

Concrete :-

Concrete is a mixture of fine aggregate, coarse aggregate & water.

In the concrete mixture cement having a range of 9-15 %.

Fine Aggregate having a range of 25-30 %.

Coarse Aggregate having a range of 30-45 %.

Water having a range of 15-16 %.

Air having a range of 2-6 %.

Fine Aggregate :-

Normally we are called it as sand. this component can be obtained by natural process of eroding rock due to river flowing & the crushing of stones.

Coarse Aggregate :-

It may be either gravel or the crushed stone. The coarse Aggregate present in the concrete mixture around 45 %.

Generally greater than 4mm size aggregate is called coarse Aggregate.

* In 1824 Joseph Asphadin, an England engineer invented the modern portland cement in our construction process.

* The first Cement testing was done in Germany in 1936.

→ Tests are Tensile & compressive Strength Tests

- * In 1850, the first concrete road was appeared in Austria and 1865 in England and 1891 in U.S
- * The first reinforced concrete was introduced in 1854 by William B & Willinkson.

Manufacturing of Ordinary Portland Cement :—

The raw materials required for manufacturing Ordinary Portland Cement (i) Calcareous materials such as lime stone & chalk and Argillaceous materials such as clay (ii) shale.

The process of cement manufacturing consists grinding the raw material mixing them in to required proportions. It depends upon the purity & compositions.

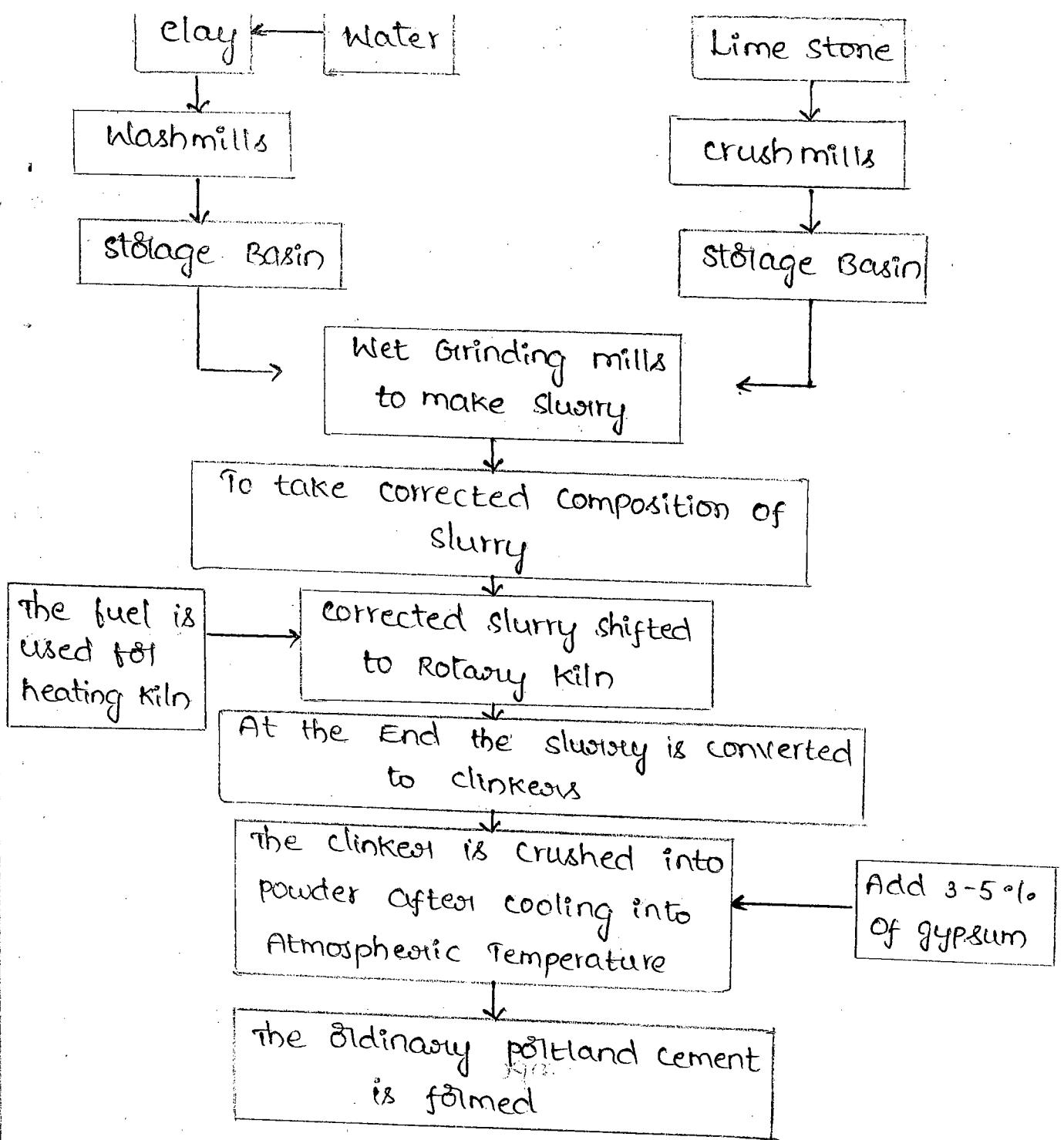
There are two processes for manufacturing of cement (opc)

1. Dry process
2. Wet process

Wet process :—

Rotary kiln is an important component in cement factories. It is a thick steel cylinder having a diameter 3m to 8m.

It having a length 30m to 200m in the process of cement manufacturing 20-30% material are get fused.



those are Lime, Alumina & silica in recombined state. After completion of oxidation reactions a hardened clinkers are deposited at the end of rotary kiln. the cooling process takes place in various conditions. After that the clinkers are powdered & adding 3-5% of Gypsum to form O.p.c.

Note :

The clinkers are in Nodular form & of size 3mm to 20mm.

Influence of rate of cooling on compressive strength :-

Type of cement	cooling condition	MPa (N/mm ²)		
		3 days	7 days	28 days
Normal cement	Quick	9.9	15.3	26
	Moderate	9.7	21.0	27
	Slow	9.7	19.3	24
	Very slow	8.7	18.7	23
High early strength cement	Quick	10.2	18.8	29
	Moderate	14.2	26.7	33
	Slow	10.2	21.0	29
	Very slow	9.1	18.1	28

From the above table the moderate rate of cooling condition gives high compressive strength results. By moderate cooling condition we are brought down the clinkers temperature 1200°C to 500°C in 15 min time and we are brought down the temperature 500°C to atmospheric temperature in 10 min of time.

Chemical compositions of cement :-

The raw material used for the manufacturing of cement consists of Lime, silica, Alumina & Iron Oxide.

These materials interact with one another to form complex compounds (Bogue's compounds). The relative proportions of these oxide compounds are

..... the physical properties of cement in addition to rate of cooling & fineness of grinding.

The approximate chemical composition content

Oxide	Content
CaO	60-69%
SiO ₂	17-25%
Al ₂ O ₃	3-8%
Fe ₂ O ₃	0.5-6%
MgO	0.1-4%
{ K ₂ O Na ₂ O	0.4-1.3%
SO ₃	1.3-3.1%

Whether the change in chemical composition in raw material. The type of cement may vary.

Bogues compounds : —

- | | | |
|---------------------------------|--|-----------------------|
| 1. Tri calcium silicate | $3\text{CaO}\text{SiO}_2$ | C_3S |
| 2. Dicalcium silicate | $2\text{CaO}\text{SiO}_2$ | C_2S |
| 3. Tri calcium aluminate | $3\text{CaO}\text{Al}_2\text{O}_3$ | C_3A |
| 4. Tetra calcium Aluminoferrate | $4\text{CaO}\text{Al}_2\text{O}_3\text{FeO}$ | C_4AF |

Also known as complex compounds,

Hydration of cement : —

The hydration of portland cement is systematically as follows :

Raw materials \rightarrow Lime, shale, clay
↓
Calcareous and Argillaceous

chemical compositions in raw materials - Ca, Al, Mg, Si,
↓
O₂, Fe

Oxide composition in raw materials - CaO, MgO, SiO₂,
↓
Al₂O₃, Fe₂O₃

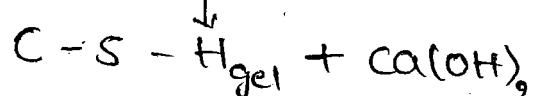
Burn in Rotary Kiln

↓
Complex compounds are formed - C₃S, C₂S, C₃A, C₃AF

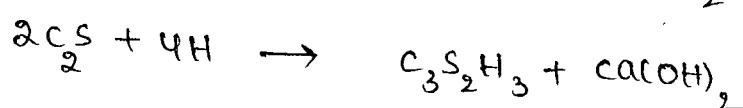
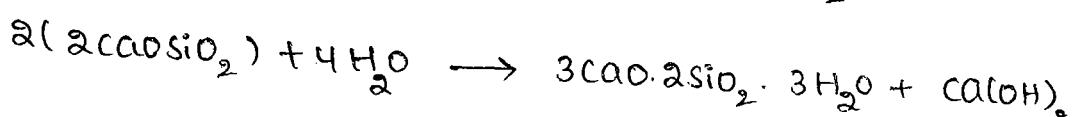
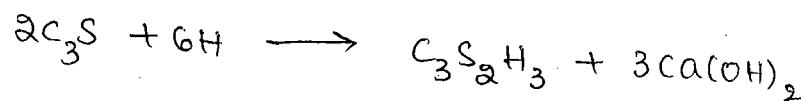
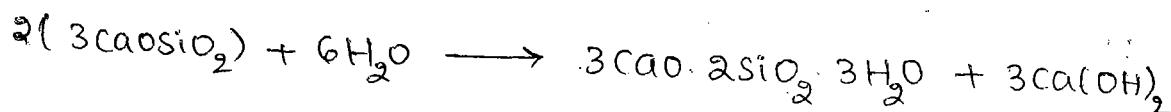
↓
Adding gypsum 3-5%.

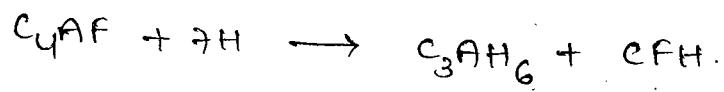
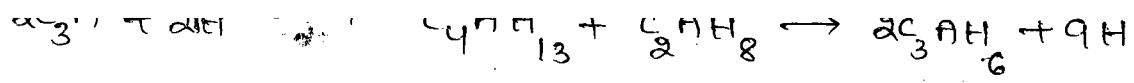
↓
It turns into portland cement

↓
After completion of hydration process

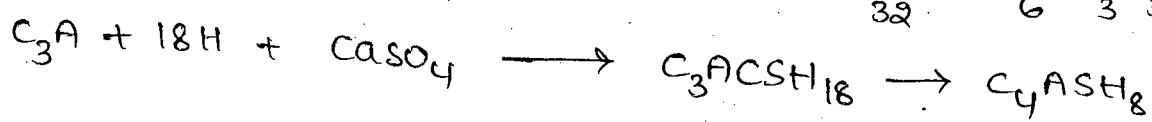
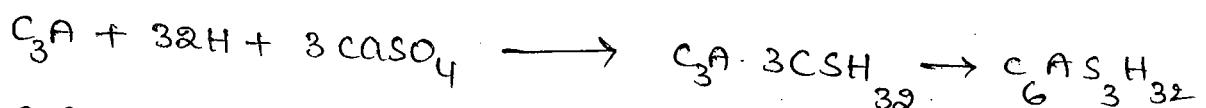


the extent of hydration of cement and the resultant micro structure of hydrated cement influences the physical properties of cement.





Reaction in the presence of Gypsum :-



Types of cements :-

Based on the chemical composition and the process of manufacturing cement. Cement may classified as follows :

1. Ordinary Portland cement
 - a. OPC of 33 grade IS 269 - 1989
 - b. OPC of 43 grade IS 8112 - 1989
 - c. OPC of 53 grade IS 12269 - 1987
2. Rapid Hardening cement IS 8041 - 1990
3. Extra Rapid Hardening cement
4. Sulphate Resisting cement IS 12330 - 1988
5. Portland Slag cement IS 445 - 1989
6. Quick setting cement
7. Super sulphated cement IS 6909 - 1990
8. Low Heat cement IS 12600 - 1989
9. Portland Pozzolana cement IS 1489 part I - 1991
10. Air Entering cement
11. Coloured cement White colour IS 8042 - 1989
12. Hydrophobic cement IS 8043 - 1991

13. Masonry cement IS 3466-1988

14. Expansive cement

15. Oil well cement IS 8299-1986

16. OPC Grade 53-S Special cement IRS-T-40-1985

17. High Alumina cement IS 6452-1989

18. Very High strength cement

Cement classification based on American Society for Testing machine (ASTM) :

According to ASTM the classification cement is done by its necessity and the general information available in the raw materials.

