



CIVIL LATEST MADEEASY HAND NOTES

8.RCC & PSC NOTES-2020

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CHAPTER 1

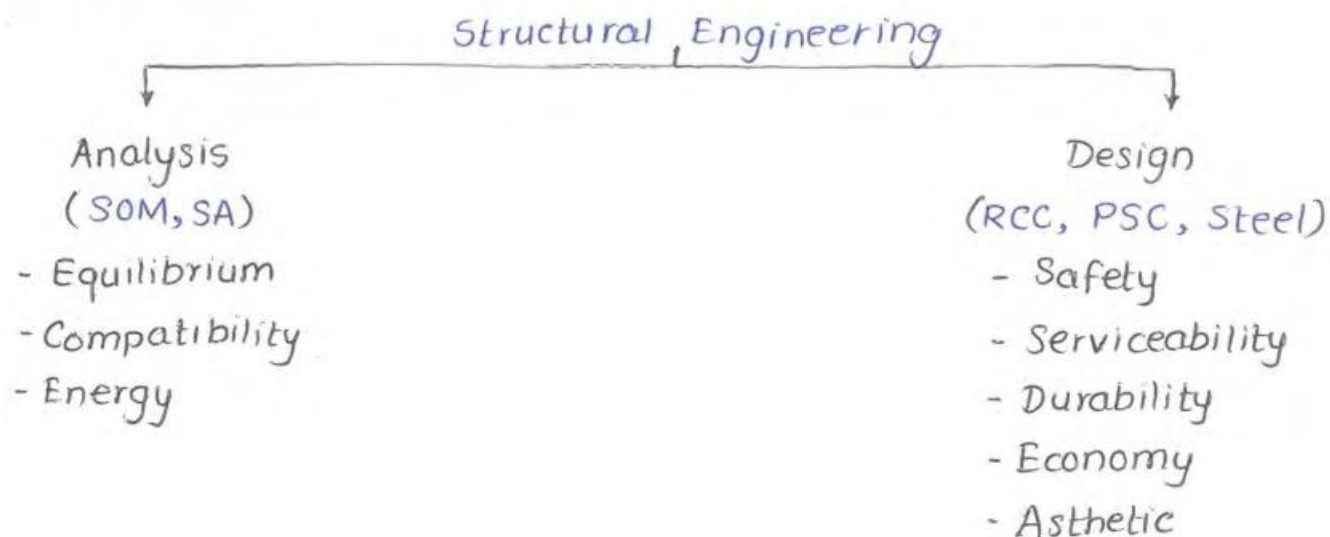
Basic Concepts

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1. Basic Concepts

1.1 Introduction:



i> Safety:

A structure must be safe with appropriate factor of safety [FOS] for loading that may come on it during its intended life.

ii> Serviceability:

A structure should provide the service for which it is constructed.

iii> Durability:

A structure should sustain loading for which it was designed and should perform well with safety and serviceability upto its whole life

Durability without serviceability or less margin of safety [FOS]

iv> has no meaning

iv> Economy:

Design and construction of any structure should be economical without affecting safety, serviceability and durability.

v> Asthetic:

IF huge investment is involved in design and construction

of a structure then aesthetic also plays an important role.

Ex. Considering a beam:

- i) Safety: Reinforcement is provided.
- ii) Serviceability: Doubly reinforced section instead of singly reinforced section to reduce depth of section.
- iii) Durability: Nominal cover, selection of material.
- iv) Economy: Monolithic casting of beam and slab designed as T-section.
- v) Aesthetic: Half round section instead of rectangular section.

1.2 Cement Concrete:

It is a mixture of binding material [cement], fine aggregate [sand], coarse aggregate, water and admixture in proper proportion to achieve concrete of desired properties at fresh state and hardened state.

1.2.1 Concrete Mix:

a) Nominal Mix:

- Based on experience.
- Mixing may be by weight or by volume. By weight is preferable.
- Quantity of water is not fixed. It is provided as per site requirement.
- Nominal mix is allowed for M5 to M20.

