Concrete Technology

(IS 456:2000)

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Good in compression and weak in tension (10%).

Introduction

It is an artificially produced material , formed by the hardening of a mixture of binding material (Cement & Lime) , Aggregate(Fine and coarse aggregate) , water and an admixture

- Aggregate = *60 to 75%* or 70 to 75 % (inert ingredient).
- Cement = 14 to 21%. (Binding ingredient)
- Water = 7 to 15%

Each gram of cement of average composition needs about 0.253 g of water for chemical reaction[21]. In addition, a

- Water = 0.38 times weight of cement (0.23 for hydration of cement) & 0.15 remain in the voids of concrete.

Objectives: -(Appox. 14 ltr water is needed for hydration)

Numerical: - To hydrate 500 kg of cement full water needed is

a. 100 kg	b. 110 kg
c. 120 kg.	d. 130 kg

Grade	Modulus of elasticity	Flexure strength
M15	19364.91	2.71
M20	22360.67	3.13
M25	25000	3.5

- Admixture = Gypsum + others used to enhance the properties of concrete.

✓ *Modulus of elasticity of concrete= 5000** $\sqrt{f_{ck}}$ *(Higher concrete has higher value)*

✓ *Flexure strength of concrete = 0.7** $\sqrt{f_{ck}}$

✓ *Thermal coefficient of concrete = 8 to 10**$10^{-6}/°C$.

Poisson’s Ratio

- Poisson’s ratio of concrete under static loads is lower than that of concrete upon which dynamic loads are applied.
- The concrete Poisson’s ratio under dynamic loads varies mostly between 0.20 to 0.25.
- By and large, it ranges from 0.1 for high strength concrete to 0.2 for low strength concrete.
- For design of concrete structures, the most common value of concrete Poisson’s ratio is taken as 0.2.
- Poisson's ratio of cement concrete is 0.1-0.2.(*decrease with richer mix*).

1. Poisson’s ratio for concrete

a. remains constant

b. increases with richer mixes

c. decreases with richer mixes

d. none of the above

Hint: -

✓ Richer mixes possess greater strength as quantity of binder is more,
and we know that Poisson’s ratio for high strength concrete is 0.1 and for low strength concrete is 0.2,thus it itself clarifies that Poisson’s ratio decreases with richer mix

Types of Concrete

A. Based On Density

1. Light weight concrete : Specific weight ***3KN/m³ to 12 KN/m³.Made*** by adding light weight aggregates like pumice etc. Obtained from *volcanic source*.
2. Normal weight concrete: Specific weight ***23 to 26 KN/m³. Made by adding granite, basalt, trap, quartz etc.***
3. Heavy weight concrete: Specific weight ***28 to 29 KN/m³*** Made by adding heavy weight aggregates like ***blast furnace slag, iron scrap etc.***

B. Based On Design

1. **Plain Cement Concrete(PCC) :** Made from the basic components of concrete(Binding material , water and aggregate). 24 KN/m3

   Portland cement (1 part), clean sand (1.5 to 8 parts) and coarse aggregate (3 to 16 parts).

   ✓ *Strong in taking compressive strength*.

2. **Reinforced Cement Concrete (RCC)** : Made by adding reinforcement (usually in the tensile zone) to increase the strength of concrete. 25KN/m3.

   Portland cement (1 part), clean sand (1 to 2 parts) and coarse aggregate (2 to 4 parts).

   ✓ *Strong in taking tensile, compressive and shear strength*.

3. **Pre-stressed Concrete :** Initial compression is induced in concrete so that it can resist tension with greater efficiency

Types of Concrete

4. Special Concrete

I. Sawdust concrete (*powdery particles of wood produced by sawing)*

sawdust is used as a partial replacement for fine aggregates in concrete production.

The optimum sawdust content is around 10% and its corresponding compressive strength at 28 days is 7.41 N/mm2

This concrete cannot be used for structural applications it is generally used for panel walls , sound proofing, heat and sound insulating etc.

MCQ : -***Sawdust can be rendered chemically inert by boiling it in water containing ferrous sulphate***.

ii. Air-entrained concrete, cellular or aerated concrete

contains billions of microscopic air cells per cubic foot.

Air-entrained concrete is produced using air-entraining Portland cement, or by the introduction of air-entraining agents like aluminum powder

Air entrainment also increases workability.

Use in heat and sound insulation.

Has strength less than 10% to 15%.

Light in weight.

Water cement ratio is reduced & Proportion of aggregates is reduced

An allowance for the entrained air is made & Strength of the concrete, is reduced

Entrained Air – Chemical admixture that increases the air in the concrete.

Entrapped Air – Natural air in concrete.

Types of Concrete

I. Vacuum concrete

- ✓ cement concrete from which entrained air and excess air after placing is removed with a vacuum pump after placing it in position.
- ✓ Removal help in increasing strength by 15 to 20%.
- ✓ Can be used for all reinforced concrete works.

II. Light weight concrete: -

- ✓ Prepared by using coke breeze, cinder or slag as aggregate.
- ✓ This type of concrete possess high insulating property.
- ✓ It is used in making precast structural units for partition and wall lining purpose.

II. Bacteria concrete

- ✓ Also called calcium carbonate concrete.
- ✓ Has a ability to seal heal the crack.

II. Pre packed concrete: -

- ✓ A concrete in which dry coarse aggregate are first packed to have the least voids and then the cement sand mortar is injected under pressure to fill all the voids, resulting in a very dense concrete.

MCQ

1. For heat and sound insulation we shall use

a. Vacuum concrete
b. Air entrained concrete
c. Saw dust concrete
d. Both b and c

2. The concrete from which excess of air and water is removes after placing in position is called

a. Vacuum concrete
b. Light weight concrete
c. Pre-stressed concrete
d. Saw dust concrete

3. The concrete made by mixing aluminum in it is called

a. Air entrained concrete
b. Cellular concrete
c. Aerated concrete
d. All

4. The cement concrete in which high compressive stresses are artificially induced before its actual use is

a. PCC
b. RCC
c. Pre-stressed cement concrete.
d. Lime concrete

MCQ

5. Light weight concrete is prepared by
a. Mixing cement with sawdust in specified amount
b. Using coke bridge, cinder and slag as aggregate
c. Mixing aluminum in concrete
d. None

6. In making precast units for wall partition and wall lining the concrete used is
a. Sawdust concrete
b. Air entrained concrete
c. Light weight concrete
d. Vacuum concrete.

7. The removal of excess air after placing help in increase the strength of concrete by
a. 15 to 20%
b. 20 to 30%
c. 30 to 40%
d. 50 to 70%

Answer	
1	d
2	a
3	d
4	c
5	b
6	c
7	a

Aggregates:

- Major ingredient of concrete
- ***Chemically inert***, inexpensive material distributed throughout the concrete so as to produce large volume
- Acts as an economical space filler
- Provides rigidity, stability, durability and strength to concrete i.e. Aggregate properties greatly influence performance of the concrete.

A. Based on source (Geological Classification)

1. Natural aggregate : Aggregate derived from **river bed** , **quarry** etc.

It is of following type

I. Aggregate from igneous rock : Hard , tough , dense in nature , e.g. **Basalt Granite**

II. Aggregate from sedimentary rock : Of varying quality , e.g. **Sandstone**

III. Aggregate from metamorphic rock : e.g. **Gneiss , Quartzite**

MCQ: - To obtain a very *high strength concrete*, use very **fine grained granite**.

Aggregates:

2. **Artificial aggregate** : Broken bricks, blast furnace slag and synthetic aggregates are artificial aggregate.

I. Broken Bricks: -

- ✓ Known as brick bats are suitable for mass concreting, for example in foundation bases.
- ✓ Not suitable in reinforced concrete works.

II. Blast furnace slag aggregate: -

- ✓ obtained form slow cooling of slag followed by crushing.
- ✓ It has good fire resisting characteristics but responsible for corrosion of reinforcement due to sulphur content.
- ✓ The sp. Gr. Ranges between 2-2.8.
- ✓ Used to make precast concrete products.

III. Synthetic aggregate: -

- ✓ produced by thermally processed materials such as expanded clay and shale used for making light weight concrete.

Contd…..

B. Based on size

I. Coarse aggregates : Larger than **<u>4.75mm</u>** and Smaller than 75mm IS Sieve

75mm size aggregate is called *<u>CYCLOPEON</u>*<u>.</u>

- ✓ Size is governed by thickness of section, spacing, clear cover mixing etc.
- ✓ For economy, the maximum size should be as large as possible but not more than *one – fourth of minimum thickness of member*.
- ✓ For reinforced section, the maximum size should be *at least 5mm less than clear spacing and also at least 5mm less than the clear cover*.
- ✓ Aggregate more than 20mm size seldom used in reinforced cement concrete structural member.

II. Graded aggregate: -

- ✓ Aggregate most of which passes through a particular size of sieve.
- ✓ For example: - a graded aggregate of nominal size 20mm means an aggregate most of which passes IS sieve 20mm.

Contd…..

III Fine aggregates :

✓ Larger than **75 micron** and Smaller than 4.75mm IS sieve

Coarse Aggregate	Fine Aggregate	Silt	Clay
75mm – 4.75 mm	4.75mm – 0.075mm	0.06-0.002mm	< 0.002mm

On the basis of particle size distribution, fine aggregate is classed into 4 zones.

IS Sieve Designation	Percentage Passing for			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10 mm	100	100	100	100
4·75 mm	90-100	90-100	90-100	95-100
2·36 mm	60-95	75-100	85-100	95-100
1·18 mm	30-70	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15

Zone I: - Coarsest & high W/C ratio.

Zone IV: - Finest

Contd…..

MCQ: -

Sand requiring a high water cement ratio, belongs to				
1	Zone I		2	Zone II
3	Zone III		4	Zone IV
Sand of Zone I are				
1	Coarse		2	Medium
3	medium to fine		3	Fine

<u>All in aggregate:</u> -

- ✓ Naturally available aggregates of different fractions of fine and coarse sizes.
- ✓ Such all-in aggregates are generally not found suitable for making concrete of high quality.

Contd…..

MCQ: -

C. Based on Shape

I. Rounded aggregate : generally obtained from river and sea shore.

: Has minimum percentage of voids ***32 - 33%*** & surface area to volume & cement paste required is minimum.

: Has less bond stress and not suitable for pavement subject to tension.

: Not suitable for **high strength concrete**.

MCQ:- The type of aggregates not suitable for high strength concrete and for pavements subjected to tension, is **rounded aggregate.** (*due to poor interlocking bond)*

Contd…..

II. Irregular aggregate:

:Partly formed by attrition e.g. Pit sand, shore gravel etc.

: Possess 35% to 38 % void.(Generally 36%)

: provide low workability and average interlocking.

: Not suitable for high strength concrete.

: Maximum water is required.

: Suitable for making ordinary concrete.

III. Flaky aggregate :

- ✓ If least (thickness) dimension is < 3/5 (or 0.6) of its mean dimension.

IV. Elongated aggregate :

- ✓ If largest (length) dimension > 1.8 times the mean dimension.

MCQ: -

If the particle passes through a 25 mm sieve and retained on 20 mm sieve, find

- Mean size of particle ?. 25+20/2= 22.5
- Flaky particle ?. 0.6*22.5= 13.5
- Elongated particle ?.1.8*22.5= 40.5mm

Contd…..

Solution,

1. Mean size = $\frac{25+20}{2}$ = 22.5 mm.
2. Flaky particle = 0.6*22.5 = 13.5 mm.
3. Elongated particle = 1.8 * 22.5 = 40.5 mm.

V. <u>Angular aggregate</u>

- ✓ Possesses sharp edges with angles.
- ✓ Posses maximum % of voids (38% to 45%). *(About 40%)*
- ✓ Requirement of cement paste is relatively more.
- ✓ Because of best interlocking property<u>, it can be used for high strength concrete.</u>

Contd…..

Based on surface texture

I. Smooth aggregate : Surface Smooth and uniformly colored e.g. marble , shale etc.

II. **Glossy aggregate: Having glossy patches e.g. Seashell, black flint.**

Note: - Not *preferred for use in concrete*.

III. Granular aggregate : Surface showing granular structure e.g. Sandstone

IV. Crystalline aggregate : Surface showing crystals e.g. Granite

V. Honeycombed aggregate : Surface shows lumpy cavities

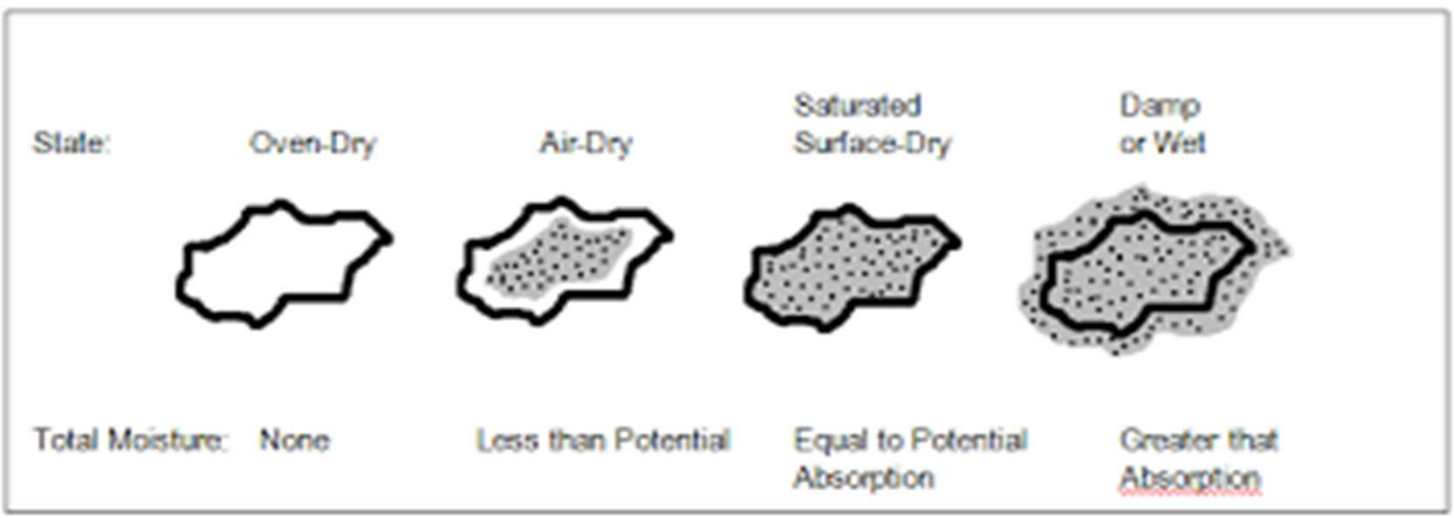
VI. Porous aggregate : Surface is made of numerous small pores

Type	W/C Ratio
Smooth	0.54
Granular or angular	0.6

Contd…..

Based on surface moisture

I. Very dry aggregate : No moisture is present in surface or pores
II. Dry aggregate (air dry aggregate) : Some moisture is present but surface is completely dry
III. Saturated surface dry aggregate : All pores are filled with moisture but there is no moisture on the surface
IV. Wet or moist aggregate : Moisture is present is voids as well as surface
V. When the same aggregate is oven dried & all of its moisture vanishes then it is said to be bone dry aggregate.



Aggregates:

Based on Unit Weight

✓ Based on weight and specific gravity, aggregate is classified as

1. Normal weight
2. Heavy weight
3. Light weight.

Aggregate	Sp. Gr.	Unit Wt. (KN/m3)	Bulk density. (Kg/m3)	Examples
Normal	2.5-2.7	23-26	1520-1680	Sand, gravel, granite, sandstone, limestone
Heavy	2.8-2.9	25-29	> 2080	scrap iron, Magnetite
Light		12	<1120	Dolomite, pumice, cinder, clay

Contd…..

<u>For the construction of cement concrete, maximum size of aggregate</u>

<u>40 mm: - Masonry work like dam, retaining wall etc.</u>
<u>20mm: - For reinforced member.</u>
<u>10mm: - For floors.</u>

<u>MCQ</u>

1. The light weight aggregates are obtained from

a) Sedimentary rocks

b) Metamorphic rocks

c) Igneous rocks

d) Volcanic source

2. Generally heavy weight aggregate obtained from _______________

a) Minerals ores

b) Palm oil shell

c) Sand

d) Crushed stone

Contd…..

3. An aggregate is called cyclopean aggregate if its size is more than

a. 4.75 mm
b. 30 mm
c. 40 mm
d. 75 mm

4. The minimum size of fine aggregate is

a. 0.075 mm
b. 0.0075 mm
c. 0.75 mm
d. 0.95 mm

5. For the construction of cement concrete dams the maximum size of aggregate is

a. 30mm
b. 40mm
c. 50mm
d. 60mm

Contd…..

6. For the construction of cement concrete floors the maximum size of aggregate is
a. 10mm
b. 20mm
c. 30mm
d. 40mm

7. For the construction of cement concrete lintels and band the maximum size of aggregate is
a. 10mm
b. 15mm
c. 20mm
d. 40mm (If question ask nominal size, answer is 15mm)

8. The type of aggregate which contain the *least amount of voids* when compacted as compared to other aggregate having same gradation are
a. Rounded aggregate. (high workability)
b. Angular aggregate. (best aggregate for high strength concrete).
c. Irregular aggregate.
d. Flanky aggregate. (Aggregate that affect durability of concrete).

Contd…..

9. The type of aggregate which is generally not preferred for use in concrete is the one with following texture

a. Smooth aggregate.

b. Glossy aggregate.

c. Rough aggregate.

d. Granular aggregate.

