates**
- **Fineness modulus**
- **Grading of aggregate**

Classification of aggregate:-It is divided in to two catagories

1. Natural aggregate
2. Artificial aggregate

1.Natural aggregate:-These aggregates are usually obtained from natural deposits of sand and gravel or from quarries by cutting rocks.The cheapest among them are the natural sand & gravel to their present size by natural agents, such as water, wind and snow etc.The river deposits are the most common and are of good quality.

2.Artificial aggregate:- The most widely used artificial qaggregates are clean broken bricks and air cooled fresh blast furnace slag.The broken bricks of good quality provide a satisfactory aggregate for the mass concrete & are not suitablr for reinforced concrete work if the crushing strength of brick is less than 30 to 35 Mpa.

Classification according to size:-

According to size the aggregate is classified as fine aggregate, coarse aggregate7 all in aggregate

Fine aggregate:-It is the aggregate most of which passes through a 4.75mm IS sieve . Sand is generally considred to have a lower size limit of about 0.07mm .Material between 0.06mm and 0.002mm is classified asm silt , and still smaller particles are called clay.

Coarse aggregate:-The aggregates most of which are retained on the 4.75mm IS sieve and contain only that much of fine material is termed as coarse aggregate. The grade coarse aggregate is described by its nominal size, i.e. 40mm, 20mm, 16mm and 12.5mmetc.

For example:-a graded aggregate of nominal size 12.5mm means an aggregate most of which passes the 12.5mm IS sieve.

All-in-aggregate:-Sometimes combined aggregates are available in nature comprising different fractions of fine and coarse aggregatees, are known as all- in-aggregate.

Classification according to shape:-The aggregate may be classified as rounded, irregularor partly rounded , angular or flaky.

Rounded aggregate:-The aggregate with rounded particles (river or seashore gravel) has minimum voids ranging from 32 to 33 percent.It gives minimum ratio of surface area to the volume, tbhus requiring minimum cement paste to make good concrete. Disadvantages is that the interlocking between its particles is less and hence the development of the bond is poor, making it unsuitable for high strength concrete and pavements.

Irregular aggregate:-The aggregate having partly rounded particles has higher percentage of voids ranging from 35 to 38 .It requires more cement paste for a given workabolity.

Angular aggregate:-The aggregate with sharp, angular and rough particles has a maximum percentage of voids ranging from 38 to 40. The interlocking between the particles is good, there by providing a good bond.

Flaky aggregate:-An aggregate is termed as flaky when its least dimension is less than three fifth of its mean dimension.The mean dimension of the aggregate is the average of the sievesizes through which the particles pass and are retained.

Classification based on unit weight:-

According to their unit weights as normal weight, heavy weight, and light weight aggregate.

Normal – weight aggregate:-The commonly used aggregates i.e. sands and gravels, crushed rocks such as granite, basalt, quartz, sand stone and lime stone and brick ballast etc. have specific gravities between 2.5 & 2.7 , unit weight ranging

from 23 to 26 KN/m^3 and crushing strength at 28 days between 15 to 40Mpa are termed normal – weight concrete.

Heavy weight or High density aggregate:-Some heavy weight aggregates such as barite n, ferro- phosphorus , goethite, hematite,ilmentite, limonite.

Concretes having unit weight of about 30, 31 , 35, 38, 40, 47, 57 KN/m^3 can be produced by using typical goethic, limonite, barite, magnetite, hematite, ferro-phosphorus & scrap iron, respectively.

Light weight aggregate:-The light –weight aggregates having unit weight up to 12 KN/m^3 are used to manufacture the structural concrete and masonry blocks for reduction of the self weight of the structure.

The main requirement of the light – weight aggregate is its low density, some specifications limit the unit weight to 12KN/m^3 for fine aggregate and approximately 10KN/m^3 for coarse aggregates for the use in concrete.

Characteristics of aggregates:-

An aggregate to be used in concrete must be clean, hard, strong, properlyshaped and well graded.

1. **Particle shape & texture:-**The physical characteristics such as shape, texture, and roughness of aggregates, significantly influence the mobility(i.e. the workability) of fresh concrete and the bond between the aggregate and the mortar phase.

- The surface texture is a measure of the smoothness or toughness of the aggregate.
- The surface texture is a measure of the smoothness or roughness of the aggregate.
- The surface texture may be classified as glassy, smooth, granular. Rough, crystalline, porous and honey combed.

2. **Specific gravity:0-**

- It is defined as the ratio of the mass of solid in a goven volume of sample to the mass of an equal volume of water at the same temperature.Since the aggregate generally contains voids, there are different types of specific gravity.
- The average specific gravity of majority of natural aggregates lie between 2.5 and 2.8

3. **Porosity and absorption of aggregate:-**

- Due to the presence of air bubbles which are entrapped in a rock during its formation or an account of the decomposition of certain constituent minerals by atmospheric action, minute holes or cavities are formed in it which are commonly known as pores.

Deleterious substances in aggregate:-

The materials whose presence may be adversely affect the strength , workability and long –term performance of concrete are termed as deleterious materials. Depending upon their action, the deleterious substances found in the aggregate can be divided in to three broad catagories:-

- Impurities interfering with the process of hydration of cement.
- Coatings preventing the development of good bond between aggregate and the cement paste.
- Unsound particles which are weak or bring about chemical reaction between the aggregate and cement paste.

- The clay and other fine materials , such as silt and crusher dust may be present in the form of surface coatings which interference with the bond between the aggregate and the cement paste.
- A good bond is essential for ensuring satisfactory strength & durability of concrete, the problem of coating of impurities is an important one.
- The soft & loosely adherent coating can br removed by washing.The well bonded chemically stable coatings have no harmful effect except that the shrinkage may be increased.
- The silt and the fine dust , if present in excessive amounts, increase the specific surface of the aggregate and hence the amount of water required to wet all particles in the mix , there by reducing the strength and durability of concrete.

Fineness modulus:-

- The fineness modulus is a numerical index of fineness , giving some idea of the mean size of the particles present in the entire body of the aggregate. The determination of the fineness modulus consists of dividing a sample of aggregate in to fractions of different sizes by sieving through a set of standard test sieves taken.
- Each fraction contains particles between definite limits. The limits being the opening sizes of standard test sieves. The material retained on each sieve after sieving represents the fraction of aggregate coarser than the sieve in question but finer than the sieve above. The cumulative % retained on the sieves divided by 100 give the fineness modulus.
- The fineness modulus can be regarded as a weighted average size of a sieve on which material is retained, and the sieves being counted from the finest . Ex- a fineness modulus of 6.0 can be interpreted to mean that the sixth sieve, i.e. 4.75mm is the average size. The value of fineness modulus is higher for coarser aggregate . For the aggregates commonly used , the fineness modulus of fine aggregate varies from 2.0 & 3.5 , for coarse aggregate it varies from 5.5 & 8.0 & from 3.5 to 6.5 for all – in aggregate.

Grading of aggregate:- The particle size distribution of an aggregate is termed as determined by sieve analysis is termed as grading of aggregate.