The classification as follows.

1. Type - I

2. Type - II

3. Type - III

4. Type - IV

5. Type - V

There are major classification according to ASTM

Type - I :-

This is the cement used for general construction purpose where the special properties of cement is not required.

Eg: Masonry work, Beam & column layouts.

In this type - I cement OPC is used for the construction work.

Type - II : —

→ this is the cement used for general construction work in addition to moderate sulphur reactions are takes place.

→ Sulphate resisting cement is comes under this type of cement.

→ And at the same time where the heat of the Hydration is occurred in the construction process.

Type - III : —

→ This is the cement is used where the early strength is required in the construction process.

→ The Rapid Hardening Cement (RHC) comes under these type of cement.

→ These type-III cement is used in construction where the saturated soils are present

Type - IV : —

→ this is the cement used where the low heat of hydration takes place.

Eg: Low Heat cement.

Type V : —

This type of cement is used where the sulphate Content is high in water

Super Sulphated cement & sulphate resisting elements are comes under Type - V cement

The minor classification of cement according to ASTM

1. Type - IS

2. Type - IP

Type - IS :-

This is cement obtained by intimate uniform mix of Portland cement of Type - I & fine granulated slag (waste material obtain from steel industry). Slag content is between 25%. & 75% of total weight of cement. This is also known as "PORTLAND BLAST FURNACE SLAG CEMENT".

Type - IP :-

This cement consists of intimate and uniform mix blend of Portland cement (30%) Portland blast furnace slag cement & fine pozzolana. This pozzolana cement is between 15 & 40%. This is called "PORTLAND POZZOLANA CEMENT".

Air Entering Agents :-

Type - IA

Type - IIA

Type - IIIA

These type of cements is used to fill the air voids which are present in the cement composite concrete mix.

Influence of cement quality :-

* The chemical & mineralogical composition of raw material

* The chemical & mineralogical composition of complex compounds.

* Rate of Heating & cooling process

* Mechanical Grinding of clinkers

* circulation phenomena

What are the physical & chemical properties of cement?

Al-

Physical Properties :-

1. Fineness of cement
2. Soundness of cement
3. Consistency of cement
4. Strength of cement
5. Setting time of cement
6. Heat of hydration
7. Loss of ignition
8. Bulk Density
9. Specific Gravity

Chemical Properties :-

1. Tri calcium silicate present in the cement
2. Tri calcium Aluminate present in the cement
3. Di calcium silicate
4. Ferrite content
5. Magnesia content
6. SO₃ content
7. Fe₂O₃ content
8. Alkalies (K₂O & Na₂O)
9. Free lime
10. Alumina content

Structure Of Hydrated Cement :—

Hydration of cement :

The water molecule reacts with cement. The chemical reaction takes place. It is called hydration of cement.

The behaviour of cement concrete is observed considerably in two phases of material those are i, Paste phase ii, Aggregate phase

The understanding of paste phase is more important as it is influence in the behaviour of the concrete much extend to the strength, permeability, durability, dry shrinkage, elastic properties and creep of concrete.

These properties are greatly influence by paste phase of hydrated cement.

The Aggregate phase is influence these properties very less extent when compared with paste phase so, we need to understand the structural behaviour of hydrated cement in paste phase in a phenomenal extent.

Laboratory Tests :—

i. fineness test :

- The fineness of a cement is an important factor for the rate of hydration and rate of gaining of strength and also the rate of evolution of heat.
- the finer cement offers great surface hydration

~~Failure~~ Increase of fineness of cement is to deteriorate early & it gets air set lumps.

- The max particle size in a sample of cement is less than 100 (μ) microns and at same time the smallest particle size in the cement is 1.5 microns
- On an average the size of the cement particles may be taken as 10 microns according to IS standards
- If the cement consists 3 micron size particles High percentage present it affects predominantly on strength parameter. and the cement consists 3-25 (μ) micron size particles.
- It mainly influence on 28 days strength
 - * the increasing of fineness of cement is directly proportional to drying shrinkage ratio of concrete
 - * In commercial use of cement 25-30% of particles having 7 microns of size

There are 2 methods are having to test fineness of cement

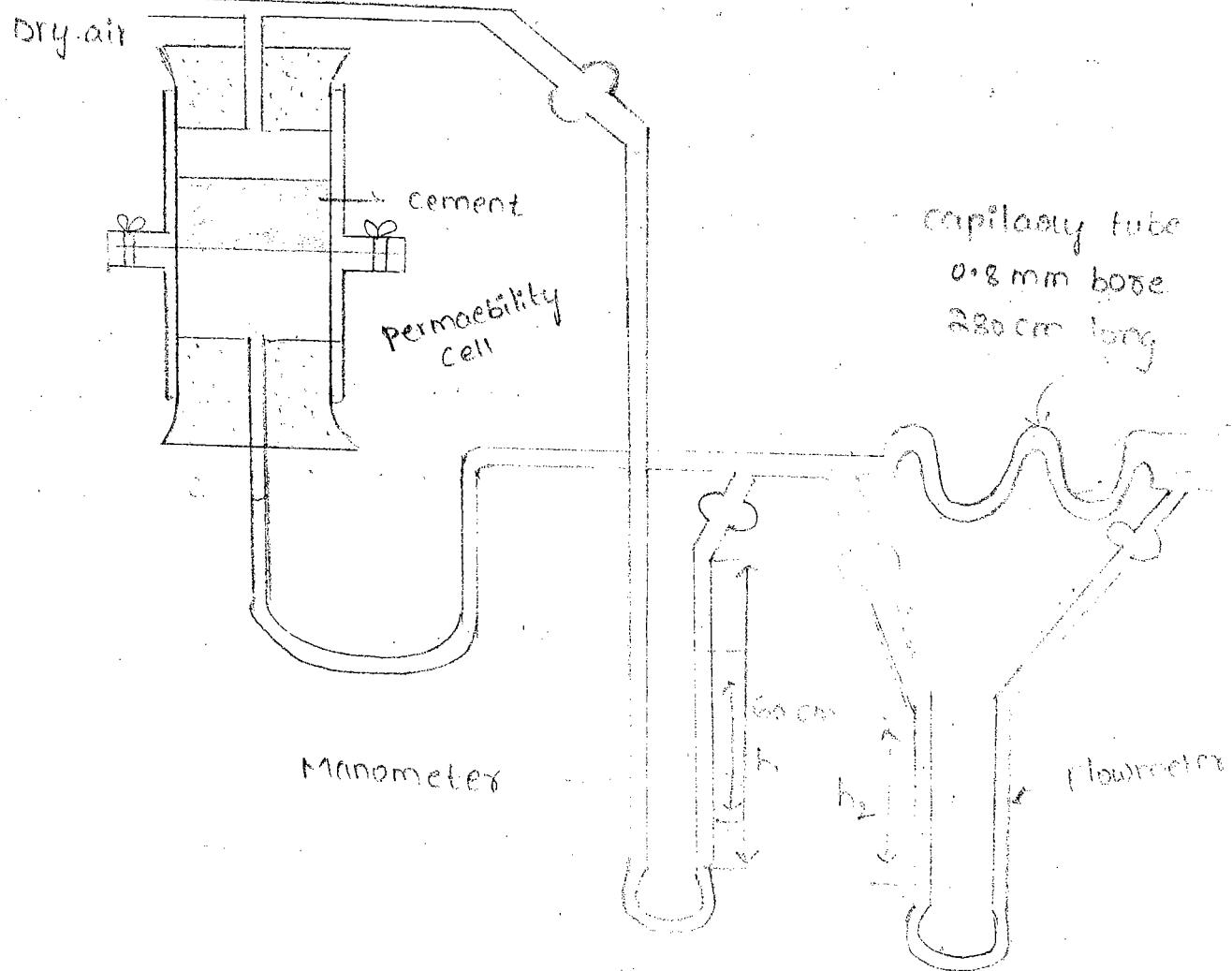
1. By sieving process
2. By using air permeability apparatus to determine the specific surface area in terms of cm^2/gms (S) m^2/kgs

Sieve Method : —

- Take 100 gms of fresh cement & avoid the air lumps by using fingers
- The 100 gms of cement is sieved by 90 microns sieve (S) sieve No. 9
- the sieving process is continuously done by

- 15 min Using circular rotations & vertical moments
- the sieving process is done by either manual or mechanical process.
- finally the residue amount shouldn't exceed 10% to the Ordinary cement.
- But Now-a-days we aren't using this sieving process to find fineness of cement

Air Permeability Test :-



By using Air permeability Apparatus we are finding the Specific Surface Area S_w .

In this Air permeability Apparatus consists a permeability shell which is connected with capillary tube in one side and flow meter and manometer connections on other side.

We were well prepared with tube height & 2.5 cm diameter in permeability cell

The dry air is passing to the permeability chamber continuously with constant velocity then initially we are measuring h_1 & h_2 readings in manometer & flowmeter.

The pressure difference is occurred after continuous flowing of air.

In generally the difference in levels is 30-50 cms

By repeating the observations we are calculating the specific surface S_w .

Specific Surface $S_w = k \sqrt{\frac{h_1}{h_2}}$ &

$$k = \frac{14}{d(l-x)} \sqrt{\frac{x^3 A}{c L}}$$

x = porosity of cement bed i.e. 0.475

A = Area of cement bed 5.066 cm^2

L = length of cement bed 1cm

d = density of cement 9 g/cm^3

c = flowmeter constant

h_1 = pressure drop across that bed

h_2 = pressure drop across the flowmeter capillary.

Addmixture : —

It is defined as a material other than cement, water & Aggregate i.e used as a ingredient of concrete and it is added to the batch immediately before (or) during the concrete mixing.

Additive : —

Additive is a material which is added at the time of grinding of cement clinkers in cement Factory.

Addmixtures are classified into a different types

1. mineral Addmixture

2. chemical Addmixture

Mineral Addmixture :

- Mineral Addmixtures are the finegrain solid materials those are fly ash, silica fume, slag
- these are generally used in concrete mix to achieve an ability of workability & Durability properties and also achieve good finishing work
- the mineral Addmixtures are replaced large amount of cement in concrete mix. so, the mineral addmixture is also known as "Supplementary cementing materials".
- By using these materials we are observed the changes in cement concrete mix.
- Moreover on strength, durability, improving of impermeability capacity (or) increase (or) decrease workability of concrete mix.

Try using mineral Addmixtures in cement
the cost of construction is predominantly decreases.

→ By using mineral Addmixtures the environmental damage & air pollution is decreases about 6-7% of CO₂ emission by using cement

→

el. by mass	P.C	GGBFS	F.F.A	C.FA	S.F
SiO ₂	21	35	50	35	90
Al ₂ O ₃	5	8	25	20	2
Fe ₂ O ₃	2	3	10	5	2
CaO	65	40	+	20	-

P.C → portland cement

GGBFS → Ground Granular Blast Furnace slag
(Bayyavaram plant)

F.F.A → Type F - Fly Ash

C.FA → Type C - fly Ash

S.F → Silica fumes (In powder form)

→ the mineral Addmixtures are the waste materials of various industries by using these waste materials as a raw material to another industry.

→ We are maintaining the sustainability of environment. the usage of these materials depending on supply & demand forces as well as potential of market

Chemical Addmixture : Eg: Sodium bentonite,
calcium carboxylic acid

* Chemical Addmixtures are mixtures that are added to concrete in a very small amount for a specific function to concrete.

* If the chemical Addmixture is added more than the required proportion it is directly affects the concrete properties like strength, Durability, workability & permeability.

and at the same time the hardening of cement concrete also.

* Generally the chemical Addmixtures used as a retarding agents, accelerating agents,塑化剂 & air entraining agents.

* Using these chemical Addmixture the setting time of cement also changes that means we get more workability and at the same time we get early strength is achieved in concrete.

Retarders :-

→ also known as Water Reducing agents

Generally for achieving good concrete workability we need to add more water to concrete mix. By adding more water to the concrete mix there is the properties such as strength is directly effected due to the segregation of concrete occurs that's why we need to add the less water reducing agents to concrete to get more workability in less w/c ratio.