10. An aggregate having all the pores filled with water but having dry surface is known as

a. Very dry aggregate.

b. Dry aggregate.

c. Saturated surface dry aggregate.

d. Moist aggregate.

Answer	
1	d
2	a
3	d
4	a
5	b
6	a
7	c
8	a
9	b
10	c

Properties of Aggregate

A. Physical Properties

I. Grading :

- The process of determining the percentage by mass occupied by various size of aggregate is called grading.
- It is done by **sieve analysis**
- Omission of certain grade of aggregate is shown by **horizontal line in grading curve.**
- Omission increases workability and increases liability of segregation.

MCQ: -

If a grading curve is a horizontal between the portion of 20mm I.S sieve & 4.75mm sieve, then graded aggregate do not contain

a. 20 mm	b. 10 mm
c. 4.75 mm	d. All of the above (right)

❖ Grading of aggregate in a concrete mix is necessary to achieve

a. Adequate workability

b. Higher density

c. Reduction of voids. (Answer)

d. Better durability

Properties of Aggregate

B. Fineness Modulus (FM):

- It is a numerical index to measure the average particle size of aggregates.
- $F.M. of\ aggregates = \frac{Summation\ of\ cumulative\ \%\ of\ wt. retained\ on\ I.S. sieve}{100}$
- Higher the F.M., higher will be coarser particles.
- Fineness modulus could be used to indicate the fineness of sand.

The following limits may be taken as guidance

a. F.M. of Fine Sand: 2.2 – 2.6

b. F.M. of Medium Sand: 2.6 – 2.9

c. F.M. of Coarse Sand: 2.9 – 3.2

d. Coarse aggregate: -5.5 -8.0

e. All in aggregate: - 3.5-7.5

Note:- It may be noted that Finesses of sand should not be less than 2.5 and not more than 3.

MCQ.

❖ The fineness modulus of an aggregate is roughly proportional to

a. Average size of particles in the aggregate.

b. Grading of the aggregate.

c. Sp. Gr. Of aggregate.

d. Shape of aggregate.

Properties of Aggregate

- % of fine aggregate to be combined with coarse aggregate (x) is determined by

X = $\frac{F_2 - F}{F - F_1}$ *100   Where, F= FM according to specified grading,

F_1= FM of fine aggregate & $\boldsymbol{F_2}$ **= FM of coarse aggregate**

MCQ: - The percentage of fine aggregate of FM 2.6 to be combined with coarse aggregate of FM 6.8 to obtain the aggregate F.M 5.4 in

a. 30%	b. 40%
c. 50% (Ans)	d. 60%

- **Solve**: - put, F = 5.4, F_2 = 6.8 and F_1 = 2.6 and Get % = 50%.
- **Note**: - Higher the FM, harsher the mix & Lower the FM, uneconomical mix.

Properties of Aggregate

MCQ: -

1. The fineness modulus of good sand shall be in the range of

a. 2-2.25 b. (2.5-3)

c. 2-2.5 d. 3-3.2

2. The value of fineness modulus of fine sand ranges between

a. 1.1 to 1.3 b. 1.3 to 1.6

c. 1.6 to 2.2 d. 2.2 to 2.6

3. Sand requiring high water cement ratio belongs to

a. Zone I (Coarse sand) b. Zone II

c. Zone III d Zone IV

4. The fineness modulus of fine sand is between

a. 2-3.5 b. 3.5-5

c. 5-6 d. 6-7.5

Answer	
1	b
2	d
3	a
4	a

Properties of Aggregate

Specific gravity

- **Apparent Specific gravity**: - defined as the weight of oven dry aggregate divided by its absolute volume, *excluding the natural pores in the aggregate particles.*
- **Bulk Specific Gravity**: - defined as the weight of oven dry aggregate divided by its absolute volume*, including the natural pores in the aggregate particles.*
- **Bulk Density:** - defined as the mass required filling a container of unit volume. It is expressed in ***kilograms per liter***.

The bulk density of an aggregate depends upon the shape, size, specific gravity, grading of the aggregate and moisture content.

- Note: - Density of Natural Aggregate lie between 2.6 to 2.7 or 2.4 to 2.8.

MCQ

❖ Density of concrete

a. Increase with a decrease in the size of aggregate.

b. Is independent of the size of aggregate.

c. Increase with increase in the size of aggregate.

d. All above

Properties of Aggregate

1. The bulk density of aggregate depends upon

a. Shape of aggregate
b. Grading of aggregate
c. Compaction
d. All of above

2. The bulk density of aggregate is generally expressed as

a. Ton/m^3
b. Kg/m^3
c. Kg/lit
d. Gram/cm^3

3. What is the range of water absorption of aggregates used in road?

a) 2.5-2.9
b) 0.1-2 (0.6)
c) 0.1-2.5
d) 2-2.9

4. The density of aggregate does not depend upon

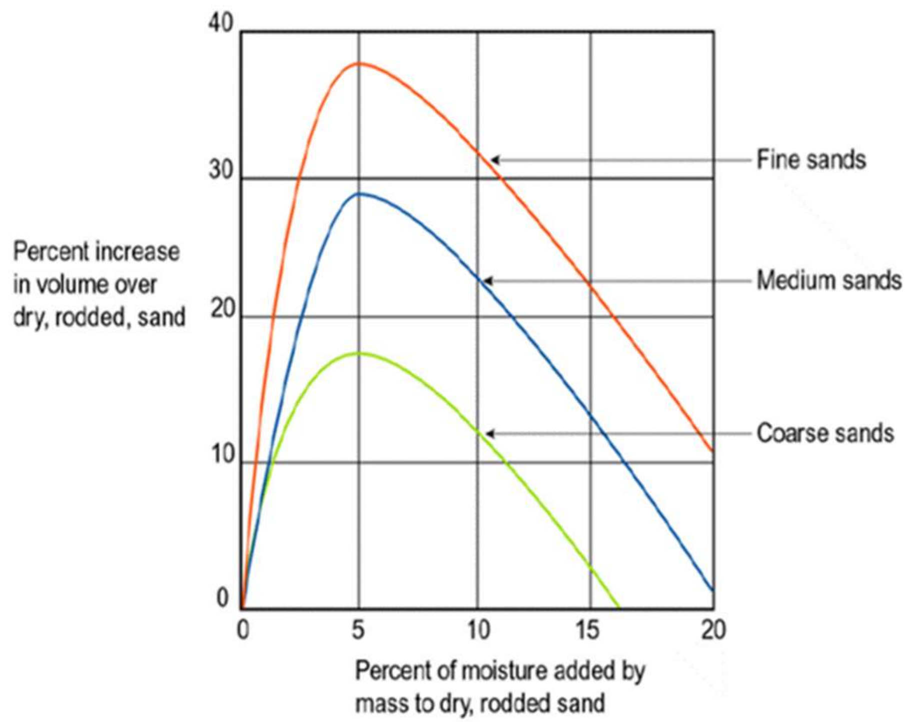
a. Shape and size of aggregate.
b. Specific gravity of aggregate
c. Grading of aggregate
d. Shape and size of container

Answer	
1	d
2	c
3	b
4	d

Properties of Aggregate

Bulking

- ✓ When water is added to dry sand, it forms a thin film around the particle which causes them to separate and volume increases.
- ✓ After a certain limit the film begins to break apart and thus again the volume starts to reduce.
- ✓ Therefore bulking is maximum at a given water content, which can be shown from the following graph



Properties of Aggregate

- Form the above graph it is *clear that fine sands tend to bulk more than coarse sands*.
- *With 10% moisture content by wt. bulking of sand increase by 50%*
- Also it is seen that *the bulking is maximum at water content of 4%.*

The relation between bulking and moisture content for fine sand is as follows

Moisture content	% Bulking
2	15
3	20
4	25-30
5	22

MCQ:-

*The proportions of ingredients in concrete mix are given by 1:2:4. What will be the actual quantity of sand per unit volume of cement, if it under goes 20% of bulking? =1.2*2=2.4*

a. 1.5 b. 2.4 c. 4.6 d. 6.5.

% of bulking

Given by: - $\frac{h_1 - h_2}{h_2} * 100$ where, h_1 = ht. of wetted sand and h_2 = ht. of fully saturated sand.

MCQ :-

1. If the depth of moist sand in a cylinder is 15 cm & the depth of sand when fully inundated with water is 12 cm, the bulking of

a. 10%	b. 12%
c. 20%	d. 25% (Ans)

Solution, $\frac{15-12}{12} * 100$ = **25 %**

Answer	
1	d
2	d
3	a

2. Bulking of coarse aggregate is

a. Less as compared to sand

b. More as compared to sand

c. 15% at 4% moisture content

d. Negligible.

3. The maximum bulking of sand is likely to occur at a moisture content of

a. 5% b. 10% c. 15% d. 20%

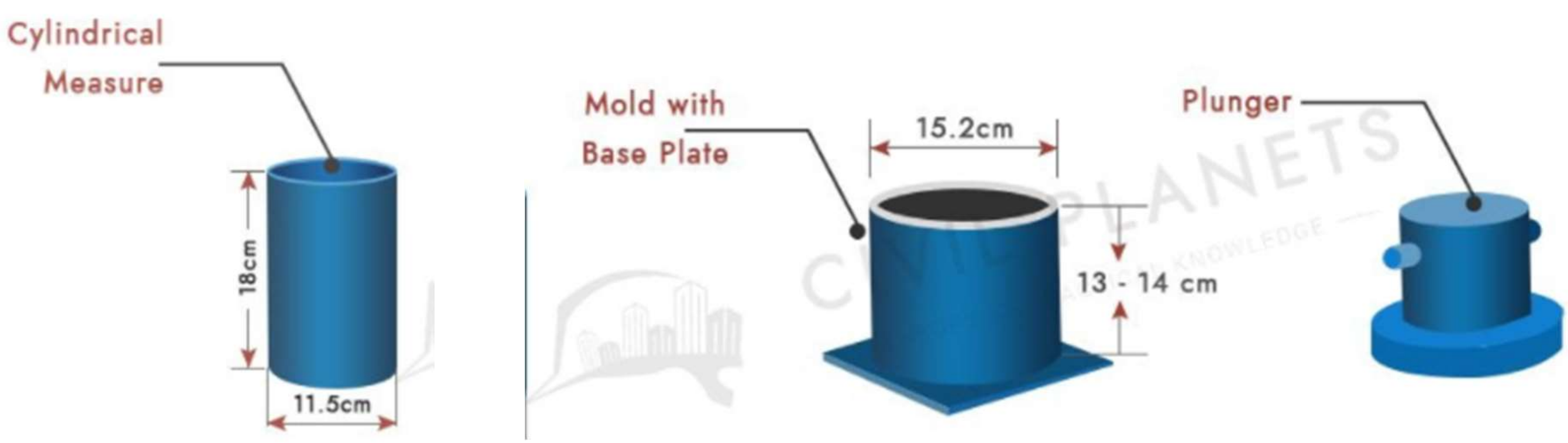
Properties of Aggregate

Strength

The resistance under gradually applied compressive loads and is measured by aggregate crushing value test.

❖ **<u>AGGREGATE CRUSHING VALUE TEST (IS 2386 PART IV):-</u>** **REFLECTION OF STRENGTH**

- The aggregate sample should be sieved through 12.5 mm sieve.
- Then the sample retained in the 10 mm sieve should be collected.
- The oven should dry the collected aggregate sample up to 4 hours at $100^{\circ}C$ to $110^{\circ}C$. Allow the sample to cool at room temperature.
- Tampering rod:- 16mm diameter and 45 to 60cm in length.



Properties of Aggregate

- First, fill the sample aggregate with one-third of the cylindrical measure in three layers
- Each layer should be tamped 25times freely.
- After filling the sample aggregate, weigh and record it as W1.
- Now fill the aggregate in the mould along with the plunger on top.
- Then place the cylinder on the compression testing machine at the correct position and lock it to ensure that there is no oscillation while applying the load.
- Now apply the pressure gradually upto 400 KN, which will reach in 10 minutes.
- Then take out the sample and sieve it through the 2.36mm IS sieve and weigh the sample as W2.

> *The crushing value of aggregate = (W2/W1) x 100*

*The aggregate Crushing value shall not exceed **45** percent by weight for aggregates used for concrete other than for wearing surfaces and **30** percent by weight for concrete for wearing surfaces, such as runways, roads and pavements*.

Properties of Aggregate

Hardness

It is the resistance to wear and tear (abrasion) and is measured by LAA Test

LOS ANGELES ABRASION VALUE TEST (LAAVT)

- The test sample shall consist of clean aggregate which has been dried in an oven at 105 to 110°C to substantially constant weight and shall conform to one of the grading's shown in Table II.
-

TABLE II GRADINGS OF TEST SAMPLES

(*Clause* 5.3.3)

Sieve Size (Square Hole)		Weight in g of Test Sample for Grade						
Passing	Retained on	A	B	C	D	E	F	G
mm	mm							
80	63	—	—	—	—	2 500*	—	—
63	50	—	—	—	—	2 500*	—	—
50	40	—	—	—	—	5 000*	5 000*	—
40	25	1 250	—	—	—	—	5 000*	5 000*
25	20	1 250	—	—	—	—	—	5 000*
20	12·5	1 250	2 500	—	—	—	—	—
12·5	10	1 250	2 500	—	—	—	—	—
10	6·3	—	—	2 500	—	—	—	—
6·3	4·75	—	—	2 500	—	—	—	—
4.75	2·36	—	—	—	5 000	—	—	—

*Tolerance of ±2 percent permitted.

Properties of Aggregate

- Abrasive charge: - cast iron sphere approx. 48 mm in diameter and each weighing between 390 and 445 kg.

Grading	*Number of Spheres*	*Weight of Charge* g
A	12	5 000 ± 25
B	11	4 584 ± 25
C	8	3 330 ± 20
D	6	2 500 ± 15
E	12	5 000 ± 25
F	12	5 000 ± 25
G	12	5 000 ± 25

- The test sample and the abrasive charge shall be placed in the Los Angeles abrasion testing machine and the machine rotated *at a speed of 20 to 33 rev/min*. For grading's A, B, C and D, the machine shall be rotated for 500 revolutions; for grading's E, F and G, it shall be rotated for 1000 revolutions.

Abrasion value = $\frac{Wt.of\ fraction\ passing\ 1.7mm\ sieve}{Wt.of\ total\ sample}$

- a) For aggregates to be used in concrete for wearing surfaces — 30 percent

  b) For aggregates to be used in other concrete — 50 percent

Properties of Aggregate

Toughness :

- It is the resistance to impact and is measured by aggregate **impact value test**

AGGREGATE IMPACT VALUE (ATV)

APPARTUS

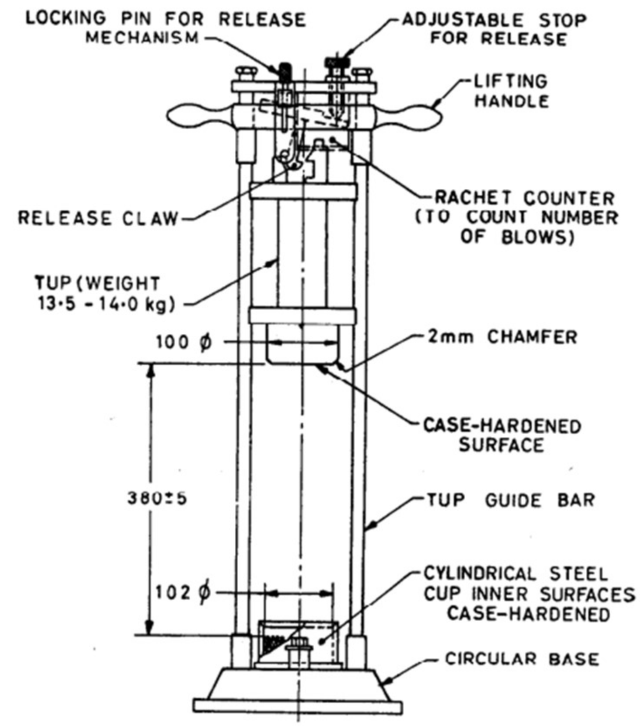
1. Impact testing machine

2. A steel cup shape as a cylinder usually internal dimension:

- Diameter = 102mm
- Depth = 50mm
- Thickness = 6.3mm

3. 13.5 to 14 kg hammer with the end of cylindrical shape is used for the impact load:-

- Diameter = 102mm
- Length = 50mm.



All dimensions in millimetres.

FIG. 2 AGGREGATE IMPACT TEST MACHINE

- Lower end is cylindrical in shape , 100mm in diameter & 5cm long with 2 mm chamfer in both end.