	C	FA	CA
M10	1	3	6
M15	1	2	4
M20	1	1.5	3

b) Design Mix:

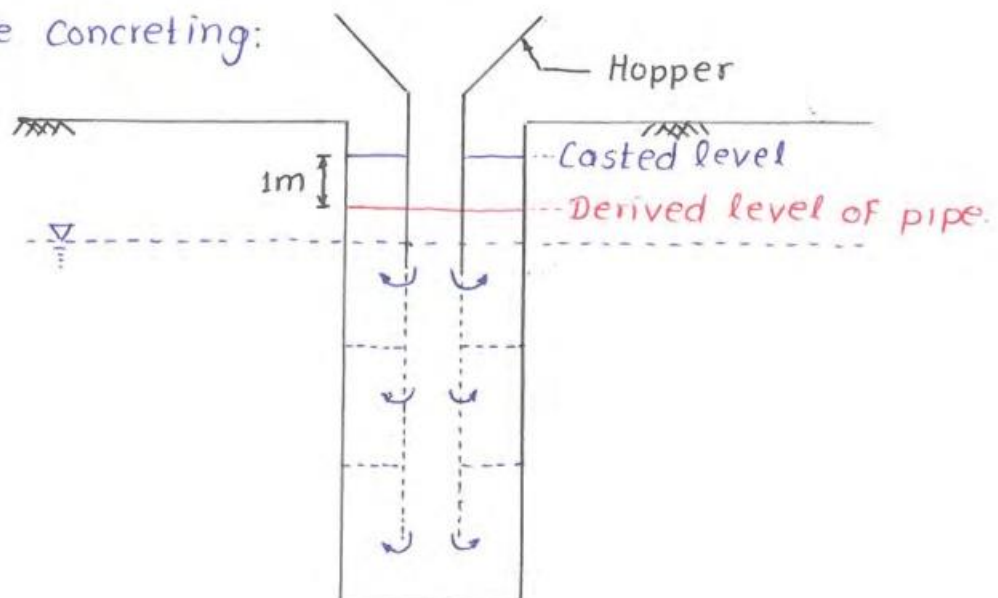
- Based on calculation as per **IS 10262 (2009)**
- Proportioning must be by weight.
- Quantity of water is also fixed.
- Design mix is allowed for M10 to M100.

1.2.2 Fresh Concrete:

Workability is the most important property of fresh concrete which is simply defined as "Ease to work with."

Sr. No.	Degree of Workability	Use	Slump	Compacting Factor	Vee-bee time (sec)
1.	Very low	- Road Construction. - Shallow Section.	-	0.75 - 0.8	10 - 20
2.	Low	- Mass concreting. - Lightly reinforced section	25 - 75	0.8 - 0.85	5 - 10
3.	Medium	- Heavily reinforced section - Concreting by concrete pump.	50 - 100	0.85 - 0.92	2 - 5
4.	High	- Piling	100 - 150	0.92 - above	-
5.	Very High	- Tremie pipe concreting.	-	0.92 - above	-

* Tremie Pipe Concreting:



* Workability of Concrete can be measured by following methods.

1. Slump test

3. Vee-bee Test

2. Compacting factor Test

4. Flow Test

1.2.3 Hardened Concrete:

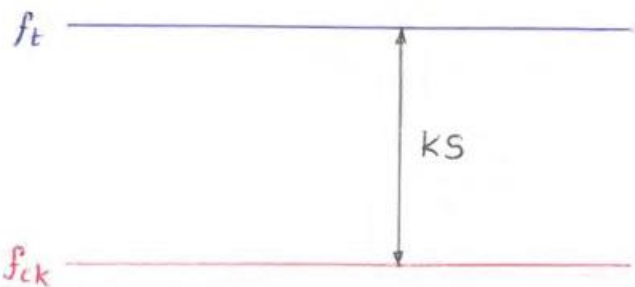
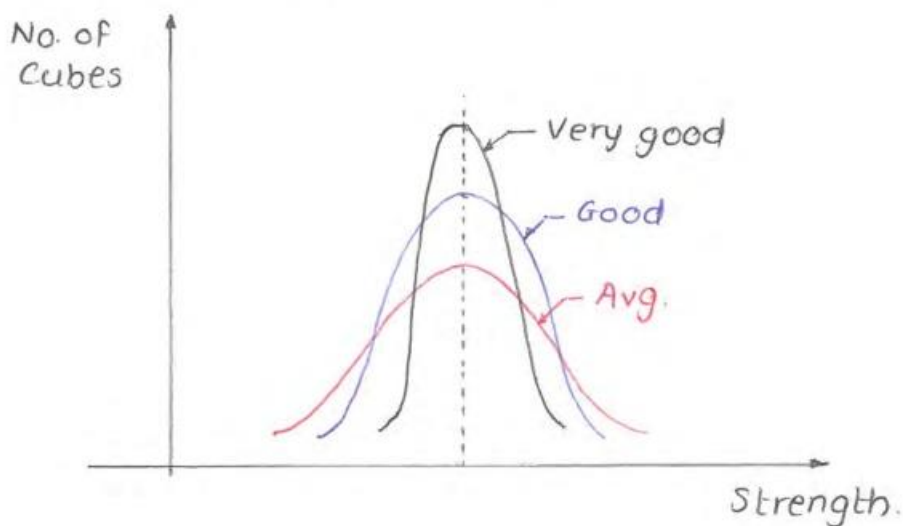
After final setting time, concrete is assumed to be hard and it keeps on gaining strength for very long time [1 to 5 years]