Generally the plasticizers are used to decrease the w/c ratio in concrete mix. At the same time

mix because of improper chemical reactions.

The limits of plasticizers adding to the concrete is 0.1 - 0.4 % by the weight of the cement

the dosage is depends on practical working conditions.

By using these plasticizers we are achieve the water reducing levels 5 - 15 %.

At a same time there is a chance of occurring air voids in case of improper mixing of add mixture to the concrete

Eg: Ligno Sulphate in addition to Ca, Mg, Na

Generally the plasticizers are allowed only 1-2 % of air voids in concrete mix of total volume.

Super plasticizer:

By using these super plasticizers in concrete mix we are achieving an expected amount of 30% of water reduction in concrete mix

Eg: Sulphonated malonic formaldehyde (SMF)

Sulphonated naphthalene formaldehyde

Modified Ligno sulphate

Poly carboxylic Ester

Accelerators:

Accelerating admixtures are adding to concrete to increase the rate of early strength development in concrete.

The factors that are influenced by accelerators are

→ It permits early removal of form work

→ It reduces the curing period

3. It allows advanced usage of structure

4. Generally the accelerators are used in concrete repair works

Eg: Dam Repair works, Bridge pier ^{column}

Sodium Benzonate $\text{NaC}_6\text{H}_5\text{O}_2$ is the example of Accelerator

Air Entraining Agents :-

Generally in cement concrete construction there is a chance to develop voids in concrete structures due to these voids present in concrete structure the strength of the structure is decreases so we need to avoid the air voids in concrete by using these air Entraining agents

Generally the air voids are developed in concrete mix due to improper selection of raw materials, improper compaction, Negligency in curing and due to improper mixing of add mixture.

So we need to avoid all these factors by adding Air Entraining Agents.

At the same time due to the environmental conditions like Freezing & thawing effects occurred in concrete construction.

Aggregates :

The classification of Aggregates is done by following factors

1. Based on size → {
 - fine Aggregate
 - Coarse Aggregate

Fine Aggregate :

The Aggregates having ≤ 4.75 mm . It is called fine aggregate

Coarse Aggregate :

Aggregates having > 4.75 mm , those are called coarse Aggregate.

2. Based on source

a) Rock forming Aggregates :

Igneous rocks :

Formed by the Molten magma and solidify the masses & cool down.

Sedimentary Rocks :

Due to the weathering action these rocks are formed

Metamorphic Rocks :

the combination of Igneous & sedimentary Rocks are Metamorphic Rocks

b) Artificial & synthetic Aggregates :

Eg: Robo sand

c) Recycled Aggregates :

d) Marginal materials

3. Based on Density of Aggregates :

Normal weight

Light weight

Heavy weight

Light weight :

The Expanded vermiculite & expanded perlite are the light weight Aggregates used in Insulating concrete works.

Pumice is the light weight Aggregate which is used in insulating & filling concrete works.

Expanded slag & Expanded shale & clay these are generally used in structural construction works.

Properties of Aggregates :-

Quality of Aggregate :

1. Presence of ^{Harmful} deleterious materials
2. Aggregate crushing value
3. Aggregate Abrasion value
4. Aggregate Impact value
5. Soundness of Aggregate

Properties Controlled by porosity :

Specific gravity test

Bulk density

Water Absorption & surface moisture

Crushing Test of Aggregate :

We need to determine the quality of Aggregate by using Aggregate crushing value

To find the crushing value of Aggregate by using the standard procedure recommended by IS: 2386-(part-4)-1963 and we have some limitations regarding to Aggregate crushing value.

Type of Aggregate	Applications	Crushing Value
Coarse Agg (12.5-10mm)	Using in wearing Coating in runways Roads & pavements	≥ 30 %
Coarse Agg (12.5-10mm)	Other than wearing coating	≥ 45 %

Impact Test : -

Type of Aggregate	Applications	Impact Value
Coarse Agg (12.5-10mm)	Using in wearing Coating in runways Roads & pavements	≥ 30 %
Coarse Agg (12.5-10mm)	Other than wearing coating	≥ 45 %

Hammer Weight → 15 kgs

Hammer Height → 30.5 cms

No. of Blows → 25 blows

2.35 → passing value
of Agg

Sieve

Abrasion Test : -

Abrasion :

It is the Frictional Resistance offered by the material against another material (over the surface)

Eg. Vehicles moving on Road

Attrition :

It is the Frictional Resistance offered by the material over the surface of same material. It is called Attrition.

Eg: Agg rubbing action in Railway Ballast

Aggregate Abrasion Test :

By using Los Angeles machine & Devels Abrasion Test Apparatus to find the Abrasion value of the Aggregate. the Test procedure is given in IS : 2368 - Part 4 - 1962 and limitations of the Abrasion value is recommended in IS : 383 - 1970.

Type of Aggregate	Applications	Abrasion value
coarse agg (12.5 - 10 mm)	using in wearing coating, pavements, Runways	+ 30 %
Coarse agg (12.5 - 10 mm)	Other than wearing coating	+ 50 %

Soundness Test :

Soundness of the Aggregate is measured of ^{resistance} to disintegration of aggregate due to chemical attack
(a) freezing & thawing actions

The soundness of fine & coarse Aggregates is represented by the loss of weight after 5 cycles of drying & immersion in standard chemical sol of Na_2SO_4 MgSO_4

The soundness of Agg is directly proportional to porosity of Aggregate

The limits of loss of weight in soundness test suggested by IS : 383 - 1970

Type of Agg	Reagent used	Soundness of Agg
Fine Agg $\leq 4.75 \text{ mm}$	Sodium sulphate	$\pm 10\%$
	Magnesium sulphate	$\pm 15\%$
Coarse Agg $> 4.75 \text{ mm}$	Sodium sulphate	$\pm 12\%$
	Magnesium sulphate	$\pm 18\%$

Fineness Modulus of the Aggregate : > 6.3

The Fineness Modulus is the measure of fineness of the Aggregate the magnitude of fineness modulus is determined by

$$F.M = \frac{\text{Cumulative \% of weight retained on IS sieve}}{100}$$

The Magnitude of Fineness Modulus is Increases the fineness of Aggregate is Increases

The Approximate Range of Fineness Modulus for coarse Aggregate is 3-5 & for fine Aggregate the range varies b/w 5-8.

In case two different types of Aggregates are mixed together then find the fineness modulus of combined mixture

$$F.M_{\text{combined}} = (F.M_1)V_1 + (F.M_2)V_2$$

Where $V_1, V_2 \rightarrow$ volume factors of those 2 materials

$F.M_1$ & $F.M_2 \rightarrow$ Fineness Modules of a diff Agg's

Find Fineness Modulus Of a Sample Aggregate which Seive Analysis is done ?

IS sieve size	% passing	% Retained
25	100	0
20	95	5
16	56	44
12.5	30	70
10	15	85
4.75	3	97
2.36	0	100

$$\sum \% \text{ retain} = 401$$

$$F.M = \frac{401}{100}$$

$$F.M = 4.01$$

Shape & Texture Of the Aggregate :

The shape is a important parameter in Aggregates why because it is directly influences the strength and workability of the concrete .

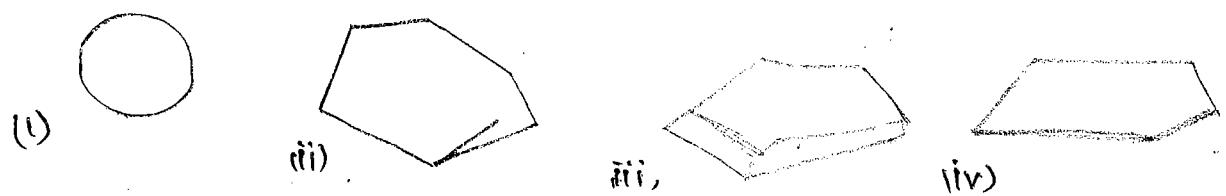
The shape of the Aggregate is classified into 4 major types

1. Spherical

3. Flaky (i) Flat

2. Irregular

4. Needle shaped



Rounded Aggregates are more preferred in concrete mix calculation because of its Bonding property

— irregular shaped aggregates are not suitable in concrete mix design and the Flaky and Elongated Aggregates also negligible in concrete mix design because of its improper shape & surface area.

Needle shape Aggregated are surely avoided in concrete mix design because of its sharp Edges.

The Flakious Index & Elongation Index & Angularity number is measured for the shape of the aggregate of size greater than > 6.3 mm.

Shape Of Aggregates :

shape of Aggregates	Details
Angular shape	Well defined edges
Elongated shape	The length of Agg is more when compared to other dimension
flaky	The Agg having thin in thickness relative to other dimensions
Irregular	The Randomness is present in perfection of shape
Rounded Agg	Absence of sharp edges

Surface Texture :

the surface texture of the Agg is important in developing Bond in Interface. the surface texture depends upon the crystalline structure, pre structure, Transport media & various other factors including the climatic conditions also

Surface Texture	Details
Crystalline Texture	Disability of crystalline prop's on the surface
Glossy Texture	It having sharp edges
Granular Texture	These are the uniform round grained aggregates
Honey combed Texture	Visibility pores on surface
Rough Texture	Medium grained Proper shaped
Smooth Texture	No sharp edges on the surface of the Aggregate

5MPTA

Specific gravity, Density, Water Absorption of Agg:

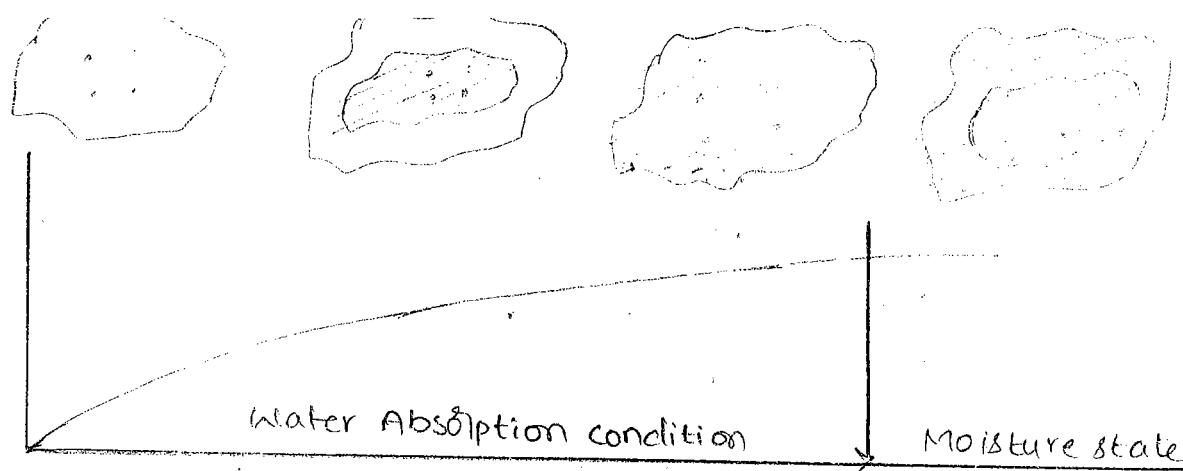
The Specific gravity of Aggregate is the ratio of Density of Aggregate to Density of Water. The Aggregate exists under 4 different moisture conditions (Water Absorption conditions) namely

- i) Bone dry condition.
- ii) Air dry condition.
- iii) Saturated surface dry condition.
- iv) Moisture condition.

The water content present in these conditions are different.

The specific gravity of the Aggregates are determined under these conditions.

Generally, the specific gravity of the saturated surface dry condition of Aggregate is used in concrete mix design.



Generally, the aggregates consists inherent pores. Some of the pores are interlinked with surface texture and remaining are interlinks with interior structure of the material (a) Aggregate.

Because of these condition the Bone dry sample may having some moisture content in the Interior structure after 24 hrs of oven dry also.

That's way the Bone dry sample specific gravity is not used in concrete mix design.

The oven dry sample is achieved by drying the sample in oven at 100°C in 24 hrs.

Air dry sample completely depends upon climatic conditions. So, we negligible this condition.

The Saturated surface dry condition is achieved by taking an Agg sample & it is immersed in water at 30°C in 24 hrs. After that taking the agg sample from water & clean the surface with cotton cloth. It is called saturated surface dry condition of Agg.

$$\text{Specific gravity of Agg} = \frac{\text{Unit weight of Agg}}{\text{Unit weight of H}_2\text{O}}$$

$$(a) \frac{\text{Density of Agg}}{\text{Density of Water}}$$

$$S.P.G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$$

M_1 = Empty wt of pycnometer

M_2 = Empty + Agg

M_3 = Empty + Agg + water

M_4 = Empty + Water.