Properties of Aggregate

Sieves:- The following IS sieves are used

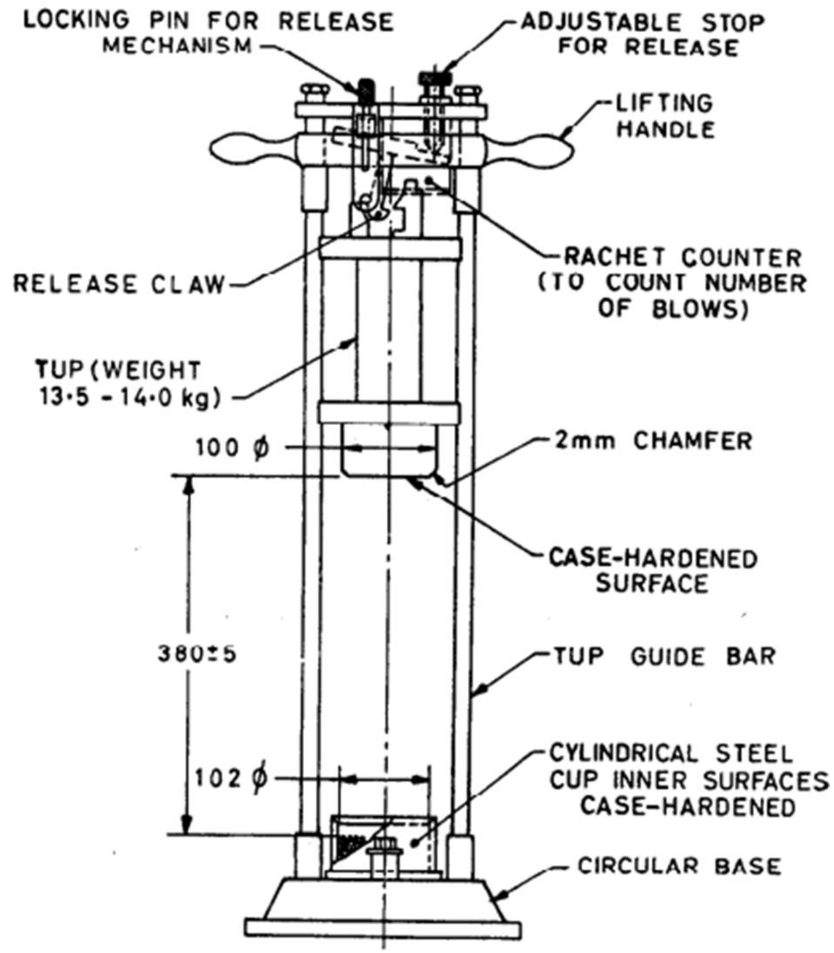
- 12.5mm
- 10mm
- 2.36mm

Measuring cylinder of

- Diameter = 75mm
- Depth = 50mm

Tamping rod

- The following are the dimension of the rod:
- Diameter = 10mm
- Length = 230mm



All dimensions in millimetres.

FIG. 2 AGGREGATE IMPACT TEST MACHINE

Properties of Aggregate

Preparation of Aggregate Sample

- The aggregate which uses for the sample is passed through the 12.5mm IS sieve and retain on the 10mm IS sieve.
- The aggregate which is retained on the 10mm sieve is dried in an oven for a time period of 4 hours at the oven temperature of 100 to 110º C.
- The cylindrical measure use for the collection sample filled about 1/3 full with the aggregates and it tamped 25 stokes with help of the rounded end of the tamping rod. Further similar 1/3 quantity of aggregates are filled in it and again 25 stokes are given. Then measure finally filled to overflowing than apply 25 stokes again and the extra aggregates are removing form the measure with the help of the straight portion of the tamping rod. (W1)

Note: -
The aggregate impact value shall not exceed 45 percent by weight for aggregates used for concrete other than for wearing surfaces and 30 percent by weight for concrete for wearing surfaces, such as runways, roads and pavements.

Properties of Aggregate

Procedure of Impact Test of Aggregate

- Transfer aggregate sample from cylindrical measure to cut fitted in an impact test machine and apply 25 strokes of the rod to compact it.
- Then the hammer is lifted 380mm and falls on the upper surface of aggregate which fills in the cup.
- A total of 15 blows are applied on the cup each delivered at an interval of not less than 1 second.
- The crushed aggregates are removed from the cup and the crushed sample is sieve from the 2.36mm IS sieve.
- Weight the fraction of sample passing through 2.36mm IS sieve accuracy up to 0.1 gm. (W2)
- Weight the fraction of sample retain on the 2.36mm IS sieve. (weight W3)
- The total weight of the sample (W2 + W3) is less than the initial weight (weight W1) by more than one gram than the result discarded.
  - **Aggregate Impact Value =** (W2/ (W1) * 100

MCQ

❖ If 60% aggregate does not pass through 2.36 mm sieve, what is aggregate impact value?

1. 60% 2. 40% 3. 25% 4. 10%

Properties of Aggregate

Requirement of water

1. The silt content should be less than 2000 ppm. It affects setting and hardening of concrete , organic content shall be less than 500 ppm and inorganic content shall be less than 3000 ppm.
2. Water may be unsuitable as mixing water when the water has a high concentration of sodium or potassium because of high risk of alkali aggregate reaction.
3. As a rule, any water with a pH of 6.0 to 8.0 i.e. which does not taste saline or brackish is suitable for use.
4. Water should be free from wild acids, alkalies and organic matter.
5. Alkali carbonates and bicarbonates in water should not exceed 1000 ppm.
6. Sea water increases the risk of corrosion in reinforcement.

Properties of Aggregate

1. Water having sugar retard the setting time of concrete. Water 0.05% sugar by wt. can retard the setting time by 4 hours.
2. Sea water reduces 28 strength by 10- 15%.
3. If 30% excess water is added, the strength of concrete reduces by 50% & 10% extra water reduces strength by 15%.
4. Water used for ordinary concrete is equal to 5% by weight of aggregate + 30% by weight of cement.
5. Mineral oil greater than 2% by wt. of cement reduce the concrete strength by more than 20%.

Table 1 Permissible Limit for Solids

(*Clause* 5.4)

Sl No.		Tested as per	Permissible Limit, *Max*
i)	Organic	IS 3025 (Part 18)	200 mg/l
ii)	Inorganic	IS 3025 (Part 18)	3 000 mg/l
iii)	Sulphates (as SO_3)	IS 3025 (Part 24)	400 mg/l
iv)	Chlorides (as Cl)	IS 3025 (Part 32)	2 000 mg/l for concrete not containing embedded steel and 500 mg/l for reinforced concrete work
v)	Suspended matter	IS 3025 (Part 17)	2 000 mg/l

MCQ: - Insufficient quantity of water

a. **Make the concrete mix harsh.** (Ans)	b. **Makes the concrete mix unworkable (Ans)**
c. Causes segregation in concrete	d. Causes bleeding in concrete

Excess quantity of water

e. Make the concrete mix harsh.	f. Makes the concrete mix unworkable
g. **Causes segregation in concrete (Ans)**	h. **Causes bleeding in concrete. (Ans)**

Method of Proportioning Concrete: -

- **Arbitrary method**. In this method, one part of cement to M parts of fine aggregate and 2M parts of coarse aggregate are taken as the basis. The quantity of water required for mixing is determined according to the desired workability. In order to obtain the required workability, the minimum quantity of water to be added to fine and coarse aggregates is determined by the following relation :

$$\frac{W}{C} \times p = 0.3p + 0.1y + 0.01z$$

W/C = Water/cement ratio,

p = Quantity of cement by weight,

y = Quantity of fine aggregate by weight, and

z = Quantity of coarse aggregate by weight.

Numerical: - if 50 kg of fine aggregate & 100 kg of CA are mixed in a concrete who's W/C is 0.6. The wt. of water required for harsh mix is

a. 8 kg	b. 10 kg
c. 12 kg (ans)	d. 14 kg

Solution: - 0.3* p +0.1*50 + 0.01*100 = 0.6*p so, p= 20kg & W/C =0.6, then Water = 12kg

Minimum voids method.

This method is based on the principle that the concrete which has the minimum voids is the densest and strongest. In this method, it is assumed that the voids in the coarse aggregate are filled by the fine aggregates and the voids in the fine aggregate are filled by the cement paste.

I. Volume of fine aggregates required for $1\ \mathrm{m}^3$ of coarse aggregate = total voids in coarse aggregate plus 10% aggregate extra

II. Volume of cement paste required for $1\ \mathrm{m}^3$ of coarse aggregate is equal to the total volume of voids in the fine aggregate plus 15% aggregate extra.

Note:- % of void in cement = 40%

1 % void in concrete reduce strength by 5%.

Storing of Ingredients of Concrete

a. The ingredients of concrete should be stored in a warehouse whose walls are of water proof and the roof is leak proof. Maximum warehouse floor = (25 cm) Minimum floor thickness = 15cm

b. The capacity of a warehouse depends upon the floor area occupied by one cement bag and the height to which the cement bags are piled.

c. In designing a warehouse, it is assumed that each bag contains 50 kg of cement and the floor area occupied by one bag of cement is $\mathbf{0.3\ m^2}$.

d. The height of each cement bag containing 35 liters of cement is 0.18 m.

e. In order to prevent the cement bags from any possible contact with moisture, the cement bags should be placed closed together in the piles and the space between the exterior walls and piles should be 300 mm.

f. The width and height of the pile should not exceed 3 m and 2.7 m respectively. The cement bags should be rolled on the floor when it is taken out for use.

g. The 'first-in, first-out' rule should be applied when cement bags are to be removed from the warehouse. It may be noted that the strength of cement decreases with the passage of time.

Contd…

Objective: - if the effective plan area of a ware house is 54 sq. m & the maximum ht. of the pile permitted is 270 cm, the number of cement bags to be stored is

a. 2000 bags	b. 2200 bags
c. 2400 bags	d. 2700 bags (Answer)

Solution,

- Ht. of bag = 0.18m
- Area = 0.3 Sq.m
- & volume = 0.18*0.3 = **0.054** Cu. m,
- Volume of room = **54*2.7** = 145.8 Cu.m
- So, No. of bags = 145.8/0.054 = **2700 bags**.

Manufacture of concrete

1. **Batching** :

- The accuracy of the measuring equipment shall be within±2 percent of the quantity of cement being measured and within ± 3 percent of the quantity of aggregate, admixtures and water being measured. IS456:2000 cl:-10.2.2
- Process of accurate measurement of all concrete materials for uniformly and desirable properties are called batching. It can be done through

a) Volume batch: -

- ✓ In volume batching, materials are measured on the basis of volume. It is less precise method of batching.
- ✓ Measurement boxes or gauge boxes of known volume are used to measure materials.
- ✓ Volume of Gauge box used is made equal to the volume of one bag of cement which is 35 liters or multiple thereof.
- Volumes of different sized fine aggregate and coarse aggregate are measured individually by these gauge boxes.
- Water is measured using water meter or water cans of known volume are used.
- To make 1:1:2 ratio concrete mix according to volume batching, one should take one bag of cement (35 liters) , 1 gauge box of fine aggregate (35 liters) and 2 gauge boxes of fine aggregate (70 liters).
- Allowance for buckling of sand is necessary.

Proportions for Nominal Mix Concrete

Grade of Concrete	Total Quantity of Dry Aggregates by Mass per 50 kg of Cement, to be Taken as the Sum of the Individual Masses of Fine and Coarse Aggregates, kg, *Max*	Proportion of Fine Aggregate to Coarse Aggregate (by Mass)	Quantity of Water per 50 kg of Cement, *Max* l
(1)	(2)	(3)	(4)
M 5	800	Generally 1:2 but subject to an upper limit of 1:1½ and a lower limit of 1:2½	60
M 7.5	625		45
M 10	480		34
M 15	330		32
M 20	250		30

Based on the required strength of concrete, maximum quantity of water required for 50kg cement is as follows;

M5 - 60 liters of water (w/c=1.2)

M7.5 - 45 liters of water (w/c=0.90)

M10 - 34 liters of water (w/c=0.68)

M15 - 32 liters of water (w/c=0.64)

M20 - 30 liters of water (w/c=0.60)

MCQ

Maximum water needed for 50kg of cement for M 15 grade of concrete is

1. 28 liters 2. 30 liters 3. 32 liters 4. 34 liters

Manufacture of concrete

b) Weight batch: -

- ✓ For all important work, weight batch is done.
- ✓ In this method, Materials are measured on the basis of weight. It is accurate method of batching.
- ✓ Weigh batchers or other types of weighing equipment are used to measure weight of materials.
- ✓ Cement, fine aggregate, coarse aggregate and water are taken by weighing.
- ✓ To prepare 1:1:2 concrete mix using weigh batching, measured quantity of materials are 50 kg of cement, 50 kg of fine aggregate and 100 kg of coarse aggregate.

- *Weight batching is more accurate and recommended for mass concrete works*.
- Volume batching: the volume of one bag of cement is taken as 35 liter (35cm X 25cm X 40cm) and the other ingredients are added as per their ratio in terms of volume
- For measuring 50 liters of aggregate, the inner dimensions of forma 31cm X 31cm X 52cm.

Manufacture of concrete

Batch volume of materials for various mixes

Grade	Concrete mix	Cement (Kg)	Fine Aggregate (ltr)	Coarse Aggregate (ltr)
M10	1:3:6	50	105	210
M15	1:2:4	50	70	140
M20	1:1.5:3	50	52.5	105
M25	1:1:2	50	35	70

1. For batching 1:2:4 concrete by volume the ingredients required per bag of cement are

a. 50 kg c: 70 kg FA: 140 kg CA

b. 50 kg c: 70 lit fine aggregate:140 lit CA

c. 50 kg concrete:100 kg fine aggregate:20 kg course aggregate

d. 50 kg concrete :100 lit fine aggregate:200 lit course aggregate

2. The inner dimension of 50 liter forma is

a. 25x25x40 b. 29x29x48

c. 30x30x50 d. 31x31x52

Manufacture of concrete

3. The dimension of 35 litre forma for measuring aggregation by volume are

a. L=30 B=25 H=30

b. L=39 B=25 H=32

c. L=27 B=27 H=32

d. L=35 B=25 H=40

4. In batching the materials should be measured with respect to the standard amount with a maximum tolerance,

a. ±1.0

b. ±2.0

c. ±3.0

d. ±4.0

Answer	
1	b
2	d
3	d
4	c

Manufacture of concrete

1. In concrete mix design, allowance for buckling of sand is necessary in case of
   a. Volume batching only
   b. Weight batching only
   c. Both a and b.
   d. None of the above

2. In concrete mix design, allowance for surface water carried by aggregate is necessary in case of
   a. Volume batching only
   b. Weight batching only
   c. Both a and b.
   d. None of the above

Answer	
1	a
2	c

Manufacture of concrete

If the effective working time is 7 hours & per batch time of concrete is 3 minutes, the output of concrete mixer of 150 liters capacity is

a. 15,900 ltr

b. 16,900 ltr

c. 17,900 ltr

d. 18,900 ltr

Solution,

Effective time= 7*60 =420 minutes

Per batch time = 3 minutes

No. of batch = 420/3 = 140

Capacity = 150 liters/batch

Out put for 140 batch = 150*140 = 21,000 ltr

Assume 90% so,

21000*0.9 = 18,900 ltr

Manufacture of concrete

2. Mixing

- The process of through mixing of the materials of concrete to obtain a uniform mixture can be done by

a. Hand mixing: - During hand mixing, *extra 10% cement is added* & mix is spread out in thickness of 200mm and water is sprinkled. For small job.

b. Machine mixing: - more efficient and better quality at faster rate.

I. Continuous plant: - Produce concrete continuously till plant is working.

II. Batch mixer: - produce concrete batch by batch with time interval

  – Tilting: 85T, 100T, 140T & 200T *(Buttering is done).*
  – Non tilting: - 200NT, 280NT, 340NT, 400NT & 800NT.
  – Reverse drum: - 200R, 280R, 340R & 400R.

- The capacity of mixture is designated by the amount in liters which it can produce in each batch.
- The speed of rotation in mixture is 15 to 20 per minute, 25-30 complete rotations & permitted time for revolution are 1.5 to 3 minutes, are required for well designed mixture. some standard recommendations are as follow

Capacity	Natural aggregate	Man made or processed aggregate
<1 m^3	1.25 min	1.5 min
1-2 m^3	1.5 min	2 min
>2 m^3	2 min	2.5 min

Manufacture of concrete

1. The process of mixing some mortar in the mixer at the beginning of first batch is called

a. Buttering

b. Burrowing

c. Initiating

d. Acceleration

Answer	
1	a
2	b

2. In case of hand mixing the extra cement to be added is

a. 5%

b. 10%

c. 15%

d. 20%

3. Which of the following type of concrete mixer is commonly used in precast concrete factories?

a. Truck mounted mixer

b. Pan type mixer. (Answer).

c. Dual drum mixer

d. Tilting drum mixer

Manufacture of concrete

3. Transportation

- The process of bringing concrete to the place of application. Transportation can be done by various methods like
- A maximum of 2 hours from the time of mixing is permitted if truck with agitator & 1 hour if truck without agitator is used for transportation.

1. Wheel barrow: -

- ✓ for concreting rigid payment at ground level.
- ✓ Suitable for small haul, small job and over muddy ground.
- ✓ Average capacity is 80kg.

2. Chutes

- ✓ Suitable to transport below ground level.
- ✓ Provided 1V:2.5H to ensure sliding without segregation.

3. Dumper and Truck: -

- ✓ Economical for haul up to 5km.
- ✓ Capacity of dumper = 2 to 3 cum and Truck = 5 cum.
- ✓ For long haul agitators are required.

4. Belt conveyer: -

- ✓ Little used method.
- ✓ Problem of segregation(due to steep slope) and drying, stiffing of concrete occur.
- ✓ For continuous transportation of concrete, the method is adopted.

Manufacture of concrete

5. **Skip and hoist method: -**

✓ Useful method of transporting concrete in multistory building.

6. **Transportation by pump :-**

✓ Suitable for concreting of multistory building, tunnel lining & Bridge.

✓ **Specifications**

a. Vertical distance lifted by pump = 50m

b. Horizontal distance by pump = 400m

c. W/C = 0.5 to 0.65

d. Slump should not be less than 50 mm and more than 80 mm.& compacting factor of 0.9 to 0.95.

e. Diameter of pipe = 30cm

f. Pump capacity 15 to 150 m3/hour.