a) Compressive Strength of Cube:

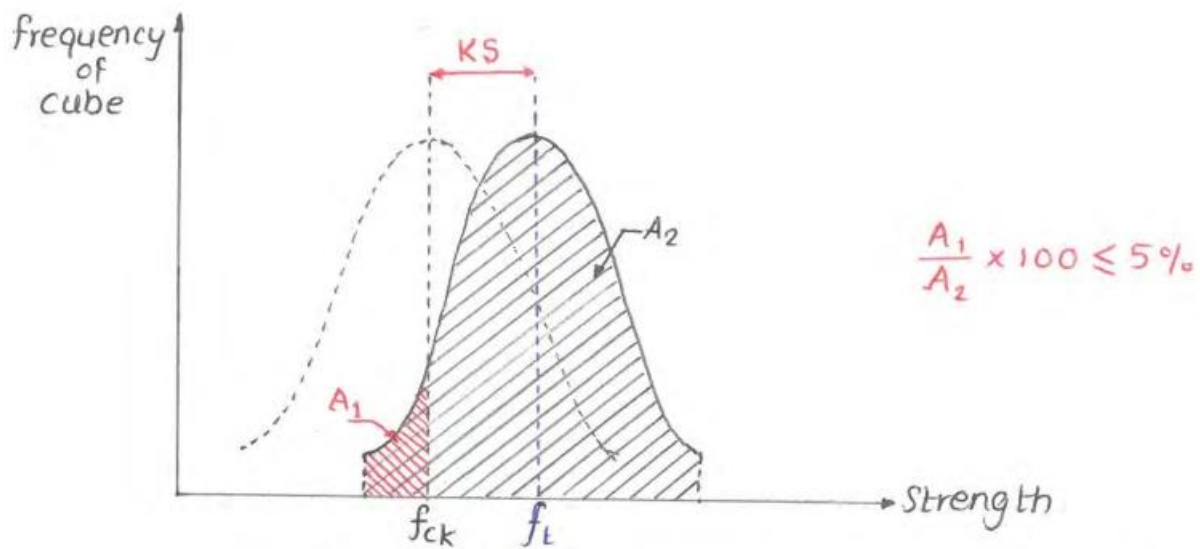
This is the compressive strength of cube size 150 mm subjected to uniaxial compression after 28 days from day of casting.

b) Characteristic Compressive Strength of Cube:

It is the strength below which not more than 5% test results are expected to fall.



$$f_t = f_{ck} + KS$$



Area under curve represents number of cubes.

$K = 1.65$ (for 5% of definition)

% of definition	K
0%	∞
5%	1.65
50%	0

S = Standard deviation that depends on quality control.

Ex. Uniaxial compression test results of 100 cubes are listed below in increasing order. Find f_{ck}

26, 26.5, 26.5, 27, 27.5,

28, 28.5, 29, 30, 30.5,

31, ...

....., 42.5 N/mm²

⇒ As per definition, f_{ck} should be 28 N/mm². Since, f_{ck} always designated in multiple of 5, so answer should be 25 N/mm² or 30 N/mm².