To find specific gravity of Agg we use pycnometer & Density bottle methods

Normal specific gravity of Agg varies in range of
~~2.5 - 2.8~~

Thermal properties of the aggregates:

The rocks and aggregates and passes thermal properties which are significant in established the quality of the aggregates in concrete construction work.

The properties of aggregates as follows

1. co-efficient of thermal expansion.

2. specific heat

3. Thermal Conductivity.

Out of these specific heat and conductivity of found very important in mass concrete work.

where rigorous control as temperature is necessary also these properties are consequent of in case of light weight concrete used for multipurpose.

An average value of linear thermal coefficient of expansion of concrete may be taken as 9.98×10^{-6} in same condition the range may be taken as range may be $-6 \text{ to } 10 \times 10^{-6} / \text{m}$ is depending

upon the other concrete properties the range of may vary from $10.8 \times 10^{-6}/^{\circ}\text{C}$ to $16.2 \times 10^{-6}/^{\circ}\text{C}$.

Similarly for Cement Mortar it may varies from $9.9 \times 10^{-6}/^{\circ}\text{C}$ to $12.6 \times 10^{-6}/^{\circ}\text{C}$. Generally the linear thermal Coefficient of is common varies in various between 0.9×10^{-6} to $16 \times 10^{-6}/^{\circ}\text{C}$.

Introduction to fresh concrete :

The production of good concrete mix is important for quality construction. The desirable characteristics of good fresh concrete mix is

1. Possibility of Easy Transport & placing.
2. Resistance to Bleeding & Segregation Reactions.

The overview of the concrete production process is systematically explain by the following flow chart

Stages Of Production Of Concrete :

Batching Of the Ingredients



Mixing Of the Ingredients In proper proportions



To obtain the fresh concrete from above 2 stages



To Transport the fresh concrete to constructions spot



Test the sample concrete mix



Place the concrete mix where it is required



After that compacting the concrete mix without air voids



Curing is done properly for req days i.e 7 days (or) 14 days



Proper finishings is done



Harden concrete is obtained

Wetting of Concrete ingredients :

In this process of Batching in concrete production work two ways to done :

1. Volumetric Batching
2. Weigh Batching

Volumetric Batching :

- In this volumetric Batching we are using box guages (a) volumetric vessels to measure the Ingradient volume
- It is an approximate method. No skilled labour is not required in volumetric Batching
- the production of concrete by volumetric batching require more materials because of its improper proportions of mix
- Generally, this type of Batching is used in unimportant concrete works

* Compute the volume of constituent materials for the Batch of 1 bag cement. the concrete mix proportions 0.45 : 1 : 1.861 : 3.583 (water : ^{cement}sand : Fine Agg : Coarse Agg) the Bulk Density of fine. Agg is 1500 kg/m³. The Bulk Density of coarse Agg is 1450 kg/m³.

Al-

Given data,

$$1 \text{ Bag} = 50 \text{ kgs}$$

$$\text{Bulk Density of cement} = 1440 \text{ kg/m}^3 \text{ (standard value)}$$

$$\text{Cement} = 1, \text{ water} = 0.45$$

$$\text{Fine} = 1.861$$

$$\text{Coarse} = 3.583$$

Weight of Cement = 50 kg

$$\begin{aligned}\text{Weight of Fine Agg} &= 50 \times 1.861 \\ &= 93.05 \text{ kg}\end{aligned}$$

$$\begin{aligned}\text{Weight of coarse Agg} &= 50 \times 3.583 \\ &= 179.15 \text{ kg}\end{aligned}$$

$$\begin{aligned}\text{Weight of water} &= 0.45 \times 50 \\ &= 22.5 \text{ kg}\end{aligned}$$

Assume,

Density of water = 1000 kg/m³

$$\begin{aligned}\text{Vol of cement for 1 bag} &= \frac{50}{1450} \\ &= 0.0349 \text{ m}^3 \\ &= 0.0349 \times 1000 \text{ lit} \\ &= 34.9 \text{ lit}\end{aligned}$$

$$\begin{aligned}\text{Vol. of fine Agg} &= \frac{93.05}{1500} \\ &= 0.0620 \text{ m}^3\end{aligned}$$

$$\begin{aligned}\text{Vol of coarse Agg} &= \frac{179.15}{1450} \\ &= 0.1235 \text{ m}^3\end{aligned}$$

$$\begin{aligned}\text{Vol of water} &= \frac{22.5}{1000} = 0.0225 \text{ m}^3 \\ &= 22.5 \text{ lit}\end{aligned}$$

Compute the

0.48 : 1 : 2.62 : 4.19 . Bulk Density of fine Agg 1510 kg/m³

Bulk Density of coarse Agg is 1480 kg/m³.

Weight of cement = 50 kg

$$\begin{aligned}\text{Weight of Fine Agg} &= 50 \times 2.62 \\ &= 118.1\end{aligned}$$

$$\begin{aligned}\text{Weight of coarse Agg} &= 50 \times 4.19 \\ &= 209.5\end{aligned}$$

$$\text{Weight of water} = 1480 \text{ kg/m}^3$$
$$= 24$$

Assume, Density of water = 1000 kg/m^3

$$\text{Vol of cement} = \frac{50}{1440} = 0.0347 \text{ m}^3$$

$$= 34.7 \text{ lit}$$

$$\text{Vol of fine Agg} = \frac{118.1}{1510} = 0.078 \text{ m}^3$$

$$\text{Vol of coarse Agg} = 0.0141 \text{ m}^3 = \frac{20.95}{1480}$$

$$\text{Vol of water} = \frac{24}{1000} = 0.024 \text{ m}^3$$

$$= 24 \text{ lit}$$

Way Batching :-

The Batching of constituent materials by weights provides better accuracy & reliability.

In this Batching procedure the weights of materials are taken into consideration.

Computer control & automatic weighing systems are used in large Batching plants (Redimix plant)

The Weight Batching Systems are calibrated frequently to maintain uniformity in quality of concrete.

Generally in Bulk production works the way Batching system is used.

A skilled labour is required for good operation of mix proportions. And also the loss of materials is very less when compared to volumetric Batching.

Due to Way Batching we are achieving good quality of fresh concrete.

Mixing :

Mixing is the process of dispersing the constituent materials uniformly in fresh concrete mix. The mixing is continued until the fresh mass becomes Homogeneous and uniform colour.

Mixing process is classified into 2 major types

1. Hand mixing

Batch

2. Machine mixing.

Batch mixing

Continuous mixing

- a) Tilting Drum mixer
- b) Non Tilting Drum mixer
- c) Pan Type mixer
- d) Dual Drum mixer

Hand Mixing :

- * Hand mixing is used in small scale & unimportant construction works
- * In Hand mixing process the quality of fresh concrete is affected by the workmanship.
- * The cement & fine Aggregate are initially mixed properly in dry condition
- * The coarse Aggregate is spread over the cement sand mixture in alternative layers
- * The dry mix is turned 2-3 times to achieve homogeneity.
- * In this Hand mixing process initially 75% of water is added to the dry concrete mix and mixed thoroughly.
- * After that remaining 25% of water is sprinkled over the concrete mix to achieve homogeneity and uniformity in colour.
- * In this hand mixing process we require non absorbing platforms (B) steel plates during the time of mixing.

FRESH CONCRETE

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$$\text{Weight of water} = 0.48 \times 30 \\ = 24$$

Assume, Density of water = 1000 kg/m^3

$$\text{Vol of cement} = \frac{50}{1440} = 0.0344 \text{ m}^3$$

$$= 34.4 \text{ lit}$$

$$\text{Vol of fine Agg} = \frac{118.1}{1510} = 0.078 \text{ m}^3$$

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2. Machine mixing

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Continuous mixing

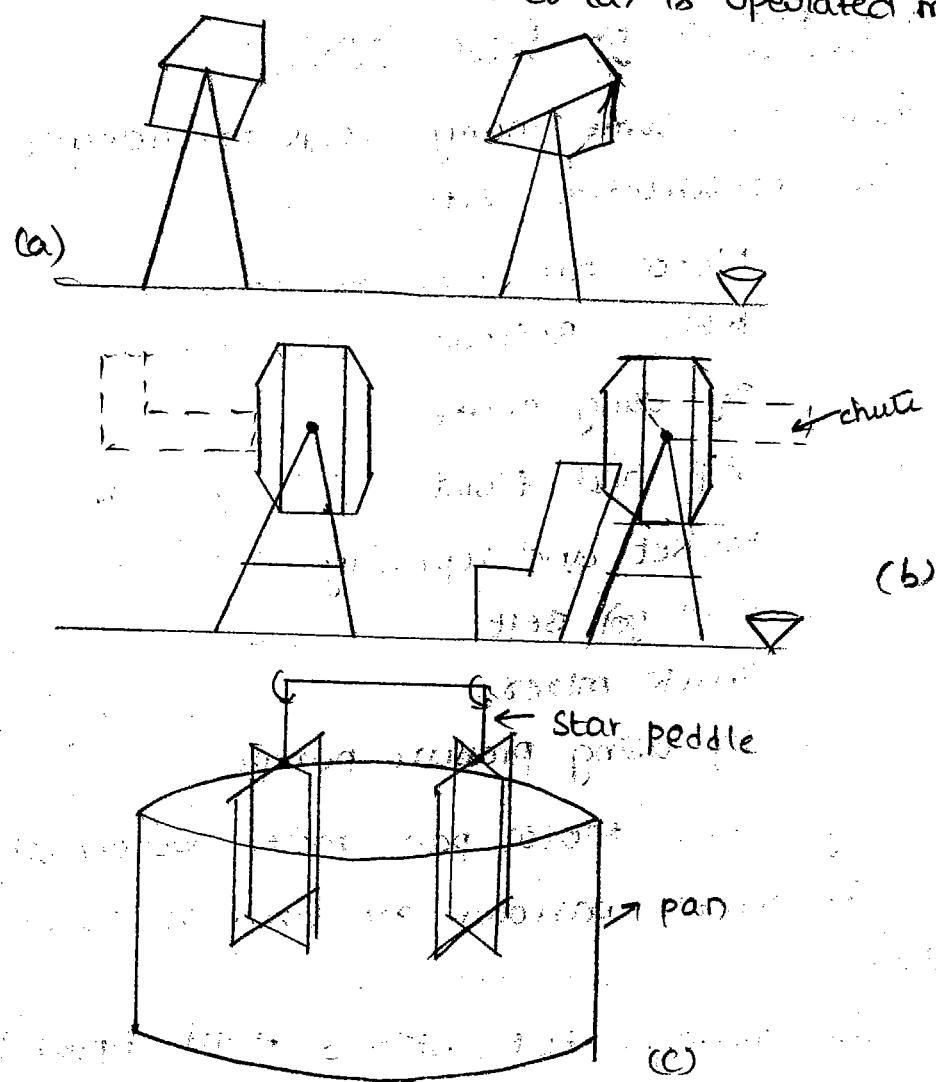
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Machine Mixing :-

- The machine mixing operators consists sharp blades to mix the concrete ingredients properly.
- Generally this concrete mixing operators are worked by using fuel (a) Electricity.
- Both Batching and continuous mixers are done in this type of mixing.
- This Tilting-type machine mixer (a) is operated manually



In this type of mixer having a problem with inconvenience in sharp blades of drum axis and other mechanical properties.

Generally all the ingredients of concrete is added to the drum 50 l. of water content is charged and thoroughly mixed sometime. After that 30 l. of water is charged into the drum & do continuous mixing until the Homogeneity and uniformity in colour is occurred.

- Remaining 20 l. of water is added before the removal of concrete mix from the machine mixer. At that time we are also adding the chemical admixture to the concrete mix.
- the pan type machine mixers are used for the mixing the cohesive concrete in less water content.
- Generally these type of mixer are used in Bricks manufacturing Industry.

Transportation Of fresh Concrete :

There are some many ways to Transport the fresh Concrete to the construction site.

- Motor pan
- Wheel Barrows
- By using chute
- Skip and Hoist
- Bucket and ropeway
- Conveyer Belt
- Truck mixer
- By using pressure pumps.