7. **Mortar pan: -**

✓ Suitable for small work.

✓ Labor intensive whereas the pans are passes from hand to hand and is slow and expensive method.

Manufacture of concrete

1. Transport of concrete by pump is done for a distance of

a. 100 m

b. 200 m

c. 300 m

d. 400 m

Answer	
1	d
2	d

2. For transportation by pump

a. water cement ratio shall be between 0.5 to 0.55

b. Slump shall be between 50-80 mm

c. None

d. Both (a) and (b)

Manufacture of concrete

Placing

The process of putting the concrete in desired place. Following precautions shall be taken

- Concrete should not be thrown from height more than 150cm. (1.0m as 1987)
- Placing is optimum at *27 ± 2^oC* and shall not be done in very cold surface.
- The layer of concrete should not exceed 15 to 30 cm.
- The process of mixing, transportation, placing and compacting the cement concrete should not take more than 30 minutes.

Compaction

- It is the process of removing excess of air void so as to make the concrete dense and strong compaction may be done.
- *5% void in hardened cement reduce strength by over 30% and 10% void reduce the strength by over 50%.*
- Strength & durability depend upon degree of compaction.
- For maximum strength, driest possible concrete should be compacted 100%.

1. **Hand Compaction: -** suitable for thin element like slab and for member with congested reinforcements.

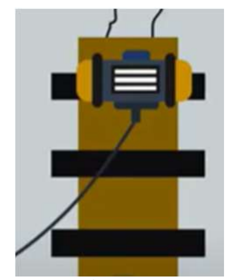
- **Rodding: -** 16mm dia, 2m long rod is used. Done continuously during concreting.
- **Ramming: -** For unreinforced concrete construction.
- **Tamping: -** Tampers are 100*100mm in section and 1m long. Tamping bar compact as well as level the top surface. Roof and floor slab are tampered.

Manufacture of concrete

Mechanically

- For roads surface, floor slab and roof slab < 15cm (can be used up to 25cm), **Screed vibrator or surface vibrator**
- ✓ Operation frequency 4,000 cycle per minutes.
- For RCC dams, beams & mass concrete structure > 20cm **Needle vibrator or internal vibrator or poker or immersion vibrator (Generally adopted)**
- ✓ Needle diameter varies from 20 to 75 mm and length 250 to 900mm.
- ✓ Average frequency of vibration is 3500 to 5000 cycle per minutes.

- ✓ Vibration about 30 seconds to 2 minutes.
- ✓ Spacing of immersion 600mm or 8 to 10*diameter of needle.
- For column, precast units & thin walls **Form vibrator or external vibrator or shutter vibrator**



- ✓ Compaction time is 1 to 2 minutes.
- ✓ Operation frequency 4,000 cycle per minutes.

Note: -

- <u>*Generally 5% of air bubble reduces the strength of concrete by 30% and 10% reduces 50%.*</u>
- <u>*The slump should not exceed 50 mm when compacting concrete with vibrators*</u>

Manufacture of concrete

1. For mechanical compaction the slump should not exceed
a. 2.5 cm
b. 5.0 cm
c. 7.5 cm
d. 10 cm

2. screed vibrator can only be used when the thickness of section does not exceed
a. 100 mm
b. 200 mm
c. 150 mm
d. 250 mm

3. Concrete is unsuitable for compaction by vibrator if it is

a. Dry
b. Plastic
c. Semi-plastic
d. Earth moist

Answer	
1	b
2	b
3	b

Manufacture of concrete

4.For compacting large sections of mass concrete in structures, the type of vibrator used is

a. Internal vibrator
b. Screed vibrator
c. Form vibrator
d. All of these

5. For compacting plain concrete or one way reinforced concrete floors, the vibrator used is

a. Internal vibrator
b. Screed vibrator
c. Form vibrator
d. All of these

6. Compaction of concrete helps in

a. Segregation of aggregate.
b. Removal of excess water.
c. Increase of Density.
d. Addition of required air voids.

Answer	
4	a
5	b
6	c

Manufacture of concrete

Finishing

- Finishing is the process of forming dense concrete with smooth and plain surface
- Best finishing is obtained when slump is ***50 mm.***

Finishing is done in following stages

a. **Screeding**: it is the process of removal of humps and hollows and give a true and uniform surface
b. **Floating**: the process of removing of irregularities left from screeding. It is done by using a wooden float of 1.5 m long and 20cm wide. Hence *ratio of length to width is 7.5.*
c. **Trowelling**: it is the final stage, it produces a smooth and dense surface

1. The process of mixing, transportation, placing and compacting should be completed within

a. 30 minutes b. 60 minutes
c. 90 minutes d. 120 minutes Answer:-a

Manufacture of concrete

Manufacture of concrete

Curing

- The process of wetting the concrete with water so as to make it able to gain strength sufficiently is called curing.(under 90% humidity)
- Concrete gains strength up to 100% after curing of 28 days.
- Water containing more than 0.08 ppm of iron is not recommended for curing.
- Curing compound used are bitumen, sodium silicate, linseed oil, wax and chlorinated rubber.
- It can be done through

a. Moist Curing: -

- ✓ Exposed surfaces of concrete shall be kept continuously in a damp of wet condition by ponding or by covering with a layer of sacking, canvas, hessian or similar materials and kept constantly wet for at least 7 days from the date of placing concrete in case of ordinary Portland Cement and at least 10 days where mineral admixtures or blended cements are used.
- ✓ The period of curing shall not be less than 10 days for concrete exposed to dry and hot weather conditions.
- ✓ In the case of concrete where mineral admixtures or blended cements are used, it is recommended that above minimum periods may be extended to 14days.

Manufacture of concrete

b. Membrane curing: -

- ✓ Impermeable membranes such as polyethylene sheeting covering closely the concrete surface may also be used to provide effective barrier against evaporation.
- ✓ Also sealing compound like rubber latex emulsion, resins, varnish, wax and bitumen can be used.
- ✓ Concrete may not achieve full hydration as in moist curing.

Note: -

- ✓ *For the concrete containing Portland pozzolana cement, Portland slag cement or mineral admixture, period of curing may be increased.*

Manufacture of concrete

c. Steam curing: -

- ✓ Also called *accelerated curing.*
- ✓ Have many advantages in producing precast concrete product

i. Mold can be removed within a shorter time.

ii. Due to shorter curing period, production is increases and cost reduced.

- ✓ The temperature can be increased by placing the concrete in steam, hot water or by passing an electric current through concrete.
- ✓ The concrete member is heated by steam at 93˚C either at high or low pressure.
- ✓ In low pressure steam curing about 70% of the 28 days compressive strength can be obtained in 16-24 days.
- ✓ High pressure steam curing can be applied to precast concrete member and give 28 days compressive strength in 24 hours but reduce bond strength by 50%.
- ✓ Low W/C respond more favorably to steam curing than those with higher W/C.
- ✓ Steam curing increased sulphate action and to freezing and thawing.

Manufacture of concrete

d. Chemical curing: -

- ✓ Liquid membrane forming curing compounds such as sodium silicate (water glass) solution prevent evaporation of moisture from concrete.
- ✓ They form a film, fill the pores, seal the surface voids and prevent evaporation.
- ✓ The application should be made immediately after the concreting has been finished.

e. Electrical Curing

- ✓ Cured by passing alternating current of low voltage and high current through electrode.
- ✓ Evaporation is prevented by using an impermeable rubber member on the top surface of concrete.
- ✓ Concrete can attain the normal 28-days strength in a period of 3 days.
- ✓ Expensive technique.

Manufacture of concrete

Curing shall commence after _____ from the time of finishing

a. 24 hour

b. 7 days

c. 14 days

d. 21 days

Steam curing is used for

a. Columns

b. Long slabs and columns

c. Mass production of precast concrete

d. All

Steam curing cannot be used for

a. OPC

b. High alumina cement

c. RHPC cement

d. All

Curing period is minimum for

a. RHPC

b. High alumina cement

c. PPC

d. OPC

Manufacture of concrete

Curing period is minimum for

a. RHPC
b. High alumina cement
c. PPC
d. OPC

As compared to moist- cured concrete, the permeability of steam- cured concrete is

a. More
b. Less
c. Same
d. None of the above.

In precast industry, best method of curing is

a. Ponding
b. covering with wet gunny bags.
c. Spraying water
d. Steam curing

Answer	
1	a
2	c
3	b
4	b
5	a
6	a
7	d

Manufacture of concrete

1. Curing period is minimum for the concrete using

a. OPC

b. PSC

c. RHC

d. Low heat portland cement.

Answer: -c

Minimum period stipulated for moist curing of concrete using OPC is

a. 3 days

b. 7 days

c. 14 days

d. 28 days

Answer: -b

Manufacture of concrete

Stripping of form

7 days for beam soffits

14 days for bottom slabs of spans 4.6 m and more

21 days for bottom beams over 6 m spans

2 days for vertical sides of columns

- Concrete is supported by framework, till it gains sufficient strength, after this formwork can be removed.
- Some recommendation for removal of

  formwork are

Type of Formwork	*Minimum Period Before Striking Formwork*
a) Vertical formwork to columns, walls, beams	**16-24 h**
b) Soffit formwork to slabs (Props to be refixed ...tely after removal ...vork)	**3 days**
...rmwork to beams ...be refixed ...tely after removal ...vork)	**7 days**
d) Props to slabs:	
1) Spanning up to 4.5 m	**7 days**
2) Spanning over 4.5 m	**14 days**
e) Props to beams and arches:	
1) Spanning up to 6 m	**14 days**
2) Spanning over 6 m	**21 days**

MCQ: -

1. For walls, columns and vertical faces of all structure, the formwork is ge...

7 days for beam soffits

14 days for bottom slabs of spans 4.6 m and more

21 days for bottom beams over 6 m spans

2 days for vertical sides of columns

a. 24 to 48 hours

b. 3 days

c. 7 days

d. 14days

Deflects of concreting

- **Bleeding**: appearance of water on surface
- **Segregation**: separation of particles from concrete
- **Laitance**: watery scum on surface
- **Honey combing**: - Honeycombing in concrete is a rough surface that contains voids in the concrete as a result of incomplete filling of the concrete against the formwork

Minimum Cement content, Maximum water cement ratio as per IS456:2000

Table 5 Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm Nominal Maximum Size

(*Clauses* 6.1.2, 8.2.4.1 *and* 9.1.2)

Sl No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m³	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete
1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Mild	220	0.60	–	300	0.55	M 20
iii)	Moderate	240	0.60	M 15	300	0.50	M 25
iii)	Severe	250	0.50	M 20	320	0.45	M 30
iv)	Very severe	260	0.45	M 20	340	0.45	M 35
v)	Extreme	280	0.40	M 25	360	0.40	M 40

Table 7 Limits of Chloride Content of Concrete

(*Clause* 8.2.5.2)

Sl No.	Type or Use of Concrete	Maximum Total Acid Soluble Chloride Content Expressed as kg/m³ of Concrete
(1)	(2)	(3)
i)	Concrete containing metal and steam cured at elevated temperature and pre-stressed concrete	0.4
ii)	Reinforced concrete or plain concrete containing embedded metal	0.6
iii)	Concrete not containing embedded metal or any material requiring protection from chloride	3.0

MCQ

1. For reinforced concrete exposed to sulphate (4%) attack minimum grade required. (expansion occur)

a. M 10

b. M 15

c. M 20

d. M 25

Workability

- It is the property of freshly prepared concrete which determines the ease and homogeneity with which it can be mixed, placed, compacted and finished.
- Higher is the workability greater is the ease for these processes.

The following are the factors which affect the workability of concrete

1. Water content: With increase in water content the workability increases
2. Size of aggregate: Concrete with larger size of aggregate is more workable for given aggregate
3. Shape of aggregate : Concrete with rounded aggregate is most and with angular aggregate is least workable provided other conditions remain same
4. Surface texture of aggregate : Smooth and glossy aggregate have higher workability while granular and porous aggregate have lower workability
5. Air entrainment : Air entrainment increases workability.
6. Temperature : Workability reduces at high temperature, because in high temperature the concrete dries too quickly and has to be placed and compacted soon which decreases the ease of working.
7. Aggregate cement ratio: Increase in aggregate cement ratio, decrease in workability. In a lean concrete, paste available for lubrication of per unit surface are of aggregates will be less and hence the workability is reduced.
8. Time of transit: - More time of transit, less will be workability.
9. Grading of aggregate: - proper grading, increases workability.
10. W/C ratio: - Workability is directly proportional to w/c.

MCQ

1. For a constant w/c ratio, decrease in aggregate-cement ratio causes
a. *Increase in workability* (Answer)
b. Decrease in workability
c. No change in workability
d. None of the above.

2. Workability of concrete is directly proportional to
a. Grading of aggregate Answer
b. Time of transit
c. Aggregate cement ratio
d. None of the above

3. Select the incorrect statement
a. High temperature reduces workability.
b. Segregation can be reduced by use of air entrainment.
c. Bleeding is increased by use of air entrainment. (Answer)
d. None of the above.

Slump Test

Tools and Apparatus used for Slump Test

IS : 7320 - 1974

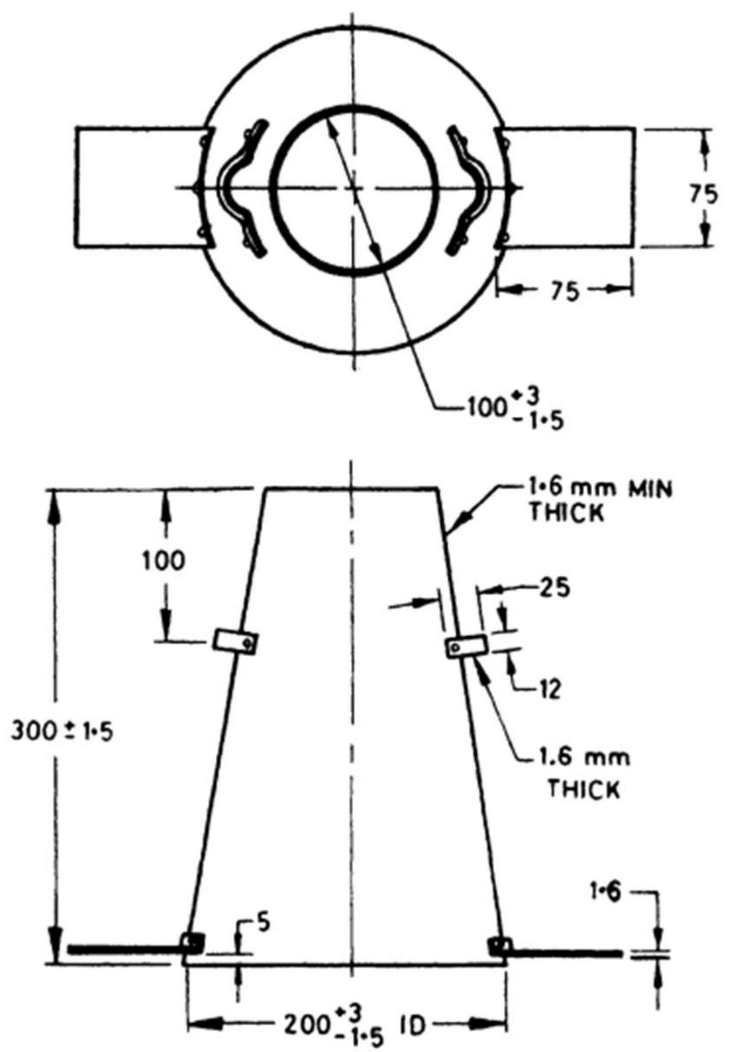
TABLE 1 INTERNAL DIMENSIONS OF MOULD

(*Clause* 3.1)

SL No.	DETAILS	DIMENSION mm	TOLERANCE (*see* NOTE) mm
(1)	(2)	(3)	(4)
i)	Bottom diameter	200	+ 3 − 1·5
ii)	Top diameter	100	+ 3 − 1·5
iii)	Height	300	± 1·5

Tamping Rod= 16mm diameter and 60 mm long. The tamping end of rod shall be rounded to a hemispherical tip

Slump Test



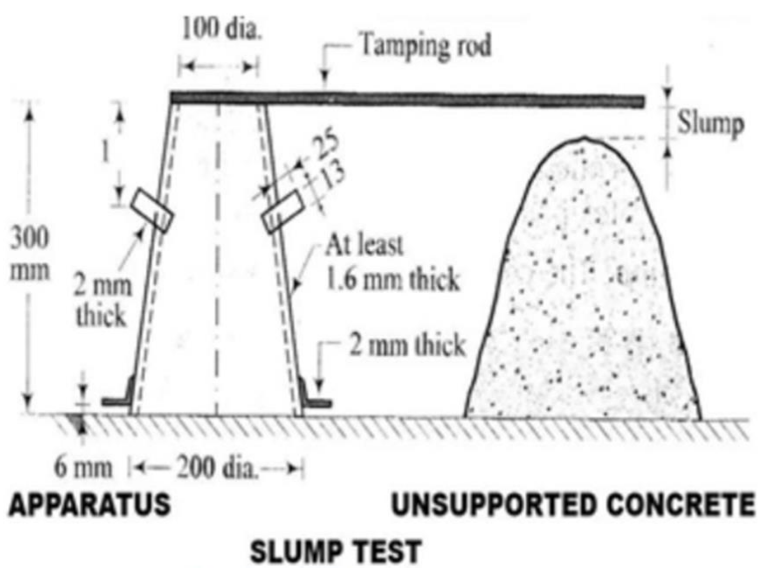
All dimensions in millimetres.