In this case, 8 samples (more than 5%) are below 30 N/mm², so 30 N/mm² can not be f_{ck}

Now, 25 N/mm² can be considered as f_{ck} because zero test results (less than 5%) is below 25 N/mm²

⇒ $f_{ck} = 25 \text{ N/mm}^2$

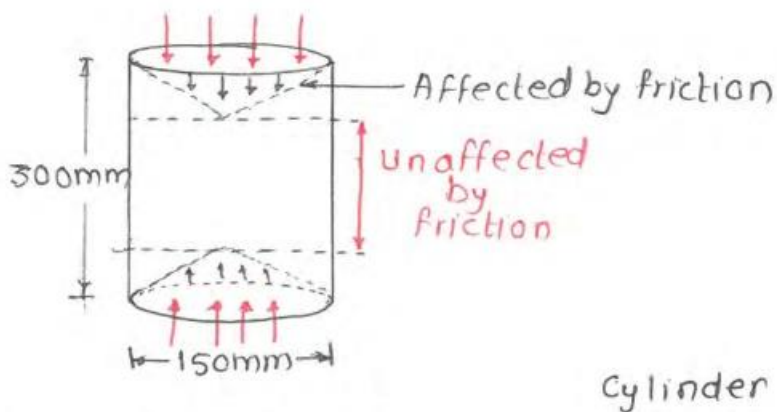
c) Characteristic Compressive Strength of Concrete:

It is obtained by dividing characteristic compressive strength of cube by a factor 1.5 to account for variation in shape of concrete [other than cube] and variation in loading condition [other than uniaxial compression].

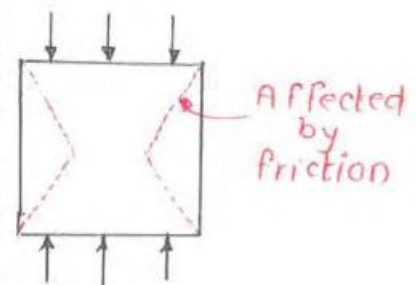
* Note:

- Factor 1.5 used here is not partial F.O.S.
- For general conversation, characteristic strength of concrete represents value obtained from characteristic strength of Cube.

1.2.4 Comparison between Cube and Cylinder:



Cylinder



Cube

What should be used

✓

✗

Actually Used.

✗

✓

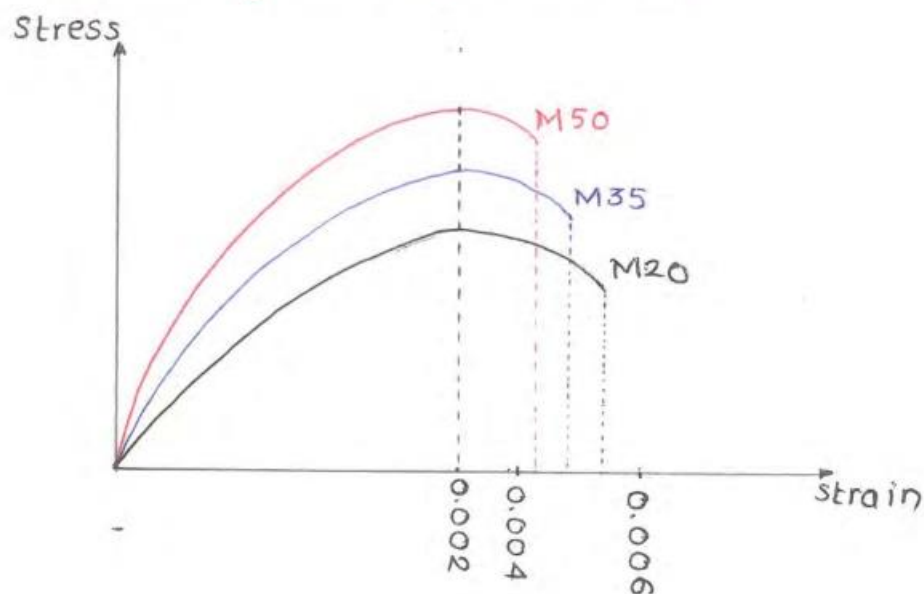
- Uniaxial compressive strength of concrete can be determined by using different shapes of specimen. (Cube, cylinder, prism, etc)