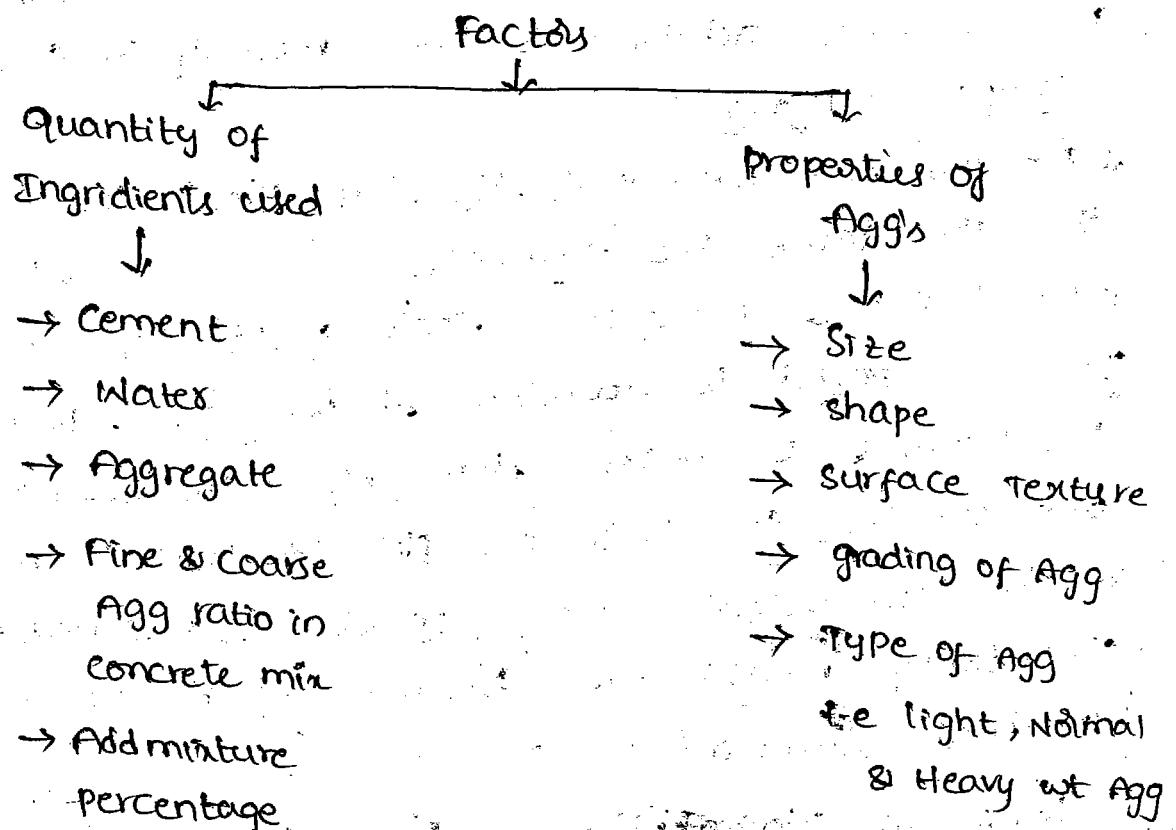
- By using Motor pan more workmanship is required.
- the wheel barrows are used in road construction works
- the conveyer belt, skip & hoist Apparatus are generally used in multi storied Building construction
- the chute Apparatus are used in transporting the fresh concrete from higher level to lower levels
- Bucket and ropeway system is used in water island works. Because the construction spot is present in water body that's why we are transporting the fresh concrete through Bucket & Ropeway.

- the truck mixer are used in Batching plants
- Generally these ready mix trucks are used in long way to transport the fresh concrete.
- The concrete is mixed in this ready mix trucks during the travelling time.

Tests on Fresh Concrete :

1. Consistency of concrete
2. Firmness
3. Stiffness
4. Solidity
5. Stability of concrete
6. Thickness of concrete
7. Flowing ability
8. Fluidity
9. Filling Ability
10. Passing Ability

Factors Influencing workability of concrete :-



Quantity Based :-

- * The Workability of concrete is increases due to increase in cement & fine Aggregate content.
- * For increasing these Ingredients in concrete mix the construction cost will be increasing.
- * We are achieving more degree of workability by increasing water content in concrete mix, but increasing of water content gives less compressive strength.
- * At the same time the admixture is also influence the degree of workability.
- * If you are adding more admixture than the required
 - In the segregation reaction takes place in concrete mix.
- * If you are increasing the mineral admixture content we shouldn't achieve bonding property in concrete mix.

Properties Based :

- * the less size (or) small size Agg yields less workability than the large size aggregates.
- * the Flaky & Elongated Agg's yields less workability when compared to rounded shape Agg's, why because the Flaky & Elongated shape Agg's are interlocked with one another to block the flow of concrete mix.
- * The less weight Agg's yields less workability than the heavy weight Agg "because of its pores in the internal structure".

Tests on Workability of Fresh Concrete :-

Fresh concrete is sub divided into 2 types:

Fresh concrete

↓

Normal Concrete mix

↓

Self Compacting Concrete

It consists cement, fine Agg, coarse Agg and water

Self compacted Concrete :

It consists cement, fine Agg, coarse Agg, mineral add mixture, chemical admixture & water content

Tests on Normal concrete mix :

1. Slump Cone Test
2. compaction factor test
3. Flow Table Test
4. Vee-bee consistency Test
5. Flow Test (IS-4103-1999)

} According to
IS-1199-1950

Slump cone Test :—

By using Slump cone Apparatus we are calculating the slump of concrete mix. Based on various ranges of slump the degree of workability to be determined. The Slump cone Apparatus consists conical shaped mould having 10 cm top dia. & 20cm bottom dia and 30 cm of cone height.

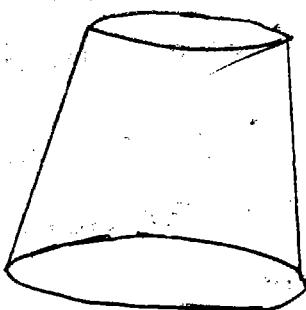
Initially we are preparing the concrete mix to our req proportion.

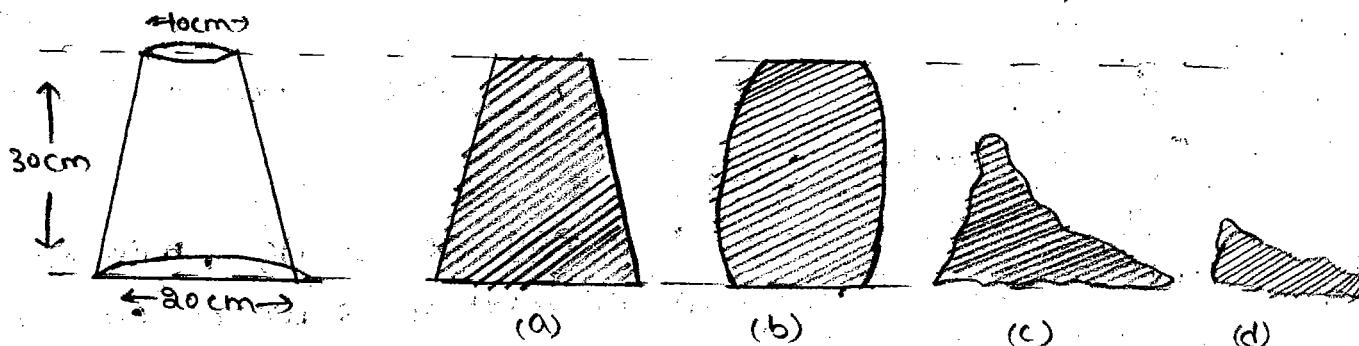
Put the conical mould on flat surface and fill with concrete mix by 3 layers. Each layer must be tamped by using Tamping Rod.

Generally in Slump cone test the following Slump conditions are occurred

- a) zero slump
- b) True slump
- c) shear slump
- d) collapsed slump

5/





zero slump indicates a stiff consistent concrete mix.

The slump test is not appropriate for measuring the workability of stiff concrete mix.

The true slump is characterize the homogeneity of the concrete mix.

The shear slump indicates the improper mix (b) Non Homogeneity mix concrete mix

The collapsed slump represents the lean concrete mix

Workability conditions:

- * If the slump value vary b/w 0 to 25 mm the concrete mix having very low degree of workability

- Generally these type of concrete mix are used in Road construction works & large sections of massive constructions where power vibrators are used

- * If the slump value vary b/w 25 to 50 mm the concrete mix having low degree of workability

- this type of concrete is used in road construction & mass concrete foundations where hand operated vibrators are used

- * If the slump value vary b/w 50 to 100 mm the concrete mix having ^{(lo) Medium} moderate degree of workability

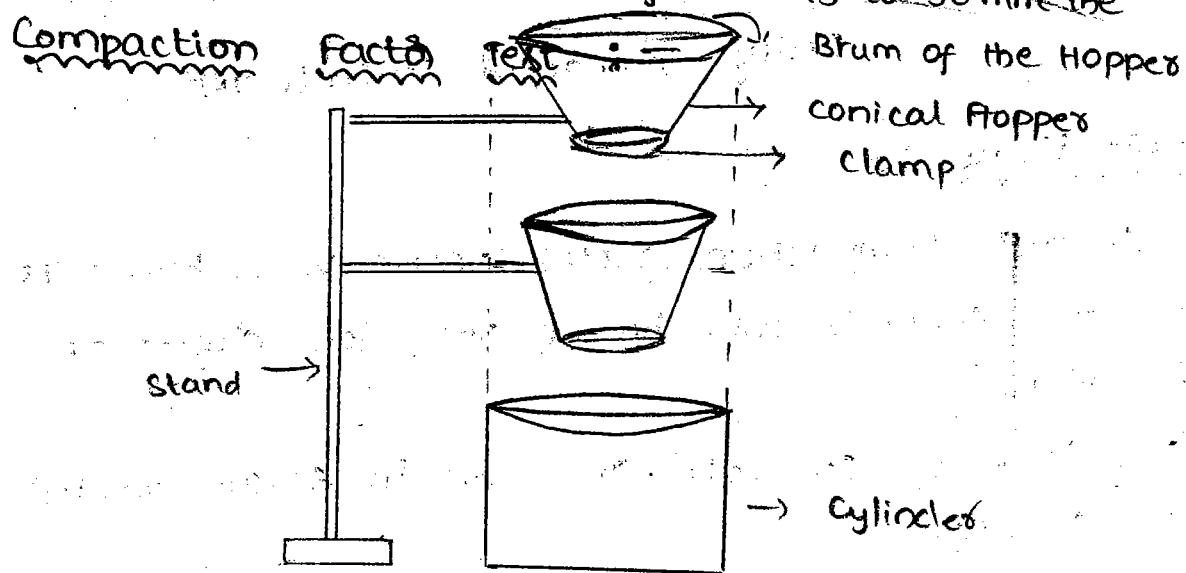
- this type of concrete used in flat slabs & Normal Reinforced construction works where manual compaction is done

If the degree of workability ranges b/w 100 to 195 mm then the concrete is Heavy (or) High degree of workability.

Generally this type of concrete are used in congested reinforcement is present in construction works. and large sections of massive constructions, power vibrators are used

* If the slump value vary b/w 25 to 50 mm the

Compaction Factor Test



It is used to determine the consistency of a stiff concrete mix.

The C-F test apparatus consisting a conical hoppers fitted to a stand (or) fixed Base and a movable cylindrical mould is present, to below of bottom conical Hopper.

Initially we must close the clamps which are present below the hoppers and prepare concrete mix to our require proportions and fill concrete mix upto the top surface of the brim of top conical Hopper

After 2 min the clamp is released than the concrete mix is filled to the bottom conical Hopper then after we are releasing, bottom clamp also the cylinder is filled with the partially compacted concrete.

Initially we are weighing the empty weight of cylinder after that we are also measure the partially

Compacted Concrete

After that we are also measuring the fully compacted concrete in the cylinder by 3 layers.

∴ The compaction factor value is

Partially compacted concrete weight

Fully compacted concrete test

Limitations :-

→ If the compaction factor value vary b/w 0.78 - 0.80 than the concrete mix having very low degree of workability.

This type of concrete are used in small oriented slc with vibration.

→ If the C-F value vary b/w 0.85 to 0.92 than the concrete mix having medium degree of workability.

Generally this type of concrete are used in light reinforced slc with vibrations.

→ If the C-F value is above 0.92 than the concrete mix having high degree of workability. Generally these are used in Heavy reinforced slc without vibrations.