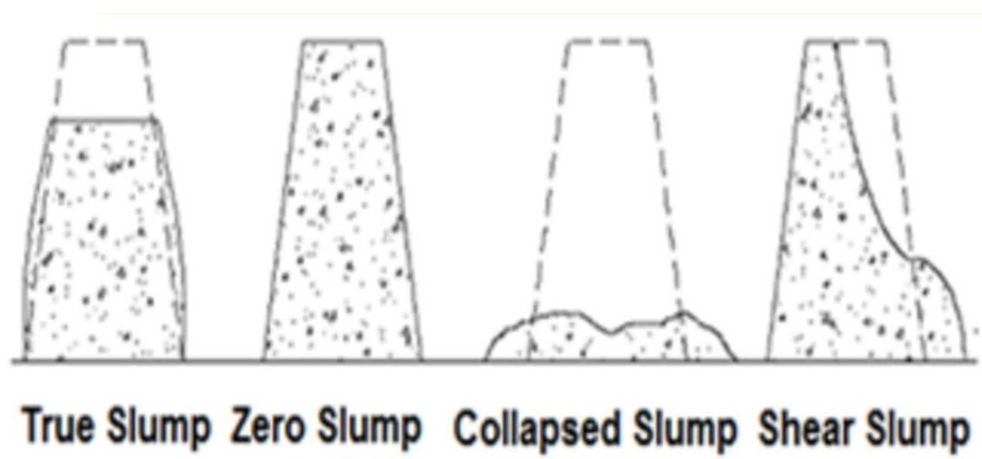
Slump Test

1. In the case of concrete containing aggregate of maximum size more than 38 mm, the concrete shall be wet-sieved through one and half inch screen to exclude aggregate particles bigger than 38 mm.
2. The internal surface of the mold shall be thoroughly cleaned and free from superfluous moisture and any set concrete before commencing the test. The mold shall be placed on a smooth, horizontal, rigid and non-absorbent surface, such as a carefully leveled metal plate, the mold being firmly held in place while it is being filled.
3. The mold shall be filled in four layers, each approximately one-quarter of the height of the mold. Each layer shall be tamped with 25 strokes of the rounded end of the tamping rod.
4. The bottom layer shall be tamped throughout its depth. After the top layer has been rodded, the concrete shall be struck off level with a trowel or the tamping rod, so that the mold is exactly filled.

Slump Test

5. After the top layer has been rodded, strike off the surface of the concrete by means of screeding and rolling motion of the tamping rod.
6. Any mortar which may have leaked out between the mold and the base plate shall be cleaned away. The mold shall be removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allows the concrete to subside and the slump shall be measured immediately by determining the difference between the height of the mold and that of the highest point of the specimen being tested.
7. The above operations shall be carried out at a place free from vibration or shock, and within a period of two minutes after sampling.
8. The workability of concrete by slump test is expressed as mm.





Slump Test

The different types of profile for the concrete are named as:

1. Collapse slump
2. Shear slump
3. True slump
4. Zero slump

1. Collapse slump

- ✓ Collapse slump is the type of the slump that indicates the concrete mix is too wet. This shows the mix is so lean, water-cement ratio is so high and concrete have high workability.

2. Shear slump

- ✓ Slump which indicates the *deficiency of cohesion* in the concrete mix and water cement ratio is slightly increased.
- ✓ If one-half of the concrete in slump cone slides down in an inclined plane the slump is called as shear slump.
  The slump is also *not preferred* and concrete mix is remixed for the good results.

Slump Test

3. True slump

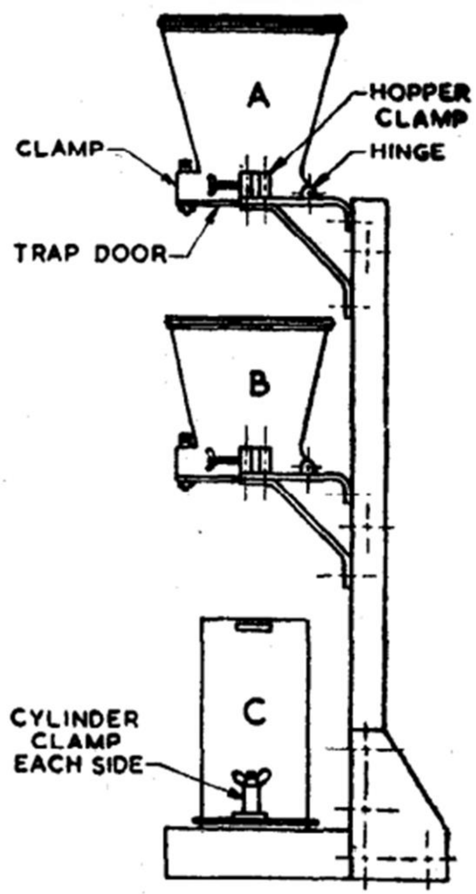
- ✓ Slump in which the *concrete mix retains its shape* and just slightly slips down.
- ✓ True slump is obtained *when concrete mix is prepared with full consistency*.
- ✓ This type of the slump is desired in all the type of concrete constructions.

5. Zero slump

- ✓ When *concrete blend is not workable and is also not consistent, you'll get zero slump*. This type of slump shows excessive cohesion between the ingredients. Such a concrete is not easy to pour or work with at site.
- ✓ This type of slump is *also not preferred in most concrete structure.* However, with slight adjustments you can convert this slump into the other types. One of the useful characteristic of the true and zero slumps is that you can transform them into shear and collapse slumps.

Compaction Factor Test

Compacting Factor Test :- Concrete mixes of very low workability.



Upper hopper, *A*	
Top internal diameter	25·4
Bottom internal diameter	12·7
Internal height	27·9
Lower hopper, *B*	
Top internal diameter	22·9
Bottom internal diameter	12·7
Internal height	22·9
Cylinder, *C*	
Internal diameter	15·2
Internal height	30·5
Distance between bottom of upper hopper and top of lower hopper	20·3
Distance between bottom of lower hopper and top of cylinder	20·3

All dimension are in cm.

Compaction Factor Test

Procedure:

1. The upper hopper is filled with concrete, this being placed gently so that, at this stage, no work is done on the concrete to produce compaction.
2. The bottom door of the hopper is then released and the concrete falls into the lower hopper. This lower hopper is smaller than the upper one.
3. The lower hopper is filled to overflowing and thus always contains approximately the same amount of concrete in a standard state.
4. The bottom door of the lower hopper is released and the concrete falls into the cylinder.
5. The weight of the concrete in the cylinder shall then be determined to the nearest 10 g. This weight shall be known as the weight of partially compacted concrete .
6. The cylinder shall be refilled with concrete from the same sample in layers approximately 5 cm deep, the layers being heavily rammed or preferably vibrated so as to obtain full compaction.
7. Weight the fully compacted concrete.

Compaction Factor Test

$$\text{Compacting Factor} = \frac{\text{Density actually achieved in the test}}{\text{Density of the same concrete fully compacted}}$$

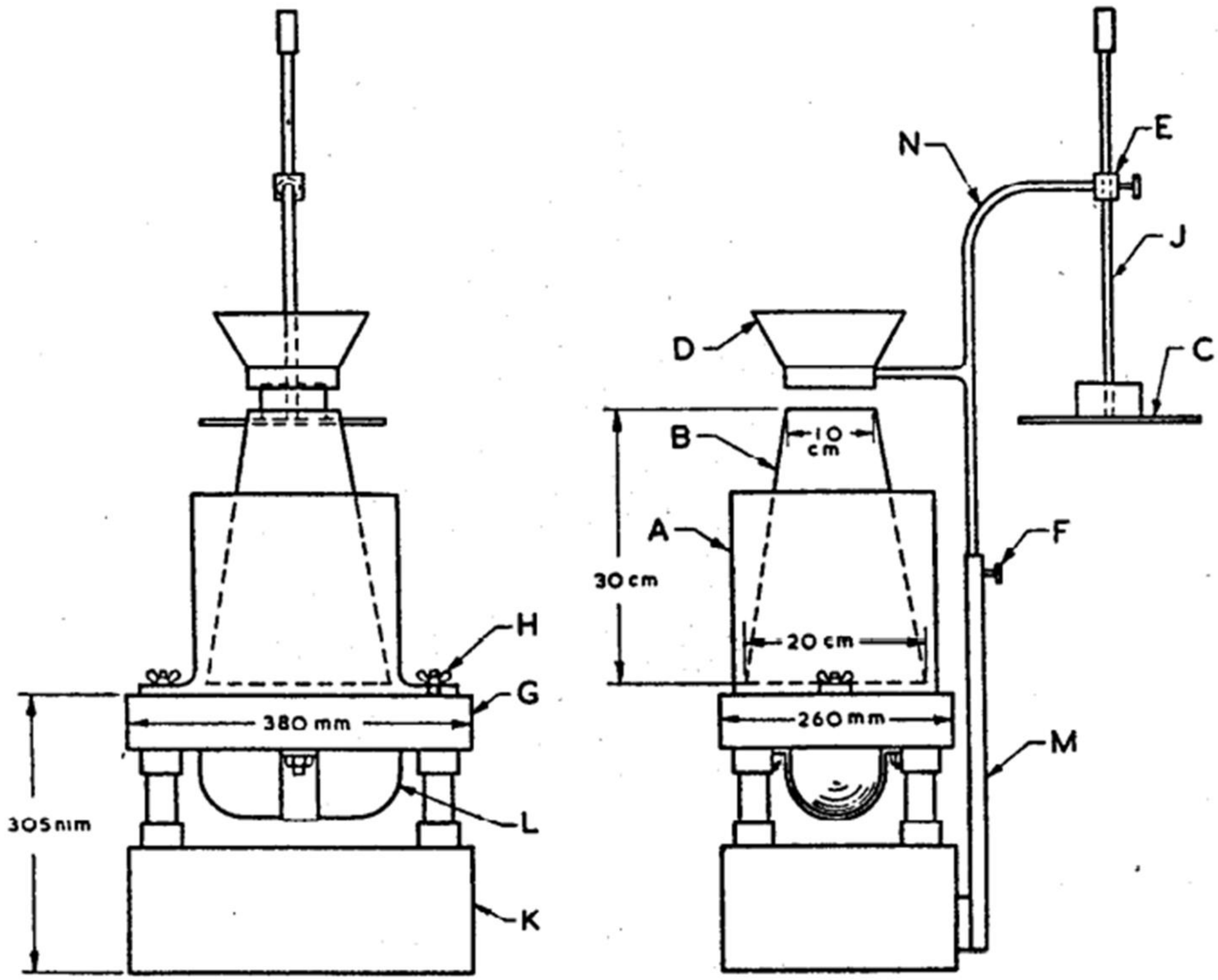
or

$$\frac{\text{Wt. of partially compacted concrete}}{\text{Wt. of fully compacted concrete}}$$

Compaction Factor Test

VIDEO

Vee-Bee Test



- Slump Cone (20 cm lower dia., 10 cm upper dia., 30 cm height)
- Container (300mm diameter and 200mm height)
- Vee bee Table (380 mm x 260 mm)

Vee-Bee Test

- The freshly mixed concrete is packed into the slump cone in a standard manner. The cone stands within a special container on a platform, which is vibrated with an eccentric weight rotating at 50 Hz so that the vertical amplitude of the table is approximately ±0.35 mm.
- Vibration is performed after the cone has been lifted off the concrete.
- The time taken for the concrete to be compacted is measured.
- Greater is the vee-bee time in seconds lower is the workability and vice versa.

MCQ

For given workability the grading requiring the least amount of water is one that gives

1. greatest surface area for the given cement and aggregates. (Answer)
2. least surface area for the given cement and aggregates
3. least weight for the given cement and aggregates
4. greatest weight for the given cement and aggregates

VIDEO

Result

The different types of concrete based on workability are as follows

Test \ Workability	Very low	Low	Medium	High
Slump	0-25	25-50	50-75	75-100
Compaction factor test	<0.85	0.85 – 0.90	0.90 – 0.95	>0.95
Vee bee test	10-20	5-10	2-5	0-2

Note: ***- Higher Vee- Bee test, show lower workability: Higher slump test, show higher workability: Higher compaction factor test show, show higher workability.***

MCQ

If the slump of a concrete mix is 60 mm, its workability is

1. Very low
2. Low
3. Medium. (Answer)
4. High

Workability

Recommended value of slumps for various concrete works.

S.No.	Types construction	Recommended value of slump in mm		Remarks
		Minimum	Maximum	
1	Pavements	20	30	
2	Mass concrete structure	25	50	
3	Unreinforced footing	25	75	
4	Cassions and bridge works	25	75	
5	Reinforced foundations, footings and walls	50	100	
6	Reinforced slabs and beams	50	100	
7.	Columns, retaining walls and thin vertical members	75	150	

<u>**Workability**</u>

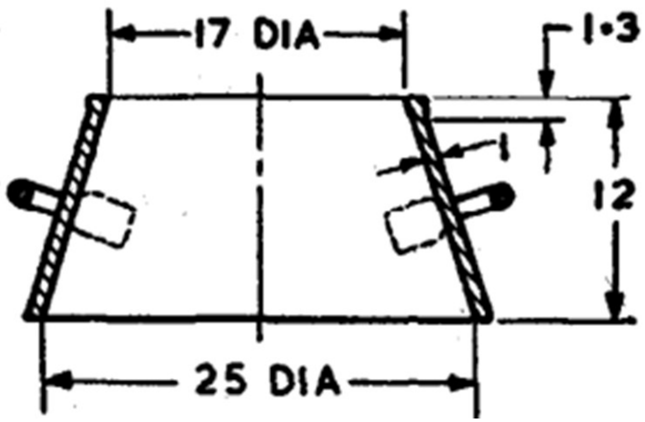
- ➢ Compaction factor Test:-
- More accurate than slump test.
- Especially for concrete mixes of medium and low workability i:e compacting factor of 0.9 to 0.8.
- *More popular to determine the workability in lab.*

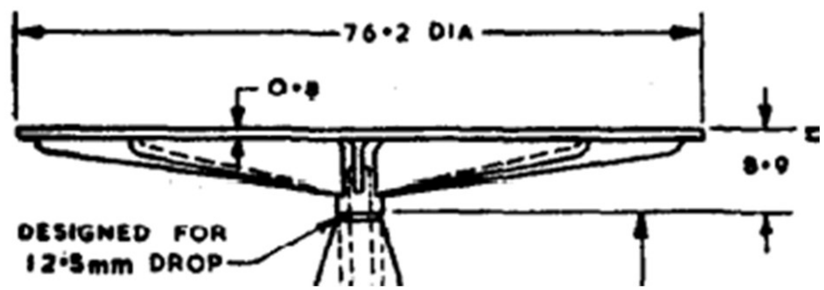
- ➢ Vee-Bee Test
- Suitable for stiff concrete of low and very low workability.

Flow Test:- For high workability.

Apparatus:-

1. Mold - The mold shall be made of a smooth metal casting, as shown in Fig. 3 in the form of the frustum of a cone with the following internal dimensions. A base 25 cm in diameter, upper surface 17 cm in diameter, and height 12 cm. The mold shall be provided with handles.





2. Flow table:- it is mounted on the concrete base having height of 40 to 50cm and weight not less than 140 kg. The diameter of table= 76.2 cm.

Flow Test: - Procedure

1. The mold, centered on the table, shall be firmly held in place and filled in two layers, each approximately one-half the volume of the mold. Each layer shall be rodded with 25 strokes of a straight round metal rod 1.6 cm in diameter and 61 cm long, rounded at the lower tamping end. The strokes shall be distributed in a uniform manner
2. After the top layer has been rodded, the surface of the concrete shall be struck off with a trowel so that the mold is exactly filled. The excess concrete which has overflowed the mold shall be removed and the area of the table outside the mold again cleaned. The mold shall be immediately removed from the concrete by a steady upward pull.
3. The table shall then be raised and dropped 12.5 mm, 15 times in about 15 seconds.
4. The flow of the concrete shall be recorded as the percentage increase in diameter of the spread concrete over the base diameter of the molded concrete,
5. calculated from the following formula:

$$\text{Flow, percent} = \frac{\text{spread diameter in cm} - 25}{25} * 100$$

Workability MCQ

1. Workability of concrete can be improved by addition

a) Iron

b) Sodium

c) Zinc

d) Sulphur

2. Which test used for fiber reinforced concrete?

a) Slump test

b) Compacting factor test

c) Flow table test

d) VeBe test

3. Which test used for high workable concretes?

a) Slump test

b) Compacting factor test

c) Flow table test

d) Vee-Bee test

4. Higher workability of concrete is required if the structure is

a) Made with cement concrete.

b) Thick and reinforced.

c) Thin and heavily reinforced.

d) Thick and heavily reinforced.

1	b
2	c
3	c
4	d

4. For high degree of workability, the slump value vary between

a. 0 to 25 mm	b. 25 to 50 mm
c. 50 to 80 mm	**d.** 80 to 100 mm

5. For high degree of workability, the compaction factor is

a. 0.65	b. 0.75
c. 0.85	**e.** 0.95

6. Vibrated concrete needs .... Slump value.

a. Less	b. More
c. medium	d. none

4	D
5	E
6	A
7	D
8	C
9	D

7. The workability of concrete by slump test is expressed as
   a. minutes b. mm/h c. mm2/h d. mm.
8. The compaction factor of 0.88 indicates the workability of
   a. very low b. low c. medium d. high
9. For concreting of heavily reinforced sections without vibration, the workability of concrete expressed as compacting factor should be

a. 0.75-0.80 b. b. 0.8-0.85
c. 0.82-0.92 d. d. Above 0.92

Manufacture of concrete

For a constant w/c ratio, decrease in aggregate-cement ratio causes

a. Increase in workability	b. Decrease in workability
c. No change in workability	d. None of the above.

Which of the following workability tests is most suitable for concrete of very low workability?

a. Slump test	b. Compacting Factor test
c. Vee-Bee test.	d. None of the above.

Note:- Very low workability = Vee- Bee Test.
Low workability = Compacting factor Test.
Medium and high workability = Slump Test.
High workability = Flow table test

For a satisfactory workable concrete with a constant W/C ratio, increase in aggregate/ cement ratio

a. Does not change strength of concrete	b. Decrease the strength of concrete
c. Increase the strength of concrete	d. None of the above.

Minimum w/c ratio required for full hydration of cement is

a. 0.23	**b. 0.36**
c. 0.45	d. 0.6

Water cement ratio

- Water cement ratio (w/c ratio) is defined as the ratio of the weight of water to the weight of cement used in the concrete mix.
- W/C is responsible for

✓ Strength of concrete.

✓ Porosity of concrete.

- For proper workability, w/c varies from 0.4-0.6.
- For complete hydration, the water requirement is 38%.
- Despite this a minimum water cement ratio of 0.4 is necessary to prohibit the phenomena of honeycombing, improper consistency and workability.
- At w/c more than 0.6, porosity increases and strength reduces.

❖ Similarly the range of water cement ratio to be maintained for different grades of concrete are as follows:-

- *M10 = 0.6 to 0.65*
- *M15 = 0.55 to 0.6*
- *M20 = 0.5 to 0.55*
- *M25 = 0.45 to 0.5*

✓ For ordinary concrete works; 0.4 to 0.6 w/c ratio is used.

✓ For high-quality concrete works; 0.4 w/c ratio is specified.

✓ When 2% plasticizers or super-plasticizers are used in high-quality concrete; commonly 0.3 to 0.38 w/c is used.

✓ (Note: Plasticizers or super-plasticizers can be used to increase the flow ability and workability of higher strength Concrete.)

❖ For concrete of higher strengths *further lower value of water cement ratio is not permissible* therefore *plasticizer is to be used.*

Water-cement ratio

- **Following reasons why high water-cement ratio is not recommended:**
- Chances of segregation and bleeding.
- Less durability.
- Development of voids
- Decrease in strength of concrete
- Decrease in life of structure
- Leakage and chances of corrosion
- Freeze-thaw effect etc.
- **Following major reasons why the low water-cement ratio is recommended:**
- Increase in strength
- Small creep and shrinkage
- Increase in durability
- Greater density & lower permeability.
- No leakage or dampness
- Increase frost resistance.
- Better bond with reinforcement & greater weather resistance.

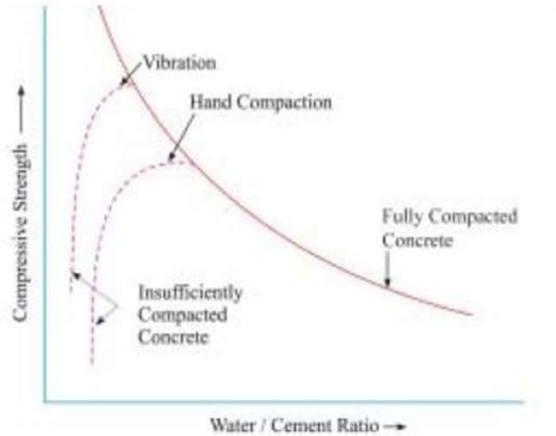
Manufacture of concrete

1. Minimum w/c required for full hydration of cement is

a. 0.23 b. 0.36 c. 0.45 d. 0.60

Water cement ratio vs. strength

- The relation between strength and water cement ratio is given by



The relation between strength and water/cement ratio of concrete

- Up to a certain water cement ratio the *strength of concrete is not attained due to honeycombing (Generally 0.4).* Beyond this water content,
- *For machine compacted concrete* the strength of concrete *decreases with increase in water content.*
- In the case of hand compacted concrete, *the strength initially increases* on addition of water due to *increased ease of compaction*, but after a certain point when full compaction is possible *the strength decreases with increase in water content.*

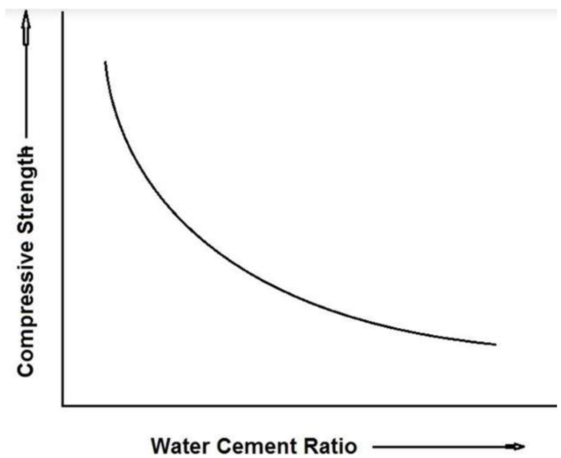
Water-cement ratio

1. Abrams water/cement ratio law

- In 1918, Abrams' law states that 'assuming full compaction, and at a given age and normal temperature *"strength of concrete can be taken to be inversely proportional to the water/cement ratio*"

$$S = A/B^x$$

- where $\mathrm{x} =$ water/cement ratio by volume and for 28 days results the constants A *and* B *are 96* N/mm^2 *and 7* respectively.
- *Strength of concrete primarily* depends upon the *strength of cement paste*.
- The *strength of paste increases with cement content and decreases with air and water content*.
- This law is valid for plastic concrete.



Note: -

✓ *If w/c ratio increases, the strength of concrete decreases and vice versa.*

✓ *If c/w ratio increases, the strength of concrete increases and vice versa*.

Abrams water/cement ratio law

LIMITATIONS

“The strength of concrete is only dependent upon W/C ratio.

but

W/C ratio of concrete is also depend upon

- Degree of hydration of cement.
- Temperature at which hydration takes place.
- Formation of cracks due to bleeding and shrinkage.
- Air content in case of air entrained concrete.
- Change in the water/cement ratio.

Thus it is concluded as the strength of concrete depend upon hydration product i:e gel space ratio.

Water-cement ratio

2. Feret water cement law: -

- ✓ S= K*$\left(\frac{c}{c+w+a}\right)^2$

Where,

C= volume of cement

W= volume of water

A= volume of air

K= a constant

In this expression, the volume of air is also included, which means the voids in concrete are taken into account in estimating the strength.

MCQ

1. If the water cement ratio is more, then the
(a) strength of concrete will be less
(b) durability of concrete will be less
(c) capillary voids will be more in the physical structure of hydrated cement
(d) *all of the above.*

2. Water-cement ratio is, usually, expressed in
(a) *litres of water required per bag of cement.*
(b) litres of water required per kg of cement
(c) both (a) and (b)
(d) none of these

3. Which of the following statement is correct?
(a) *Duff Abram's law is valid only when the concrete is of workable plasticity.*
(b) If the water-cement ratio is less, the strength of concrete will be less.
(c) The strength of concrete decreases with age.
(d) A rich mix of concrete provides low strength than a lean mix.

4. Water cement ratio is generally expressed in volume of water required per

a. 10 kg
b. 20 kg
c. 30 kg
d. 50 kg. (Answer)

<u>MCQ</u>

1. Water cement ratio may be defined as the ratio of

a. volume of water to that of cement in a concrete mix.

b. weight of water to that of cement in a concrete mix

c. volume of water to that of concrete in a concrete mix

d. weight of water to that of concrete in a concrete mix

2. The rule of water cement ratio was established by

a. Duff Abram

b. Plowman

c. W. Simms

d. Dr. Karl Terzaghi

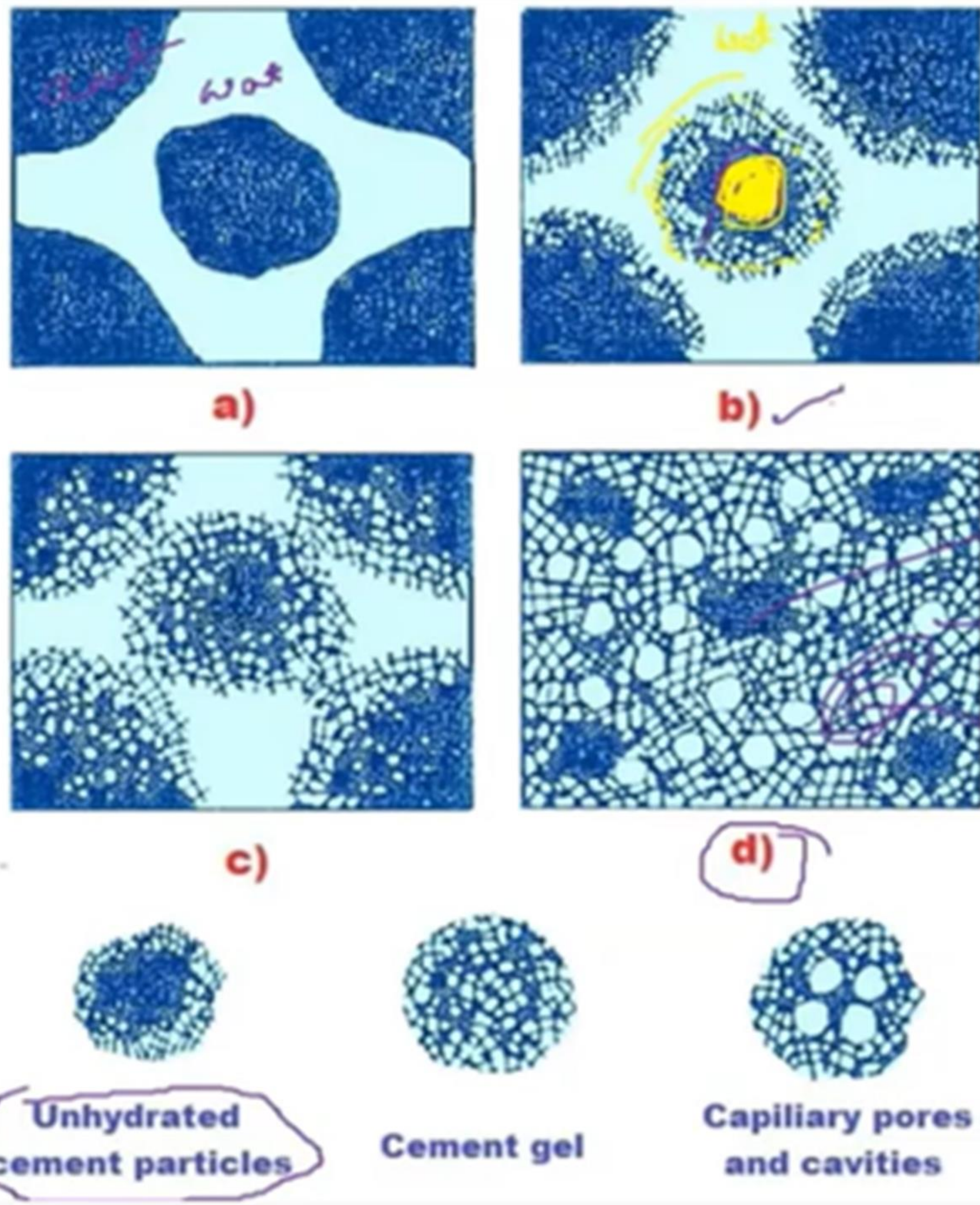
3. According to the rule of water cement ratio, the strength of concrete wholly depends upon

a. the quality of cement

b. the quality of cement mixed with aggregate

c. the amount of water used in preparation of concrete mix

d. all of the above



Cement left to get hyd

capila pores /
Cavity } water

Hydrated/Cement gel

$$\frac{\text{Volume of Hydrated gel}}{\text{Vol of hyd gel + vol of Cap pores}} = \text{Gel space Ratio}$$

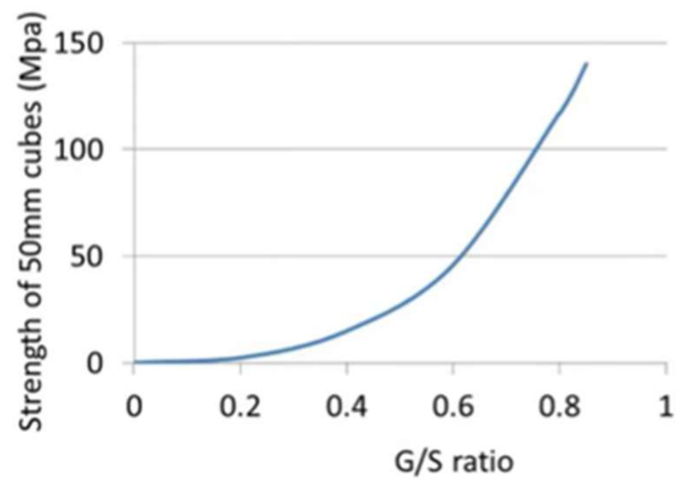
Factors on which strength depends

The following are the main factors on which the strength of concrete depends

1. Water cement ratio : Strength decreases with increase in w/c ratio
2. Gel space ratio : defined as the volume of hydrated cement paste to the sum of volume of hydrated cement and that of capillary pores.

According to Mr. Power (or powers law)

- Theoretical Strength = $240X^3$ N/mm^2
- Where X = Gel space ratio = $\frac{0.657C}{0.319C+ \quad w}$
- C = Weight of cement
- W_w = weight of water.



Note: -

✓ *1 ml of cement on hydration produces 2.06 ml of gel.*

✓ *Limitation of this theory*

- Theoretical Strength >>>> Actual strength of concrete.

Gel space ratio

- Calculate the gel space ratio and theoretical strength of a sample concrete made with 500 g of cement with w/c ratio as 0.55.

a. On full hydration.

Solution,

$W_{w=}$ 500*0.55 = 275ml

gel space ratio (X) = $\frac{0.657C}{0.319C+W_w}$ = $\frac{0.657*500}{0.319*500+2}$ = 0.756.

Theoretical strength = 240*$(0.756)^3$= 103.72 N/mm2.

b. On 75% hydration

Solution

$W_{w=}$ 500*0.55 = 275ml

gel space ratio (X) = $\frac{0.657C\alpha}{0.319C\alpha+W_w}$ = $\frac{0.657*500*0.75}{0.319*500*0.75+275}$ = 0.6423

Theoretical strength = 240*$(0.6426)^3$= 58.4 N/mm2.

Note: -

- A *higher gel/space* ratio *reduces the porosity* and therefore increases the strength of concrete.
- A higher water/cement ratio decreases the gel space ratio increasing the porosity thereby decreasing the strength of concrete.

Factors on which strength depends

3. Size of aggregate :

- ✓ As size of aggregate increases the strength of concrete increases.
- ✓ For w/c ratio less than *0.4*, concrete with crushed aggregate has higher strength *by more than 38%* than gravel is used.
- ✓ At w/c of 0.6, influence of type of aggregate does not exist.

5. Admixture : Strength increases when admixture is added.
6. Porosity: -

- ✓ strength decreases with increase in porosity.
- ✓ 5% air void reduces strength by 30% and 10% by 50%.

7. Air entrainment : Air entrainment decreases strength
8. Age : The strength of concrete increases with age.

Days	3	7	21	28	90	180	360
Strength	40%	65%	90%	100%	115%	120%	130%

9. Temperature: - High temperature reduces strength.

Test on concrete

Rate of loading: -

- ✓ Strength of *concrete increases* with *increase in rate* of loading.
- ✓ Rate of loading for cube specimen is 14N/cm2/min.

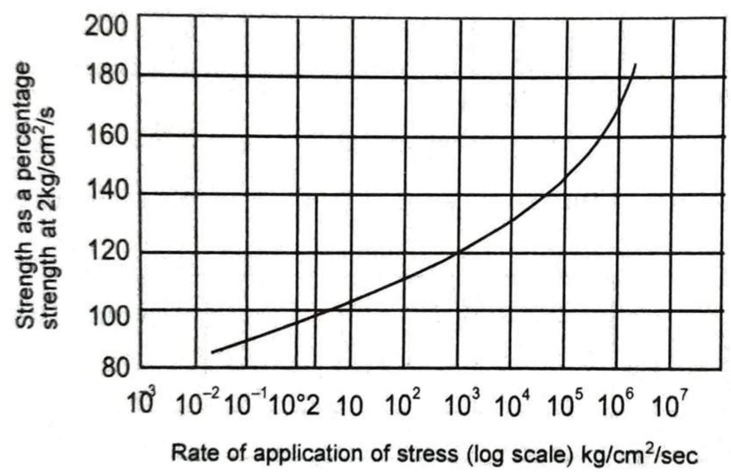


Fig. 10.22 **Influence of Rate of Application of Load on Strength of Concrete**

Gain in strength with age: -

- ✓ *Concrete gains with age.*
- ✓ Initially strength developed is more. However, the ratio of gain in strength diminishes with age.
- ✓ It is customary to assume the 28 days strength as full strength of concrete.