Vee-Bee Consistency Test :-

The Vee-Bee consistency Apparatus is used to determine the workability of stiff concrete mix.

The Test Apparatus consist a vibrating table and a cylindrical mould with "slump cone" Apparatus and a stand. Base is fitted to the vibrating table in addition to a conical funnel and movable glass disk.

Required proportions and fill the concrete mix into slump cone mould by layers and slowly remove the mould (by layers and slow) from the cylinders and place the glass disk at top surface of cone shaped mix and start the vibratory machine & stopclock at a time and measure the time of settlement of (vee-bee time) particular concrete mix.

Limitations :

- If the vee-bee time vary b/w 10-20 sec. the degree of workability is very low and the concrete is used in small slc with vibrations.
- If the vee-bee time vary b/w 10-5 sec, the degree of workability is low
- If the vee-bee time vary b/w 5-2 sec, then the degree of workability is medium (a) High
- The concrete is generally used in high reinforced slc without vibration

Flow Table Test :

* It is used to determine the fluidity of concrete mix

The flow table test apparatus consisting a frustum of a cone is used to place the concrete

The concrete is filled in the mould & kept on the top of table

The top surface of the conical mould is trimmed and lift it.

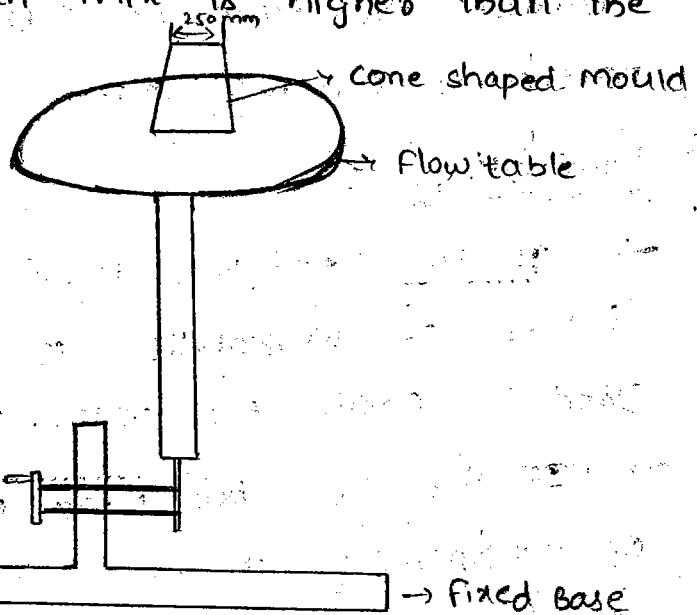
The base dia of conical mould is 250 mm

the table is raised and dropped 15 times at a standard speed

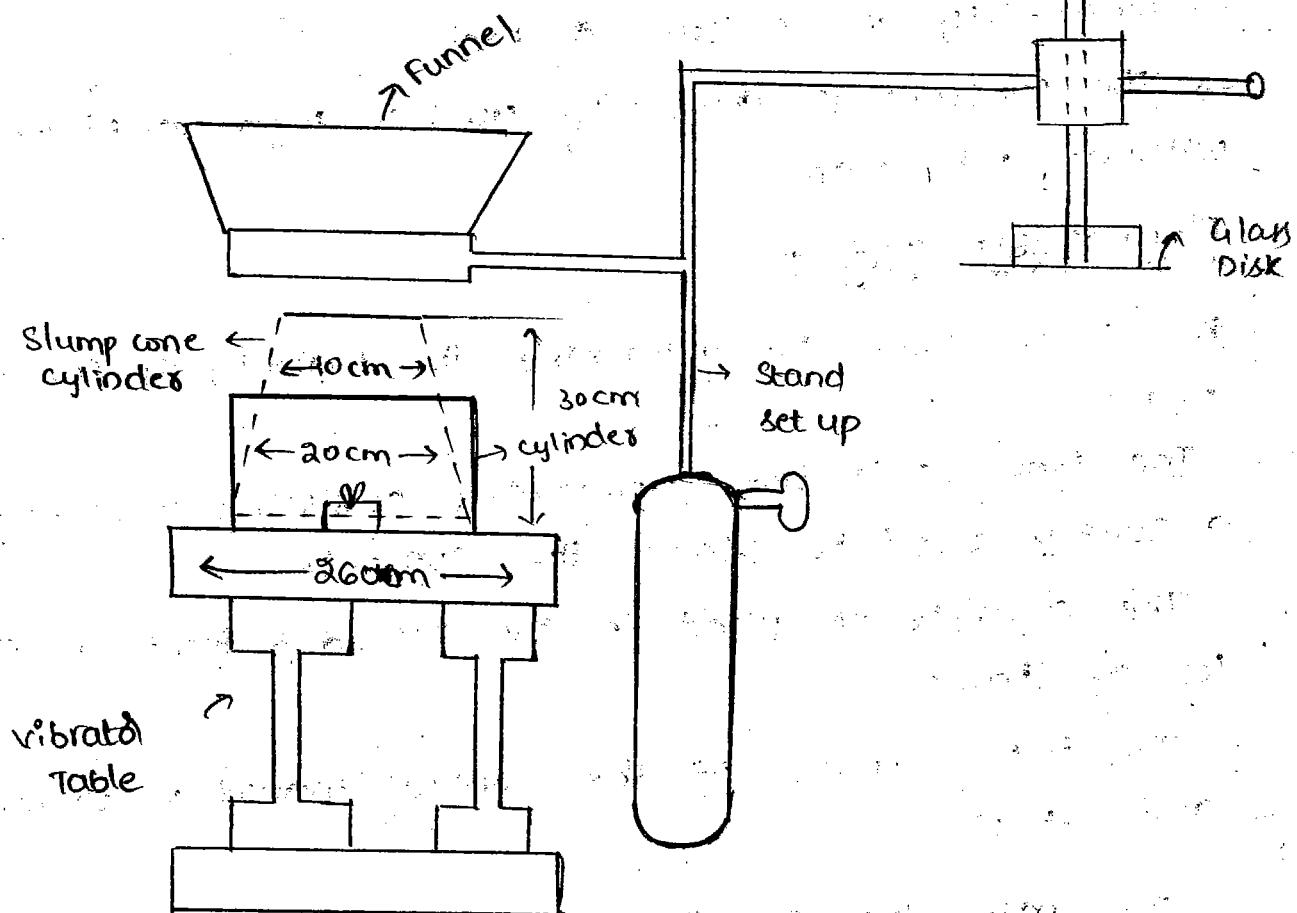
the spread of concrete on the table recorded

Flow is the percentage increase in the dia of the spreaded concrete over the original dia

The flow of the lean mix is higher than the stiff mix



FLOW TABLE SET UP



VEE - BEE APPARATUS

Workability Test

Normal concrete

IS 1199 - 1950

Slump Test

Compacting factor Test

Flow Table Test

Vee-bee consistency test

IS 1903 - 1999

Flow Test

Self compacting concrete

Slump Flow Test

V-funnel Test

L-box Test

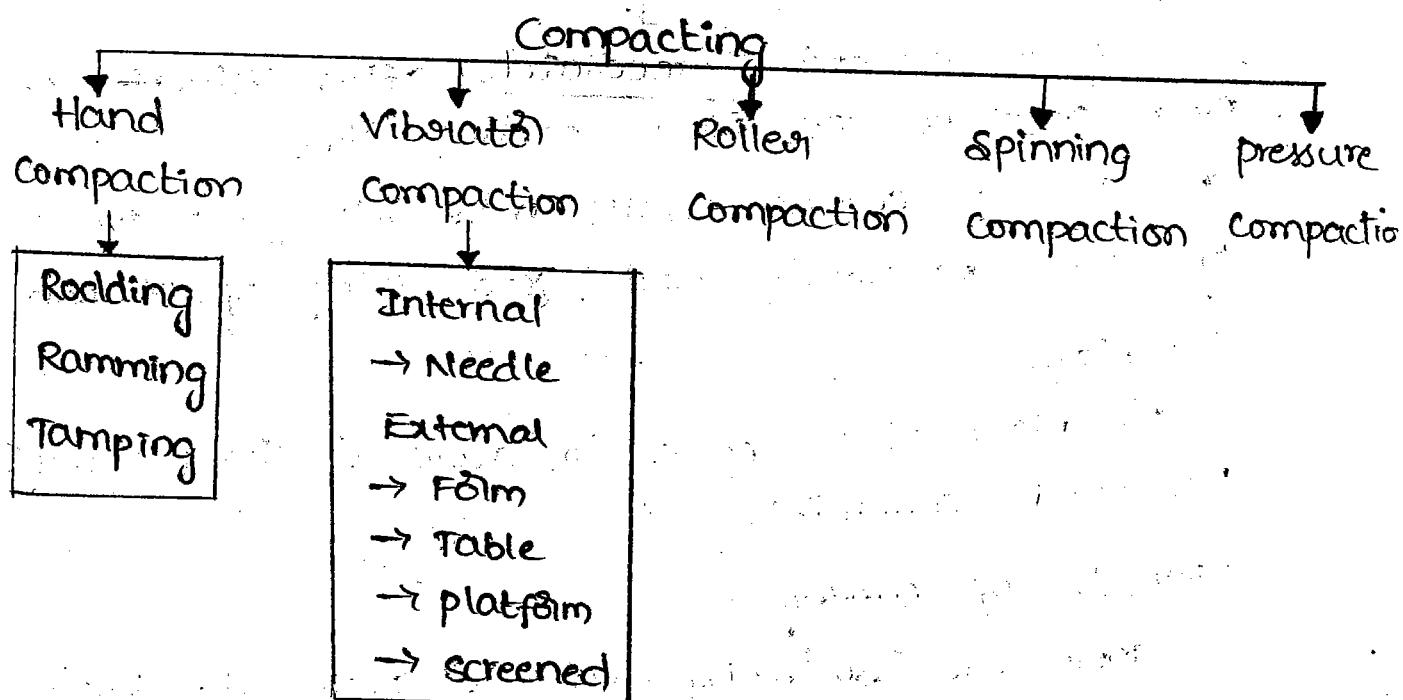
U-box Test

J-Ring Test

Otmet Test

GTM Screen stability Test

Compacting :



Compaction is the process of removing entrapped air bubbles from the fresh concrete and improving the tamping packing of Agg to form dense concrete.

The presence of air bubbles in concrete mix results in honey coombing & blow holes in concrete.

It directly effects the strength of structure

The approximate air content in fresh concrete is 25%.

which is reduced to 2-5%. By proper compaction the compacted concrete is dense, strong and durable. A poorly compacted concrete requires to be repaired in early stages of its service.

Curing :

Curing is the process of controlling the moisture loss from the concrete during the hydration of cement.

Curing influences the strength and durability properties of the hardened concrete.

The surface of the concrete exposed to sun (8) drying wind.

It is sensitive to curing.

Curing is started immediately after stiffening of fresh concrete or final setting time.

The proper curing results more strength to the structure, durability and good living of human.

Advantage

Advantage of curing is to avoid structural cracks in hardened concrete.

Methods of curing :

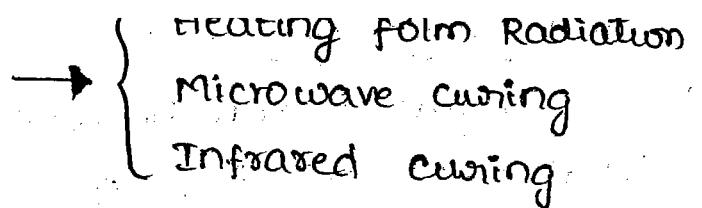
There are so many ways to curing the concrete structure.

1. Water curing → { Immersion
Ponding
Fogging & spraying

2. Steam curing → { Steam at Atmospheric pressure
Steam at High pressure

3. Covering curing → { Wet covering
Membrane curing

4 Special methods



5. Electrical curing



Flow ability of concrete

Effect of Temperature on Workability :-

When fresh concrete is laid at the side then proper curing of concrete is required because the structures are exposed to the environment and in these conditions if there is such arrangements against environment is not provided then so many factors effecting the workability of the concrete.

Temperature is one of the factor among all other environmental conditions.

When the temperature increases than in the same proportion the workability of fresh concrete is decreases.

When the temperature decreases the workability of concrete may increases at some extent. the reason that stands behind is when temperature increases the rate of evaporation of water also increases due to hydration of cement.

The rate of evaporation is decreases hence the concrete will gain early strength. Due to the fast hydration of concrete the concrete gets hard in early time.