Test on concrete

Type and size of aggregate

- ✓ Crushed stone and gravel give higher strength.
- ✓ A *cubical shaped aggregate* give higher strength *than irregular and flaky aggregate* of same nominal size.
- ✓ The *larger aggregate* give lower surface area for development of gel bonds leading the *lower strength.*
- ✓ *High strength concrete give less strength* as compared to *lean concrete* if large *size aggregate is used.*

<u>Test on concrete</u>

1. Compression test: -

- ✓ For compression test, the maximum nominal size of aggregate does not exceed *38 mm* and temperature of test is *27±3˚C.*
- ✓ Weighing: -The quantities of cement, each size of aggregate and water for each batch shall be determined by weight, to an accuracy of 0·1 percent of the total weight of the batch.
- ✓ Mixing Concrete - The concrete shall be mixed by hand, or preferably, in a laboratory batch mixer. Each batch of concrete shall be of such size as to leave about *10 %* excess.
- ✓ Mixing:
- ➢ The *cement and fine aggregate* shall be mixed dry until the mixture is thoroughly blended and is *uniform in color*.
- ➢ The *coarse aggregate* shall then be added and *mixed with the cement and fine aggregate* until the coarse aggregate is uniformly distributed throughout the batch, and
- ➢ The *water shall then be added* and the entire batch mixed until the concrete appears to be homogeneous and has the desired consistency.

Test on concrete

Size of Test Specimens –

- Test specimens cubical in shape shall be *15 X 15 X 15 cm*. If the largest nominal size of the aggregate does not exceed *19 mm,* 10 cm cubes may be used as an alternative.
- Cylindrical test specimens shall have a length equal to twice the diameter. They shall be *15 cm* in diameter and *30 cm* long. ($\frac{l}{d} = \frac{2}{1}$)

Tamping Bar –

- The tamping bar shall be a steel bar *16 mm* in diameter, *0·6 m* long and bullet pointed at the lower end.

Compaction: -

- The concrete shall be filled into the mold in layers approximately *5 cm* deep.
- The number of strokes per layer required to produce specified, conditions will vary according to the type of concrete.
- For cubical specimens, in no case shall the concrete be subjected to less than *35 strokes per layer for 15 cm* cubes or *25 strokes per layer for 10 cm cubes*.
- For cylindrical specimens, *the number of strokes shall not be less than 30 per layer.*

Test on concrete

Curing –

- The test specimen shall be stored in a place, free from vibration, in moist air of at least *90 % relative humidity* and at a temperature of *27° ± 2°C* for *24 hours ± $\frac{1}{2}$ hour* from the time of addition of water to the dry ingredients.
- After this period, the specimens shall be removed from the molds and, unless required for test within *24 hours*, immediately submerged in clean, fresh water.
- The water or solution in which the specimens are submerged shall be renewed every *7* days and shall be maintained at a temperature of 27° ± 2°C.

Number of Specimen –

- At least *3 specimens*, preferably from different batches, shall be made for testing at each selected age.
- The load shall be applied without shock and Increased continuously at a rate of approximately *140 kg/sq. cm per min or (14N/mm2)* until the specimen break.

Test on concrete

$$\text{Compressive strength} = \frac{Maximum\ load}{Cross\ sectional\ area}$$

- Average of three values shall be taken as the representative of the batch provided the *Individual variation* is not more than ± 15 percent *of the average.* Otherwise repeat tests shall be made.

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

8.2.8 *Concrete in Sea-water*

Concrete in sea-water or exposed directly along the sea-coast shall be at least M 20 Grade in the case of plain concrete and M 30 in case of reinforced concrete. The use of slag or pozzolana cement is advantageous under such conditions.

Hence their relation can be given as:

Compressive Strength of cylinder = 0.8 x (Compressive Strength of Cube)

Given the same concrete mix is used in both samples.

Test on concrete

- ✓ Factor affecting strength of concrete: -

Size of specimen

- ✓ *Cylinders fail by shear at 60˚and cubes at 45˚to the horizontal.*
- ✓ *The factor of safety for cube strength is 3 and that of cylindrical strength is 2.4.*
- ✓ *A cube of concrete is expected to have a strength of 20-25% greater than a cylindrical specimen.*

If ht./side change, change in compressive strength of prism (cylinder) relative to cube, shown in table

*C= 0.8*cube*

Height/side	0.5	1.0	2.0	3.0	4.0	5.5
Relative strength (C/cu)	1.5	1.0	0.8	0.72	0.68	0.6

Beyond, ht./side ratio 4, it stabilize.

&,

If, size of cube decreases,

compressive strength increases

Cube size (mm)	100	150	200	300
Relative strength to 150mm cube	1.05	1.0	0.95	0.87

Uses

S.N	Grade	Proportion	Uses
1	M 10	1:3:6	Mass concrete in pier, abutments, massive reinforced concrete members.
2	M 15	1:2:4	Normal RCC works i:e slabs, columns, beams, walls, small span arches
3	M 20	1:1.5:3	Water retaining structures i: e reservoirs, columns and piles.
4	M 25	1:1:2	Long span arches and highly loaded columns
5	M 30	-	Mass concrete foundations
6	M 35	-	Post tensioned pre-stress concrete
7	M 40	-	Pre tensioned pre-stress concrete

M refer mix

Number refers characteristics strength of concrete at 28 days expressed in MPa.

MCQ

1. For highly loaded column , the concrete mix is

a. 1:1:2 b. 1:1.5:3 c. 1:2:4 d. 1:3:6

2. For mass concrete of pier and abutment, the grade of concrete mix used is

a. 1:1:2 b. 1:1.5:3 c. 1:2:4 d. 1:3:6.

3. The preliminary test should be repeated if the difference of compressive strength of three specimen exceeds

a. 0.5 N/mm2 b. 1 N/mm2 c. 1.5 N/mm2 d. 2N/mm2

MCQ

1. The individual variation between test strength of sample should not be more than

a. ± 5% of average

b. ± 10% of average.

c. ± 15% of average.

d. ± 20% of average.

2. With the increase in rate of loading during testing, compressive strength of concrete

a. Increase

b. Decrease

c. Remain same

d. None of the above.

3. The compressive strength of concrete determined by 150mm X 150mm cube as compared to that determined from 150 X 300 mm cylinder is

a. More

b. Less

c. Equal

d. None of the above.

Test on concrete

4. The compressive strength of concrete determined by 150mm X 150mm cylinders as compared to that determined from 150mm cubes is

a. More

b. Less

c. Equal

d. None of the above.

Reason

The basic reasons why cube strength is more than cylinder strength:

✓ The length to diameter ratio of a cylindrical specimen used for the compressive strength test is 2: 1, while that for a cube is 1:1. Hence, cubes are found stronger than cylinders.

1	c
2	a
3	a
4	c

MCQ

1. The cube strength of concrete exceed the cylinder strength by (in percent)

a. 10 to 50

b. 10 to 15

c. 15 to 20

d. 20 to 25

2. During application of load on cylindrical specimen, the failure plane makes an angle of …….. With the horizontal.

a. 30˚

b. 45˚

c. 60˚

d. 75˚

1	D
2	C

Hint:-

- ✓ *Cylinders fail by shear at 60˚and cubes at 45˚to the horizontal.*
- ✓ *The factor of safety for cube strength is 3 and that of cylindrical strength is 2.4*

Tensile test of concrete

1. Direct method (Briquette test): - may not reflect the correct tensile strength because of the practical difficulties involved.

   $f_t = (0.5 - 0.625) * f_{cr}$ .... (i)

2. Indirect method

i. Flexural tensile test **(f_{cr}) : -** = $0.7 * \sqrt{f_{ck}}$

ii. Split tensile strength test:- (f_{ct}) = $\underline{0.35 * \sqrt{f_{ck}}}$

   $f_{ct} = 0.67 * f_{cr}$ .... (ii)

From equation (i) & (ii)

$$\mathbf{f_{cr} > f_{ct} > f_t}$$

Flexure Test (f_{cr})

- The Flexural Strength of Concrete starts to happen when a road slab with insufficient sub-grade support is exposed to wheel loads and / or there are volume changes because of temperature / shrinking.
- Indirect test of finding tensile strength of concrete.
- REFERENCE STANDARDS: IS: 516-1959
- TOOLS & APPARATUS:

1. Beam mold with size *15 x 15x 70 cm* (when size of aggregate is under *38 mm*) or with size *10 x 10 x 50 cm* (when size of aggregate is under *19 mm*).
2. Tamping bar (*40 cm* long, weighing 2 kg and tamping section with size of 25 mm x 25 mm).
3. Flexural test machine– The bed of the testing machine should contain two steel rollers, *38 mm in diameter, on which the specimen should be supported,* and these rollers should be mounted in such a manner that the distance from center to center remains *60 cm for 15.0* cm specimens or *40 cm for 10.0 cm* specimens.

Flexure Test (f_{cr})

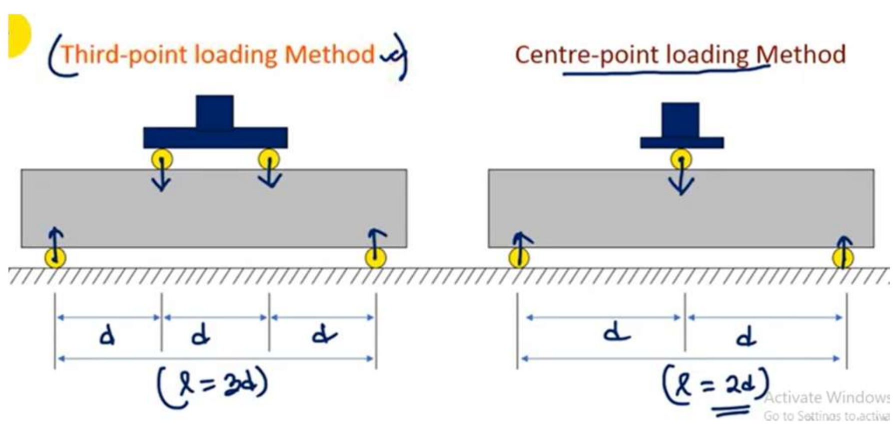
The load should be employed through two similar rollers mounted at the third points of the supporting span that is placed at *20 or 13.3 cm* center to center.

- METHOD:

✓ Arrange the test specimen by filling the concrete into the mold in *3 layers* maintaining similar thickness roughly. Apply *tamping bar to tamp each layer 25 times*. Tamping should be divided consistently over the whole cross section of the beam mold and all through the depth of each layer.

✓ Cleanse the bearing surfaces of the supporting and loading rollers , and eliminate any loose sand or other material from the surfaces of the specimen where they are in touch with the rollers.

✓ Circular rollers formed with steel contain cross section with diameter 38 mm. It should be applied for giving support and loading points to the specimens. The length of the rollers should be minimum 10 mm surpassing the width of the test specimen.



Flexure Test (f_{cr})

- ✓ The specimen preserved in water should be examined instantly while removing from water; when they are still wet. The test specimen should be arranged in the machine properly centered with the longitudinal axis of the specimen at correct angles to the rollers. In case of molded specimens, the mold filling direction should be normal to the direction of loading.
- ✓ The load should be employed *at a rate of loading of 400 kg/min for the 15.0 cm* specimens and at a rate of *180 kg/min for the 10.0 cm* specimens.
- ✓ **CALCULATION:**
  The Flexural Strength or modulus of rupture is provided as

$$\text{Modulus of rupture} = \frac{pl}{bd^2}$$

- ➢ (when $a > 20.0\ cm\ for\ 15.0\ cm\ specimen\ or > 13.0\ cm\ for\ 10\ cm$ specimen)

or

$$\text{Modulus of rupture} = \frac{3pa}{bd^2}$$

- ➢ (when $\mathrm{a} < 20.0\ \mathrm{cm\ but} > 17.0\ \mathrm{for}\ 15.0\ \mathrm{cm\ specimen\ or} < 13.3\ \mathrm{cm\ but} > 11.0\ \mathrm{cm\ for}\ 10.0\ \mathrm{cm}$ specimen.)

  Where.
  $a =$ the span among the line of fracture and the nearer support, calculated on the center line of the tensile side of the specimen
  $b =$ width of specimen (cm)
  $d =$ failure point depth (cm)
  l = supported length (cm)
  $\mathrm{p} = \mathrm{max.}$ Load (kg)

Split tensile strength test (IS:5816)

Specimen

- ✓ Cylinder
- ➢ The cylindrical specimen shall have *diameter not less than four times the maximum size of the coarse aggregate and not less than 150 mm*. The *length of the specimens shall not be less than the diameter and not more than twice the diameter.* For routine testing and comparison of results, unless otherwise specified the specimens shall be *cylinder 150 mm in diameter and 300 mm long.*
- ✓ Compacting : - The specimens will be made as soon as practicable after mixing.

i. The mold will be wiped clean and applied oil here.

ii. The obtained concrete will be filled in the molds in layer approx*. 5 cm thick*.

iii. Each layer will be compared will less not than *35 times, using tamping rod (16 mm diameter and 60cm long).*

iv. The top surface will be leveled and smoothed with a trowel.

Split tensile strength test (f_{ct})

Rate of Loading : -

- ✓ The load shall be applied without shock and increased continuously at a nominal rate within the range *1.2 N/ (mm2/min) to 2.4 N/ (mm2/min)*.
- ✓ The measured splitting tensile strength (fc), of the specimen shall be calculated to the nearest 0.05 N/mm2 using the following formula :

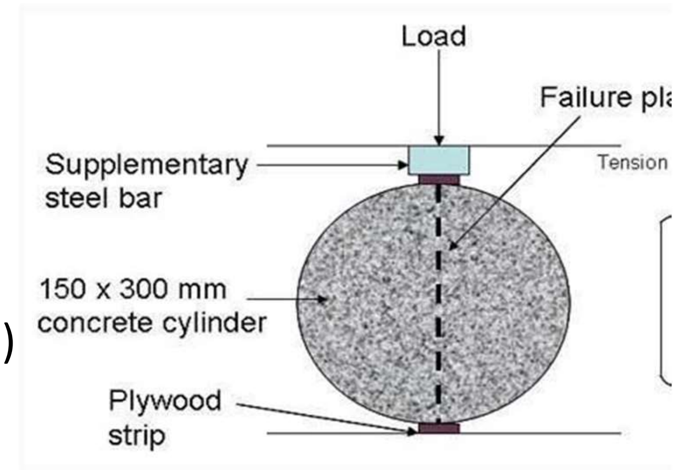
$$fc = \frac{2p}{\pi l d}$$

Where,

P = maximum load in Newton's applied to the specimen.

I = length of the specimen (in mm),

and d = cross sectional dimension of the specimen (in mm)



Maturity

- ✓ Strength of concrete depends upon both *time and temperature* during the early stage of gain in strength.
- ✓ Maturity = ∑ (time * temperature).
- ✓ Its unit are ˚C hour or ˚C days.
- ✓ A sample of concrete is cured at 18˚C for 25 days is taken to be fully matured which is equal to

$$M_{28\ days} = 28*24*(18-(-11)) = 19488˚\text{C hour.}$$

- ✓ The temperature -11˚C is considered as origin in computation of maturity.

Percentage of maturity at maturity of 19800˚C hour = $A+B\,log_{10}\frac{maturity}{10^3}$

- ✓ Plowman has given the following values of constant A and B is.

28 days strength at 18˚C	A	B
<175	10	68
175-350	21	61
350-525	32	54
525-700	42	46.5

Maturity Numerical

Example 10.3 The strength of a fully matured concrete sample is found to be 500 kg/cm^2. Find the strength of identical concrete at age of 7 days when cured at an average temperature of 20°C in day and 10°C in night.

Maturity of concrete at the age of 7 days = Σ (time × temperature)

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

$$= 4368°\text{C hr}$$

Now A = 32 B= 54, thereby

percentage of strength of concrete at maturity of 4368°Chr

$$= A + B \log_{10} \frac{4368}{1000} = 66.5\%$$

$$\therefore \text{Strength at 7 days} = 500 \times \frac{66.5}{100} = 332.5 \text{ kg/cm}^2$$

MCQ:-

The datum temperature for maturity by plowman is

a. 23˚C

b. 0 ˚C

c. -5.6 ˚C

d. -11.7 ˚C

Hot Water Concreting- (IS 7861 (Part 1).

- ✓ Any operation of concreting done at atmospheric temperatures above *40°C*.

Effect of hot weather in concrete

- ✓ Accelerating setting - *High temperature increases the rate or setting* of the concrete. The duration of time during which the concrete can be handled is reduced. It may also result in cold joints.
- ✓ Reduction in strength - *High temperature results* in the increase in the quantity of *mixing water to maintain the workability* with consequent *reduction in strength.*
- ✓ Increase tendency to crack- Either before or after hardening *plastic shrinkage cracks* may form in the partially hardened concrete *due to rapid evaporation of water.*
- ✓ Rapid Evaporation of water during curing- It is difficult to retain moisture for hydration and maintain reasonably uniform temperature conditions during the curing period.
- ✓ Difficulty in Control of air in Air-Entrained concrete : -It is more difficult to control air content in air-entrained concrete. This adds to the difficulty of controlling workability. F*or a given amount of air-entraining agent, hot concrete will entrain less air than concrete* at normal temperatures.

EFFECTS OF HOT WEATHER ON CONCRETE PROPERTIES

EFFECTS ON COMPRESSIVE STRENGTH

- ✓ Concretes mixed, placed and *cured at elevated temperatures* normally develop *higher early strength* than concretes produced and *cured at normal temperatures*; but at *28 days or later the strengths are lower*.

EFFECT ON WORKABILITY AND WATER DEMAND

- ✓ For maintaining the *same workability*, the quantity of water in the concrete mix has to be increased as the *concrete temperature increases*.