Segregation process :-

Segregation can be defined as the separation of constituent materials of concrete mix. A good concrete exhibits good compressive strength and absence of structural cracks.

The tendency of segregation in concrete mix due to improper selection of concrete ingredients and poor workmanship.

Due to the Segregation process in concrete mix we achieve weak strength to the structure and the surface cracks and structural cracks are developed in concrete structure.

In generally, the Segregation process is of 3 types :

1. The Separation (i) settling down of coarse Agg from cement matrix (ii) other than coarse Agg in concrete mix
2. the separation of cement matrix from coarse Agg
3. the separation of Excess water (i) the water content present in the concrete mix proportion these are the 3 ways of segregation process

→ The favourable conditions for Segregation process are

1. Due to the Excess water content using in the process of Mixing
2. In long columns (slenders) (i) deep foundations the dropping of concrete mix from High levels

How to avoid Segregation

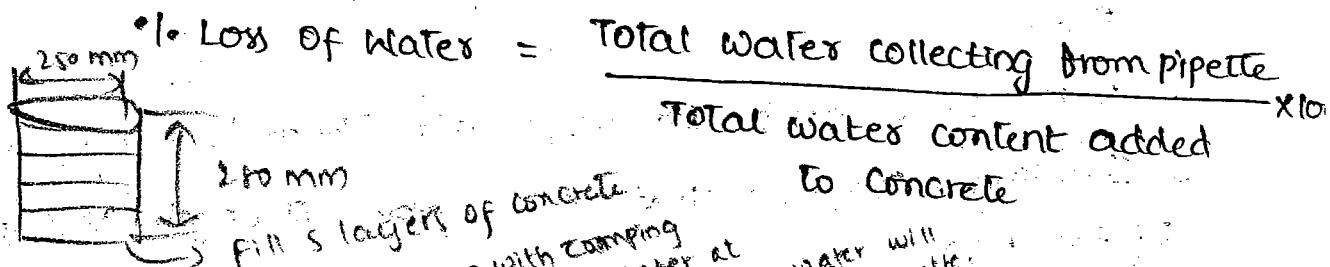
To take care about the selection of materials like grading, shape, texture & optimum moisture content will results good concrete mix proportion

It gives good bond strength to the concrete structure
the cohesive mix shouldn't allow any type of segregation
process.

Bleeding Of Concrete mix :

The separation (a) the exhibition of excess water content present in the concrete mix appear on the Top surface of the concrete structure after placing. It is called Bleeding Of concrete in Concrete mix.

So, we are finding the % of Bleeding water content in concrete mix proportion is the Ratio of Total water content loss (a) present on the surface of the concrete structure to the Total water content adding to the sample concrete mix.

$$\% \text{ Loss of Water} = \frac{\text{Total water collecting from pipette}}{\text{Total water content added to Concrete}} \times 10$$


Then we Tamp with tamper rod then we get a water at above layer the layer of water will take it out by pipette

HARDENED CONCRETE

The compressive strength of the concrete is one of the most important and useful property of concrete in most structural applications. Concrete is employed primarily to resist compressive stress.

In some conditions the tension, shear stresses are plays an important role in structural construction.

In these cases the compressive strength of concrete is take into consider to design (or) to satisfy the other stresses developed in structural members.

Factors Effecting the Strength of Concrete (Hardened Concrete)

1. Water - cement ratio and degree of compaction ratio
2. Ratio of cement to aggregate (both fine & coarse Agg)
3. Grading, surface texture, shape, strength and stiffness of the Agg
4. Max size of Agg used

These are the important factors which are influencing the strength of concrete.

Water Cement Ratio & Degree of Compaction :-

The strength of concrete primarily depends on the strength of cement paste.

It has been shown that the strength of cement paste depends upon the dilution of the cement paste (or) in the other voids the strength of the cement paste increases with the increase of cement content & also it is decreases with increasing the air voids & water content.

In 1918 Duff Abrams proposed a statement that

Assuming fully compacted concrete, δ_1

$$= \frac{1}{2} \left(\frac{P}{\rho g} \right)^{1/2}$$

$$= \frac{1}{2} \left(\frac{100000}{1000 \times 9.81} \right)^{1/2}$$

$$= 25.0 \text{ mm}$$

$$\therefore \delta_1 = 25.0 \text{ mm}$$

Gel Space Ratio : $\frac{w}{c} \uparrow$ G/S \downarrow por \uparrow strength J,

the concrete is a brittle material so the porosity is primarily influences the strength.

The compressive strength is severely decreases due to the increasing of its porosity

The porosity of the concrete which governs the strength of the concrete is affected by the gel space ratio in concrete mix

The G/S ratio is the ratio of the solid products of hydration to the space available for these hydration products

A Higher Gel space ratio reduces the porosity and therefore strength of the concrete is increases

The Gel space ratio governs the porosity of the concrete after its strength effected by water cement ratio.

The higher water cement ratio gives less G/S ratio due to less G/S ratio the porosity of concrete is increases thereby strong the decrease of strength of concrete occurs $w/c \uparrow$ G/S \downarrow , por \uparrow str \downarrow .

"THE POWERS" Experiment shows that the strength of the concrete bears a specific relationship with the G/S

He proposed a formula to calculate the theoretical strength of concrete

$$S = 240 (x)^3$$

where $x = \text{Gel}/\text{space ratio}$

The value 240 represents the Inherent strength of the Gel

For the type of cement is specifically used

To calculate the Gels ratio in fully hydrated cement is

$$x_f = \frac{0.657C}{0.319C + W_0}$$

C = Weight of cement (in gms)

W_0 = Volume of Mixing Water (in ml)

To calculate the Gels ratio for partially hydrated cement

$$x_p = \frac{0.657Cx\alpha}{0.319Cx\alpha + W_0}$$

α = % of hydration

Problem :

1. Calculate the Gels space ratio and theoretical strength of sample of concrete made with 500 gms of cement and 0.5 w/c ratio for fully hydrated & at 75% of hydration

A)

~~For fully hydrated cement :~~

Given: C = 500 gms

$$\alpha = 75\% = \frac{75}{100} = 0.75$$

$$w/c = 0.5$$

$$100 \text{ ml} \rightarrow 910 \text{ gms}$$

$$? \rightarrow 250 \text{ gms}$$

274.92

$$\frac{W}{500} = 0.5$$

W = 250 gms of water

$$W_0 = 250 - 274.92 \text{ ml}$$

$$x_f = \frac{0.657 \times 500}{0.319 \times 500 + 274.92}$$

$$x_f = 0.35$$

$$x_p = \frac{0.657 \times 500 \times 0.75}{0.319 \times 500 \times 0.75 + 274.9}$$

$$x_p = 0.62$$

$$Th S = 240(x)^3 = 240 \times (0.62)^3 = 59.19 \text{ N/mm}^2$$

$$\rho = \frac{m}{V}$$
$$1440 = \frac{500}{S}$$
$$S = \frac{500}{1440(x)^3}$$
$$= 240(0.35)^3$$
$$Th = 109.5 \times 0.35 \text{ N/mm}^2$$

1. calculate the GIs ratio and theoretical strength of a sample of concrete made with 500 gms of cement and having with the W/c ratio 0.5 on fully hydration & 60% of hydration ?

Al-

Given, weight of cement used for sample = 500 gms

MID
PROBLEM
2M

$$W/C \text{ ratio} = 0.5$$

$$\text{the weight of water used } W = 0.5 \times C$$

$$= 0.5 \times 500$$

$$= 250 \text{ gm}$$

$$\text{vol of water used } w_0 = 250 \text{ ml}$$

for water
1 lit \rightarrow 1kg
1gm \rightarrow 1ml

for fully hydrated concrete

$$GIs \text{ ratio } X_f = \frac{0.657 \times C}{0.319 \times C + w_0}$$

$$X_f = 0.8021 \approx 0.8$$

theoretical strength for fully hydrated cement

$$\begin{aligned} S &= 240(X_f)^3 \\ &= 240(0.8)^3 \\ S &\approx 123 \text{ N/mm}^2 \end{aligned}$$

for 60% hydration

$$\begin{aligned} X_p &= \frac{0.657 \times C \times \alpha}{0.319 \times C \times \alpha + w_0} \\ &= \frac{0.657 \times 500 \times 0.6}{0.319 \times 500 \times 0.6 + 250} \end{aligned}$$

$$\therefore X_p = 0.57$$

theoretical strength for partially hydrated cement

$$S = 240 \times (0.57)^3$$

$$S = 44.44 \text{ N/mm}^2$$

compute the w/c ratio & theoretical strength of a sample of concrete 680 gms of cement and having w/c ratio 0.48 on fully hydrated & at 72.1% of hydration

G/w ratio of fully hydrated cement

$$x_p = \frac{0.657 \times C}{0.319 \times C + W_0}$$

The weight of cement used $C = 680$ gms

volume of water used in mix $W_0 = ?$

$$\frac{W}{C} = 0.48 \Rightarrow W = 0.48 \times 680 \\ = 326.4 \text{ gms}$$

Vol of Water $W_0 = 326.4 \text{ ml}$

For fully Hydrate $x_p = \frac{0.657 \times 680}{0.319 \times 680 + 326.4}$

$$\underline{x_p = 0.822}$$

Theoretical Strength for fully Hydrated cement

$$S = 240(x_p)^3$$

$$S = 240(0.8)^3 \Rightarrow S \approx 123 \text{ N/mm}^2$$

$$\underline{S = 122.88 \text{ N/mm}^2}$$

For 72.1% Hydration

$$x_p = \frac{0.657 \times C \times \alpha}{0.319 \times C \times \alpha + W_0} \\ = \frac{0.657 \times 680 \times 0.72}{0.319 \times 680 \times 0.72 + 326.4}$$

$$\underline{x_p = 0.6}$$

Theoretical Strength for partially hydrated cement

$$S = 240(x_p)^3$$

$$S = 51.8 \text{ N/mm}^2$$

$$\underline{S \approx 5.2 \text{ N/mm}^2}$$

Maturity Concept of Concrete :

While dealing with curing & strength development we have so far consider only the time aspect but the strength development of the concrete is not only depend on time it also depends on the Temperature during the early period of hydration that influences the the rate of gain of strength of the concrete

The strength development of the concrete can be explain a function of summation of the product of Time & Temperature.

The function of summation is called maturity of the concrete

$$\therefore \text{Maturity } M = \sum (\text{Time} \times \text{Temperature})$$

The Temperature is Established by No. of calculations from an origin laying b/w -12°C to 10°C

By Experimentally It is found that the hydration of concrete continuous to takes place upto about -11°C .

-11°C is taken as a datum line for computing the Maturity of concrete

The Maturity is measured in terms of $^{\circ}\text{C hrs}$ (deg C days)

Note :

A sample of concrete is cured at 18°C in 28 days
The full Maturity of the concrete is

$$M = \sum (\text{time} \times \text{temperature})$$

$$\text{Datum line temp} = -11^{\circ}\text{C}$$

$$\text{Given Temp.} = 18^{\circ}\text{C}$$

$$M = 28 \times 24 (18 - (-11))$$

$$= 19,488 ^{\circ}\text{C hrs}$$

The full maturity of concrete mix for 28 days at 18°C curing Temperature is. 19,488 °C hrs

For more calculations and Research Oriented we are considered the full maturity of the concrete mix is 19,800 °C hrs.

The Maturity Concept is useful for estimating the strength of concrete at any other maturity value as a percentage of strength of the concrete at no maturity value.

The % of strength of identical concrete at any other maturity value = $A + B \log_{10} \left(\frac{\text{Maturity}}{10^3} \right)$ Powlman's Coefficients

1. The strength of a sample for fully matured concrete is 40 MPa. find the strength of identical concrete at the age of 7 days when cured at an avg temperature during the day time is 20°C and night time 10°C.