EFFECTS ON SHRINKAGE

- ✓ *In the hot weather*, whenever the rate of evaporation of water from the concrete mix is greater than the rate at which water rises to the surface of freshly placed concrete (bleeding), *plastic shrinkage cracking will occur*.

MCQ

High increase in temperature

a. Increase in strength of concrete.

b. Decrease in strength of concrete. (*Answer)*

c. Has no effect on the strength of concrete.

d. All of the above.

EFFECTS OF HOT WEATHER ON CONCRETE PROPERTIES

- At higher temperature a fresh *concrete results in accelerated setting time* and *may reduce long term strength*.
- The *rapid hardening of concrete* before compaction accelerated chemical activity result in *rapid setting and rapid evaporation of mixing water*.
- Due to rapid evaporation, *plastic shrinkage in concrete occurs* and would cause cracking.
- Increases in tendency to cracking. The precautionary measures to take for concreting in hot weather are:
  - The temperature of concrete may be kept as low as possible *by shading aggregate and mixture.*
  - The temperature of aggregate may be *lowered by sprinkling water over them.*
  - *Rapid hardening is also reduced by working at night*.
  - For *curing moisture retaining materials are used.*

Cold water concrete (IS 7861 (Part 2).

- ✓ Cold Weather Concrete- Any operation of concreting done at *about 5°C.* atmospheric temperature or below.

EFFECTS OF COLD WEATHER ON CONCRETE

- ✓ Delayed setting- When the temperature is *falling to about 5°C or below*, the *development of concrete strength is retarded* as compared with the strength development at normal temperature.
- ✓ Freezing of concrete at early stage- When concrete is *exposed to freezing temperature*, there is the *risk of concrete suffering irreparable loss of strength*.
- ✓ Repeated freezing and thawing of concrete- If concrete is exposed to repeated freezing and thawing after final set and during the hardening period, *the final qualities of the concrete may also be impaired.*
- ✓ Stresses due to temperature differential- It is a general experience that large temperature differentials within the concrete member may promote cracking and have a harmful effect on the durability. Such differentials are likely to occur in cold weather at the time of removal or form insulations.

Cold water concrete

TABLE 1 PRECAUTIONARY MEASURES

(*Clause* 3.3)

Conditions	Precautions to be Taken
a) At low temperature	1) Keep formwork in position longer, or use rapid hardening cement; 2) Cover the top of the concrete with insulating material; 3) Insulate steel formwork; and 4) Make sure that concrete is delivered to the point of placing at not less than 5°C.
b) When there is frost at night	Take all the precautions given at (a) and the following: 1) Insulate all formwork, 2) Make sure that concrete is not placed against a frozen sub-grade or against reinforcement or forms covered with snow or ice, and 3) Place concrete quickly and insulate.
c) When there is severe frost day and night	Take all the precautions given at (a) and (b) and the following: 1) Heat the water and, if necessary, the aggregate; and 2) Make sure that concrete is delivered to the point of placing at not less than 10°C, place quickly and insulate; or make sure concrete is delivered to the point of placing at not less than 5°C, place quickly and provide continuous heating to the concrete.

Cold water concrete

- ✓ Aggregate - Heating of aggregate shall be such that frozen lump., ice and snow are eliminated and at the same time over-heating is avoided. At no point shall *the aggregate temperature exceed 100°C*, the average temperature of aggregate for an individual batch shall not exceed 60˚C. The heating of aggregates to temperatures higher than *15˚C is rarely necessary with mixing water at 60°C.*
- ✓ If the coarse aggregate *is dry and free of frost and ice lump*, adequate temperatures of fresh concrete can be obtained *by increasing the temperature of only the sand,* which will seldom have to be higher than about 40°C, if mixing water is at 60°C.
- ✓ Water having temperature up to the boiling point may be used provided the aggregate is cold enough to *reduce the temperature of the mixing water and aggregate to appreciably below 40°C*. In fact this temperature shall not normally exceed 25°C.
- ✓ During winter concreting, it is preferable to use *Rapid Hardening Portland cement.*

Cold water concrete

TABLE 5 RECOMMENDED MINIMUM TIME LIMITS FOR STRIPPING FORMWORK TO NORMAL STRUCTURAL CONCRETE, WHEN THE MEMBER IS CARRYING ONLY ITS OWN WEIGHT

		Beam Sides, Walls and Columns	Slabs (Props Left Under)	Beam Soffits (Props Left Under)	Removal of Props to Slabs	Removal of Props to Beams
		Days	Days	Days	Days	Days
Ordinary Portland cement concrete	Cold weather air temperature about 3°C	5	7	14	14	28
	Normal weather air temperature about 16°C	1	3½	7	7	14
Rapid hardening Portland cement concrete	Cold weather air temperature about 3°C	3	4	8	8	16
	Normal weather air temperature about 16°C	1	2	4	4	8

Cold water concrete

- ✓ Under-water concrete : - The water-cement ratio *shall not exceed 0.6* and may need to be smaller, depending on the grade of concrete or the type of chemical attack. For aggregates of *40 mm maximum particle size*, the cement content shall be at least *350 kg/m3* of concrete.
- ✓ De-watering by pumping shall not be done while concrete is being placed or until *24 h* thereafter.
- ✓ The tremie pipe shall be not less *than 200 mm* in diameter.

Cold weather concreting

The effects of cold weather concreting are:

- Hydration will be hampered
- Setting time will be prolonged
- Low workability.
- Disruption in strength gaining of freshly placed concrete because of freezing
- Freezing and thawing effect.
- Improper curing.
- Workmanship is affected.

The precautionary measures to take for concreting in cold weather are:

- Using hot water
- Providing enclosure i.e. covered area.
- Using air entraining agents.
- Using admixtures accelerators such as calcium chloride.
- Use of type III or high early strength cement i.e. cements containing more C_3S and C_3A.
- Using sufficient amount of cement.
- Concreting shouldn't be done in frozen surfaces.

Cold weather concreting

1. Concreting shall be stopped when the temperature falls below
a. 4.5® C
b. 15® C
c. 20® C
d. 25® C
2. At freezing point of water concrete
a. Sets slowly
b. Sets freely
c. Sets rapidly
d. Does not set
3. The datum temperature by plowman is
a. 23® C
b. 0® C
c. -5.6® C
d. -11.7® C
4. Concrete is not recommended to be placed at a temperature below __________ ^{o}C.
a. 2
b. 3
c. 4
d. 5

Answer
1. a 2. d 3. d 4. d

Shrinkage , Creep, Relaxation and proportioning

Shrinkage :

- Contraction of concrete in the absence of load.

i. Plastic shrinkage: - due to *absorption of water by aggregate, evaporation of water and bleeding.*

ii. Dry shrinkage: - shrinkage taking place *after the concrete has set or hardened*.

- Shrinkage of concrete increases with high W/C ratio and high cement content.

It is estimated using Schorer's formula : - $\mathcal{E}_s$ = 0.00125(0.90-h), where h= humidity

Factors affecting shrinkage

- ✓ Water cement ratio (Directly): More water cement ratio means more amount of water will be dried from the concrete and thus shrinkage is more for higher water cement ratio.
- ✓ Richness (Directly): Richness is the amount of cement per m^3 of concrete. With increase in richness i.e. the amount of cement shrinkage increases
- ✓ Age (Directly): Shrinkage increases non-linearly with age

- 2 weeks = 75% of total
- 3 months = 80% of total
- 1 Year = 85% of total

Creep

- Continuous deformation with time under gradual applied load

Factors affecting creep

- ✓ Concrete mix proportion: Creep is *inversely* proportional to the richness of the mix i.e*. richer the mix lesser will the be creep*.
- ✓ Properties of aggregate: Aggregate with *higher modulus of elasticity show less creep*. Also light weight aggregate show higher creep.
- ✓ Age of loading: Quality of gel improves with loading therefore the amount of *creep decreases with delay in loading*
- ✓ Curing of concrete: Curing prevents rapid evaporation and therefore improves the strength *which reduces creep in concrete*
- ✓ Cement quality*: Finer cement will cause higher creep*.
- ✓ Stress: Higher load induces more amount of creep.

Age at Loading	*Creep Coefficient*
7 days	2.2
28 days	1.6
1 year	1.1

Relaxation

- The reduction in stress at constant strain is called relaxation

MCQ

1. Shrinkage in concrete
a. Is proportional to water cement ration
b. Is proportional to cement content
c. Increases with age
d. All

2. Shrinkage in concrete is directly proportional to
a. Water content.
b. Sand content
c. Aggregate content
d. Aggregate cement ratio

3. The rate of creep rapidly ________ with time.
a. Increase
b. Decrease
c. Doesn’t affect
d. Depends on the temperature

MCQ

4. Shrinkage is proportional to
a. Cement content
b. Sand content
c. Aggregate content
d. Temperature of water

5. ____ exhibits creep upon application of load on a concrete specimen.
a. Aggregates
b. Water
c. Cement paste
d. Admixtures

Answers

1.D 2.D 3.A 4.B 5.A 6.C

Proportioning

- ✓ Object of proportioning is to *achieve concrete of requisite strength with desired workability* for which the attention should be given for the *selection of cement and aggregate accordance with specification.*
- ✓ Some of the consideration taken are

i. The *mix must be workable* so that it can be placed and finished without extra effort.

ii. *High cement content improves strength*, impermeability, density and workability.

iii. *With cement content, ingredients and workability remaining constant*, *the strength and impermeability of concrete increase with the density of mix*.

PRE-STRESSED CONCRETE

- ✓ Pre-stressing is a method in which *compression force* is applied to the reinforced concrete section.
- ✓ The effect of pre stressing is to *reduce the tensile stress* in the section to the point till the tensile stress is below the cracking stress. Thus the *concrete does not crack.*

MCQ

1. A pre-stressed concrete member is

a. Made of concrete.

b. Made of reinforced concrete

c. Is stressed after casting

d. Possesses internal stress

2. In pre-stressed concrete the steel is under

a. Compression

b. Tension

c. Shear

d. Torsion

1	D
2	B
3	B

3. In Pre-stressed concrete structure, the pre-stressing of concrete is done to compensate the stress caused by

a. Dead Load

b. Working Load

c. Live Load

d. Dynamic Load

MCQ

1. The net effect due to pre-stress in pre-stressed concrete beam is usually

a. Tension

b. Compression

c. Bending and Tension

d. Bending and Compression

2. If the maximum dip of a parabolic tendon carrying tension ‘p’ is ‘h’ and the effective length of the pre-stressed beam is ‘L’ the pressure ‘w’ shall be

a. 8ph/L

b. 8ph/L^2

c. 8Lh/p

d. 8hL/P^2

Answers

1.D 2.B

Pre-stressed Concrete: Methods

- ✓ There are two basic methods of applying pre-stress to a concrete member

1. **Pre-tensioning:** In Pre-tension, *the tendons are tensioned against some abutments before the concrete is place*.

- ✓ After the concrete hardened, the tension force is released. The tendon tries to shrink back to the initial length but the concrete resists it through the bond between them, thus, compression force is induced in concrete.
- ✓ Pretension is usually done with *precast beam, post and simply supported slabs*

2. **Post tensioning**: In post tension, *the tendons are tensioned after the concrete has hardened.*

- ✓ Commonly, metal or plastic ducts are placed inside the concrete before casting. After the concrete hardened and had enough strength, the tendon was placed inside the duct, stressed, and anchored against concrete.
- ✓ Grout may be *injected into the duct later* . It will save the *steel from corrosion, reduction in deflections and reduction in crack width.*
- ✓ This can be done either as *precast construction or cast-in-situ.*

Pre-stressed Concrete: Methods

Advantages:	Disadvantages
Take full advantages of high strength concrete and high strength steel	Need higher quality materials
Need less materials	More complex technically
Smaller and lighter structure	More expensive
No cracks	Harder to re-cycle
Use the entire section to resist the load	
Very effective for deflection control	
Better shear resistance	

Requirements of Pre-Stressed Concrete

1. High Grade of concrete: Higher grade concrete allows for smaller section thus smaller shrinkages and is preferred

- Pre Tensioned > M40
- Post Tensioned > M35

2. Pre Stressing Tendon = 1200 – 2700 MPa

Pre-stressed Concrete: Methods

Post Tensioned Concrete

a. Freyssinet system

- High strength steel wires are grouped into a tendon (usually 8 , 12 , 16 , 24) all tendon are stretched at one

b. Mangel Blaton System:

- High strength steel wires are grouped into a tendon (usually 8 , 12 , 16 , 24) two tendon are stretched at once

c. Gifford Udal System:

- High strength steel wires are grouped into a tendon (Any number of wires can be grouped to form a cable). Each wire is stretched independently using a double acting jack,

d. Lee Mc. Call system:

- In this system pre-stress is given by means of steel bars of diameter 12 to 28mm. After stretching the bars with threads are jointed to plates by means of nuts thus pre-stressing is possible

Pre-stressed Concrete: Methods

1. The minimum clear horizontal spacing between the groups of cables or ducts in grouped cables shall be greater of
a. 30mm or 5mm more than the maximum size of aggregate
b. 40mm or 5mm more than the maximum size of aggregate
c. 30mm or maximum size of aggregate
d. 40mm or maximum size of aggregate

2. The minimum clear vertical spacing between the groups of cables or ducts in grouped cables shall be greater of
a. 30mm
b. 40mm
c. 50mm
d. None of above

3. The minimum clear spacing of non grouped cables or large bars should be
a. 40mm
b. Maximum size of cable or bar
c. 5mm plus maximum size of aggregate
d. All of above

Answer

1.B 2.C 3.D

Pre-stressed Concrete: Methods

The diameter of high tensile steel tendons used is

a. 3 to 5 mm.

b. 5 mm to 8 mm.

c. 6mm to 9mm.

d. 8 mm to 12 mm.

In the case of pre-stressed concrete

a. Load carrying capacity of member increases.

b. Quantity of concrete is saved for same grade.(50% save)

c. Quantity of steel is saved for same grade.(wt. of steel by 50-75)%.

d. all of the above.

Pre-stressed Concrete: Methods

Central dip: -

h= $\frac{WL}{4P}$ Where, L is span: W= Point load at center

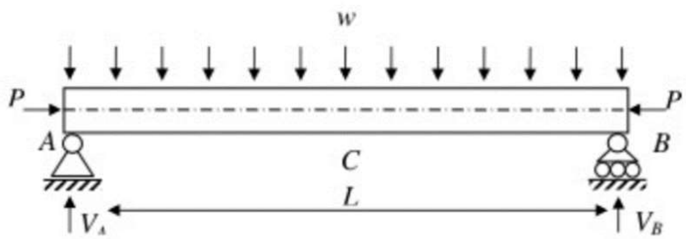
Losses of Pre-Stress

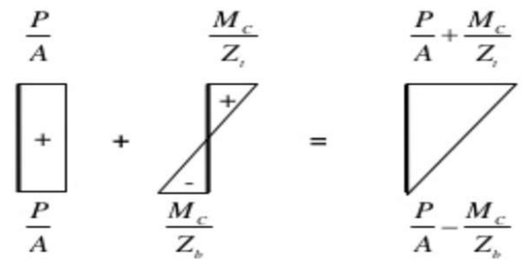
Pre Tensioning System **Total loss = 20%-25%**	**Post Tensioning System** **Total loss = 15%-20%**
1. Elastic shortening of concrete.	
2. Relaxation of steel in concrete.	1. Relaxation of steel in concrete
3. Shrinkage of concrete. (3%)	2. Shrinkage of concrete. (3%)
4. Creep of concrete. (6%)	3. Creep of concrete. (6%)
	4. Friction loss. (5-8)% 5. Anchorage slip.(5-8)%

PRE-STRESSED CONCRETE

There are basically two principles of pre-stressing of concrete

1. Pre-stressing is applied at the center of gravity of the section

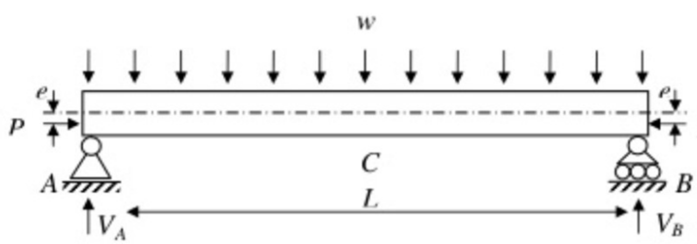


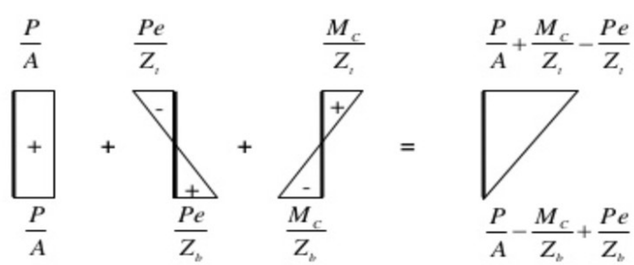


$$\frac{M_c}{Z_b}=\frac{P}{A}=\frac{wL^2}{8Z_b}$$

$$w_{II}=\frac{8Z_b}{L^2}\frac{P}{A}$$

2. Pre-stressing is applied eccentrically with respect to the c.g of the section.





$$\frac{M_c}{Z_b}=\frac{P}{A}+\frac{Pe}{Z_b}$$

$$w_{III}=\frac{8Z_b}{L^2}\left(\frac{P}{A}+\frac{Pe}{Z_b}\right)$$