AI-

Given data

Strength after 28 days at 18°C and Maturity of concrete is 19800°C	Coefficients	
	A	B
≤ 17.5	10	68
17.5 - 35.0	21	61
35.0 - 52.5	32	54
52.5 - 70.0	42	46.5

$$S = 40 \text{ MPa} \rightarrow \text{for 28 days}$$

$$\text{Age} = 7 \text{ days}$$

$$\text{Night temperature} = 10^\circ\text{C}$$

$$\text{Day Temperature} = 20^\circ\text{C}$$

$$\text{Maturity } M = \sum (\text{Time} * \text{Temperature})$$

$$= \sum ((7 \times 12 \times (20 - (-11)) + 7 \times 12 \times (10 - (-11))))$$

$$= 4888 \text{ °chrs}$$

The concrete is falls under zone III

$$\therefore A = 32, B = 54$$

$$\text{Maturity level} = A + B \log_{10} \left(\frac{\text{maturity}}{10^3} \right)$$

$$= 32 + 54 \log_{10} \left(\frac{4888}{10^3} \right)$$

$$= 32 + 35.46 = 34.57$$

$$= 67.46 = 66.57 \text{ °}$$

The strength of identical concrete for 7 days

$$= \frac{66.57}{100} \times 40$$

$$S = 26.6 \text{ mpa}$$

- a. A laboratory experiment is conducted at pune on a particular mix showed a strength of 32.5 mpa. for fully matured concrete. Find whether a beam work can be removed for an identical concrete placed at Srinagar at age of 15 days when an avg temperature of 5°C. If the concrete is likely to be subjected to a stripping stress of 25 mpa

For fully matured strength = 32.5 mpa

$$\text{Age} = 15 \text{ days}$$

$$\text{Temp} = 5^\circ\text{C}$$

$$\text{Maturity } M = \sum (\text{Time} * \text{Temperature})$$

$$= 15 \times 24 \times (5 - (-11))$$

$$M = 5760 \text{ °chrs.}$$

The concrete is falls under zone II

$$A = 21, B = 61$$

$$\text{maturity level} = A + B \log_{10} \left(\frac{\text{maturity}}{10^3} \right)$$
$$= 21 + 61 \cdot \log_{10} \left(\frac{5760}{10^3} \right)$$
$$= 69.38$$
$$= 158.38 \cdot 1.$$

The strength of identical concrete for 15 days

$$= \frac{69.38}{158.38} \times 32.5$$
$$= \frac{69.38}{100} \times 32.5$$

$$S = 21.89 \text{ MPa}$$

stripping stress = 25 MPa

From the given data

The strength of the concrete achieve in 15 days of curing is less than this stripping stress $21.90 < 25$

So we couldn't remove the form work in 15 days.

So how many days is req to get 100% to gain fully maturity strength at given curing temperature is

$$\frac{M}{24(t - (-11))} = \text{No. of days}, \quad t \rightarrow \text{curing temp of identical concrete}$$

$$\text{i.e. } \frac{19,800}{24(5 - (-11))} = 51.5$$
$$\approx 52 \text{ days}$$

At 5°C temp the identical concrete must be cured in 52 days to achieve full maturity strength

Relationship between flexural strength & compressive strength:

We all know the behaviour of the concrete under compression and tensile stresses i.e., the concrete member is strong in compression and it is weak in tension so in all structural construction the compressive strength of the concrete plays an important role and we are ignoring the tensile stress. But in some cases like pavement

Slabs in road construction works

The flexural strength of the concrete is taking into consideration due to the changing of vehicular moving load

So we need to design the pavement slabs in both compression and flexural strength

CRRRI Develops some experimental formulas to calculate (i) to estimate the tensile and compressive strengths

$$1. Y = 15.3X - 9$$

For 20 mm maximum size of Agg

$$2. Y = 14.1X - 10.4$$

For 20 mm maximum size of Natural gravel

$$3. Y = 9.9X - 0.55$$

For 40 mm maximum size of crushed stone Agg

$$4. Y = 9.8X - 2.52$$

For 40 mm maximum size of Natural gravel

Where

$X \rightarrow$ Flexural strength

$Y \rightarrow$ Compressive strength

Note :

The type of the Agg influences the relationship between compressive and flexural strengths

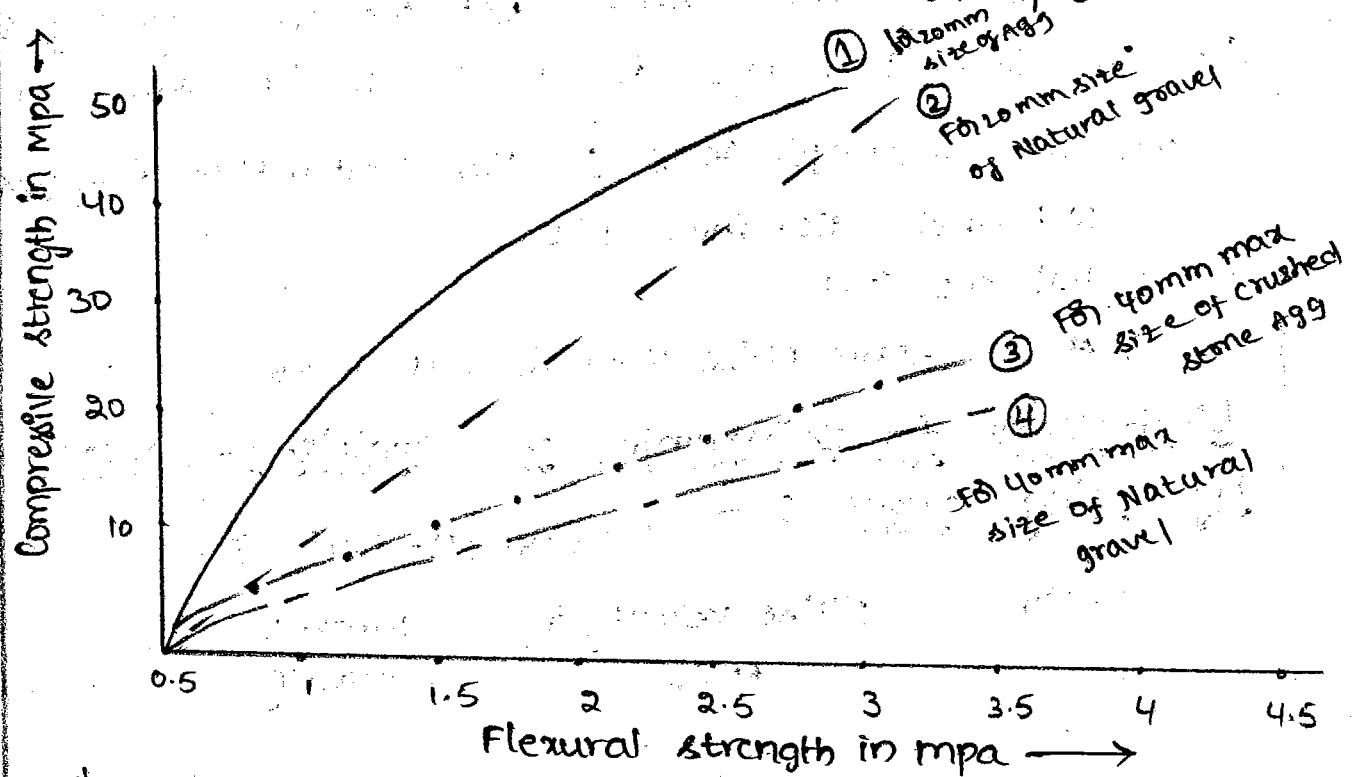
The crushed stone Agg gives relatively higher flexural strength than the compressive strength

The pozzolanic materials used in concrete mix increases the tensile strength of the concrete

As a general relationship b/w flexural and compressive strength is established CRRI is

$$Y = 11x - 3.4$$

In all these formulas the Compressive and Flexural strengths are in terms of N/mm² (or) MPa



The flexural strength of concrete is 8 to 11% of the compressive strength of concrete for higher ranges of concrete strength which means strength of concrete is greater than 25 MPa.

9 to 12.8% for lower ranges of the concrete strength which means the strength of concrete < 25 MPa

From the codal provision the flexural strength of the concrete is $0.7 \sqrt{F.C.K}$

$F.C.K \rightarrow$ characteristic compressive strength of concrete

According to (IS 456-2000)

Tests:
 { central load method (or)
 Two point load method by U.T.M.

Non Destructive Test :

By using these N.D. Tests we are estimating the surface hardness, tensile strength & quality of the concrete approximately.

While using these N.D.T test we are following some Experimental Readings & charts to find the req result.

They are 3 major tests for Non Destructive Analysis:

1. Rebound Hammer Test

2. Pull out Test

3. Ultra sonic pulse velocity Test (U.P.V)

Limitations for Determining the quality of concrete by using U.P.V :-

IS : 13-311 - part - I

S.No	Pulse velocity in km/s	Concrete quality
1	≥ 4.5	Excellent
2	3.5 to 4.5	Good
3	3.0 to 3.5	Medium
4	< 3.0	Doubtful

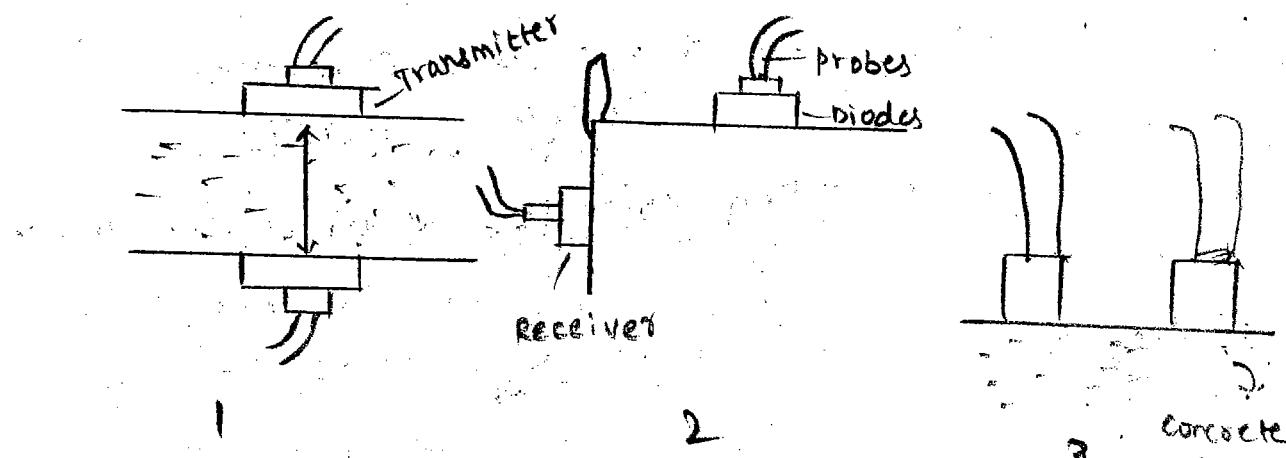
Methods of Transmission of pulse wave in Concrete member

They are 3 methods of transmission

Direct transmission

Indirect

Surface



These are the 3 ways of measuring pulse velocity through concrete

$$\therefore \text{the pulse velocity } V = \frac{d}{t}$$

Where $d \rightarrow$ path length of the pulse wave

$t \rightarrow$ Time taken by the pulse wave
blw two Diodes

Factors Effecting the measurement of pulse velocity:

The Measurement of pulse velocity through concrete is effected by following parameters

1. Smoothness of the contact surface under the test
2. Influence of path length
3. Temperature of the concrete
4. Moisture condition of the concrete
5. Presence of Reinforcement steel — 1.2 to 1.5 times to pulse velocity of Plane concrete

Note:

The National Committee for cement & Building materials proposed the quality of the concrete w.r.t Pulse velocity

S.No	Pulse Velocity km/s	Quality of Concrete
1	> 3.5	Excellent
2	$3.5 - 3.0$	Good
3	$3.0 - 2.5$	Medium
4	< 2.5	PoP

According to IS standards IS: 13-311-part-I
Sato

H- Elasticity, creep & shrinkage

Modulus of Elasticity :

The Modulus Of Elasticity Of a material specimen is the strength against unit deformation of the specimen where the body is subjected to stress the energy decipated for Elastic or plastic till Elasto plastic. The Stress - strain response under monotonic loading is used to determine the Modulus of Elasticity.

Note :

The Modulus Of Elasticity Of concrete is the initial Tangent Modulus Of the stress strain Response of the concrete.

Methods to determine Modulus of Elasticity :

there are 2 ways to determine Modulus of Elasticity

1. Axial stress Method

2 Beam Deflection Method

→ In Axial stress method specimens are compressed or pulled axially and the stress - strain response is prepared

→ In Beam deflection Method the deflection corresponding to various stages of loading in the Beam is determined and the load - deflection response in Bending is prepared

Types Of Modulus of Elasticity : -

they are 4 diff types of determining the Modulus of Elasticity

1. Initial Tangent Modulus

2. Tangent Modulus

3. Secant Modulus

4. UNIAXIAL MODULUS