$$f_{\text{cube}} \approx 1.25 f_{\text{cylinder}}$$

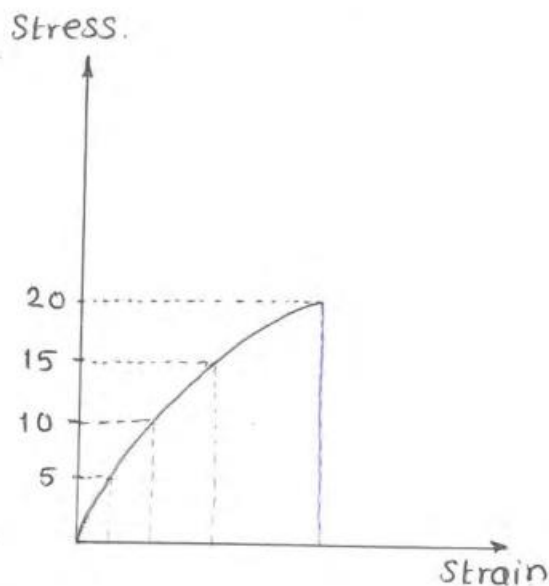
- Cylinder gives more appropriate results for uniaxial compressive strength of concrete because effect of friction between machine plates and specimen, is almost nil (zero).

*** Note:**

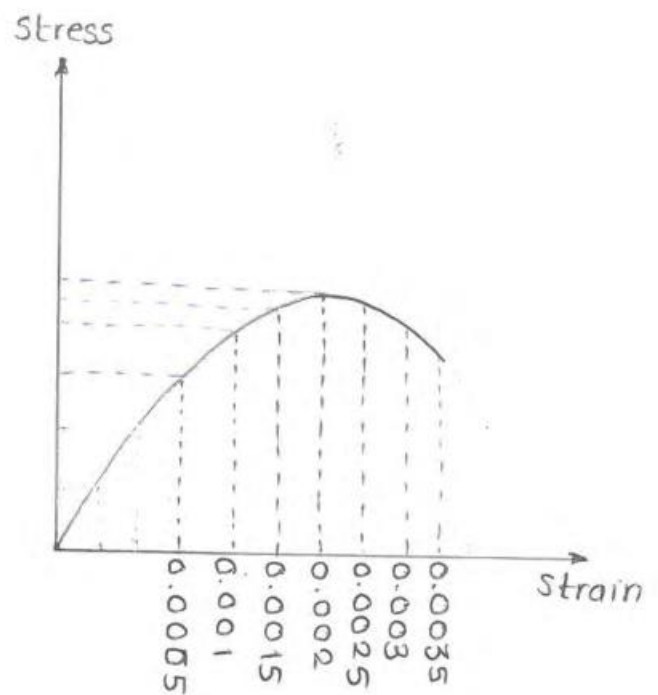
- Cube of smaller size (assuming 100mm) gives more strength than standard cube.
- A smaller cylinder also gives higher strength than standard cylinder, provided ratio of height to diameter remains constant
- These results are experimental.

1.2.5 Stress-Strain diagram of Concrete under

- Stress-strain diagram is non-linear.
- Initial portion of stress-strain diagram can be considered as linear.
- Maximum compressive stress is corresponding to approx strain 0.002
- Ultimate strain lies between 0.004 to 0.006
- Modulus of elasticity increases with increase in grade of concrete.
- Brittleness increases with increase in grade of concrete.



Controlled Stress.



Controlled Strain

1.2.6 Grade of Concrete:

Mix $\xrightarrow{M}$ $\xrightarrow{25}$ Characteristic compressive strength (N/mm^2)

M5-M20 $\rightarrow$ Nominal Mix

M10-M100 $\rightarrow$ Design Mix [as per ammendment ④]

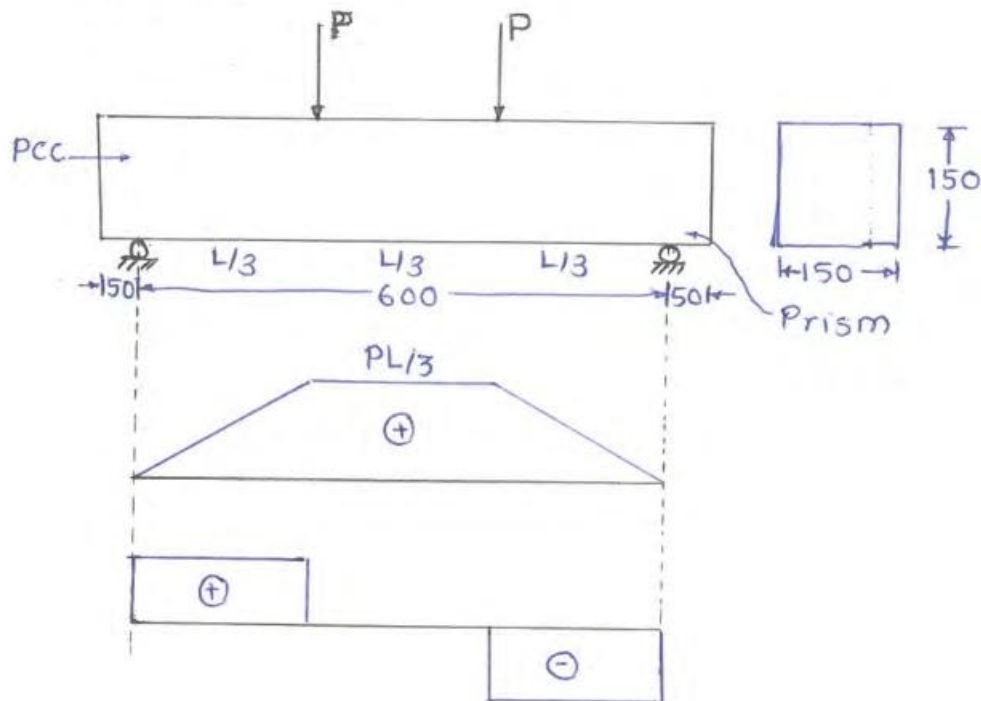
1.2.7 Tensile Strength of Concrete:

- It is approximately 10% (7% to 15%) of the compressive strength.
- Stress-strain diagram is almost linear.
- Ratio of compressive strength to tensile strength increases with increase in grade of concrete.
- Since tensile strength of concrete is ignored in RCC structure so it has very less importance. However, it is calculated to determine cracking moment.

1. Direct Tension Test;

Practically, it is very difficult to perform direct tension test because force never remains perfectly axial tension due to non-homogeneity of concrete.

2. Flexure Test



Flexure Formula:

$$\frac{M}{I} = \frac{f}{y} = \frac{E}{R}$$

$$\frac{P_{cr} \cdot L/3}{bD^3/12} = \frac{f_{cr}}{D/2}$$

$$f_{cr} = ??$$

- 3rd point loading is applied for pure bending condition. (flexure).
- Value of P is increased from 0 to value corresponding to which 1st crack develops in extreme tension fibre.
- Corresponding to cracking load, bending moment is calculated in central portion and tensile strength is calculated as illustrated above.

- IS 456 provides standard formula for flexure tensile Strength/Modulus of Rupture

$$f_{cr} = 0.7\sqrt{f_{ck}} \text{ N/mm}^2.$$

Ex. A PCC beam of section size $200 \times 300 \text{ mm}$ is made up of M30 concrete. Calculate cracking moment of section.

⇒

By Flexure Formula.

$$\frac{M_{cr}}{I} = \frac{f_{cr}}{y}$$

$$f_{cr} = 0.7\sqrt{f_{ck}}$$

$$f_{cr} = 0.7\sqrt{30} = 3.834 \text{ N/mm}^2$$

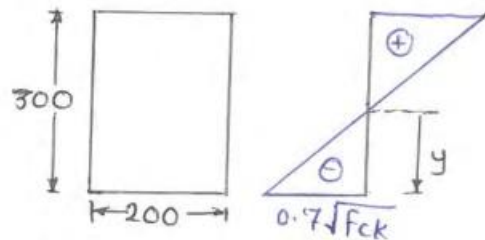
$$I = \frac{bD^3}{12} = \frac{200 \times 300^3}{12}$$

$$I = 450 \times 10^6 \text{ mm}^4$$

$$y = D/2 = 150 \text{ mm}$$

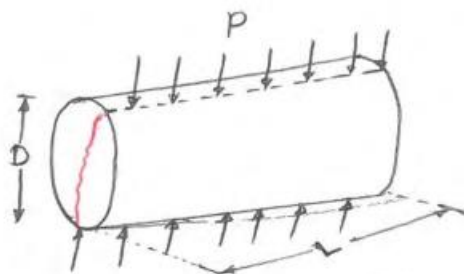
$$\frac{M_{cr}}{450 \times 10^6} = \frac{3.834}{150}$$

$$M_{cr} = 11.502 \text{ kN-m}$$



3. Cylinder Split Test:

- A line loading along length is applied at diametrically endpoints.
- Due to this loading, Cylinder splits into two parts.



$$f_{cr} = \frac{2P}{\pi DL}$$

$$f_{\text{flexure}} > f_{\text{cylinder split}} > f_{\text{direct}}$$

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1.2.8 Shrinkage of Concrete:

Concrete has shrinkage property due to presence of cement. IS 456 provides a standard value of shrinkage strain of concrete for design of RCC structure.

$$\epsilon_{st} = 0.0003$$

$$= 0.03\%$$

$$= 3 \times 10^{-4}$$

1.2.9 Durability:

Exposure Condition	Description	Minimum Grade of Concrete	Minimum Nominal Cover	Minimum Cement content	Maximum W/C ratio
Mild	- Protected from rainfall	M20	20 mm*	300 kg/m ³	0.55
Moderate	- Subjected to normal rainfall - Permanently submerged in normal water - Foundation in non aggressive soil.	M25	30 mm	300 kg/m ³	0.5
Severe	- Coastal area - Subjected to Heavy rainfall - Permanently submerged in sea water - Alternate drying and wetting in normal water - Occasional freezing.	M30	45 mm**	320 kg/m ³	0.45
Very Severe	- Subjected to sea spray (Alternate drying and wetting in sea water) - Permanent freezing.	M35	50 mm	340 kg/m ³	0.45

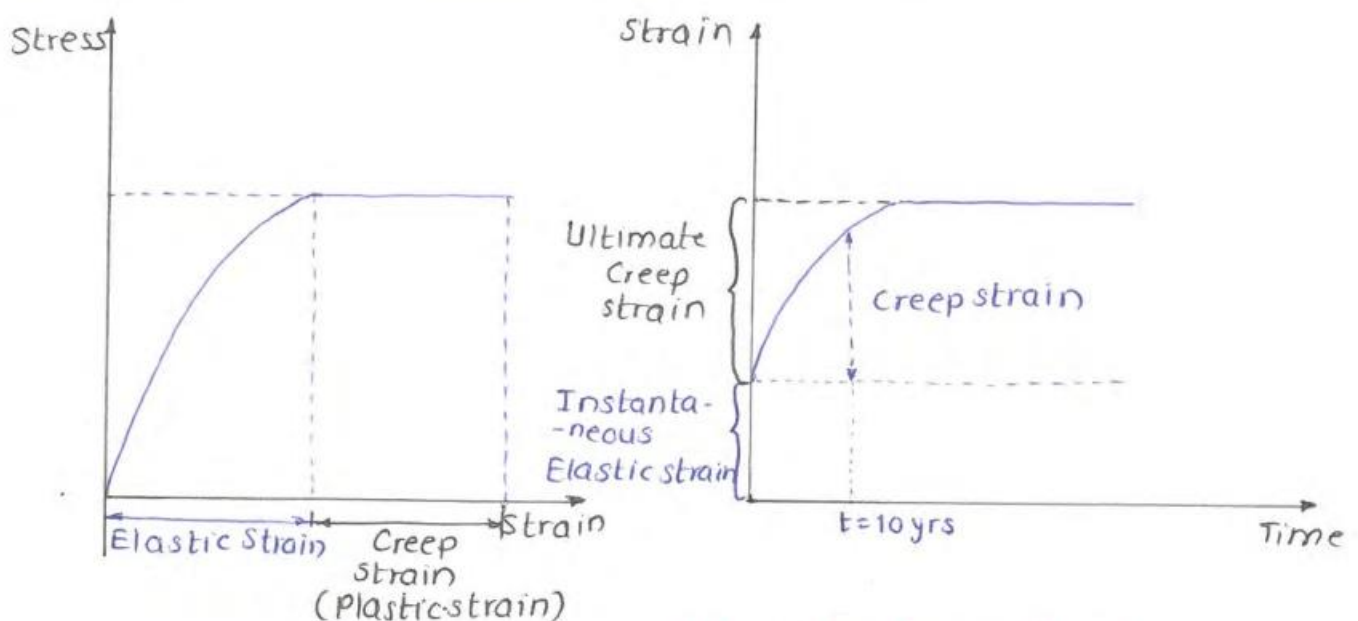
Exposure Condition	Description	Minimum Grade of Concrete	Minimum Nominal Cover	Minimum Cement Content	Maximum W/c ratio
Extreme	- Tidal zone - Subjected to aggressive chemicals	M40	75mm	360 kg/m ³	0.4

- * - This can be reduced to 15mm for reinforcing bar dia. 12mm or less.
- ** - This can be reduced to 40mm for grade of concrete M35 or higher.

1.2.10 Creep of Concrete:

It is a time dependent strain in concrete due to sustained loading (permanent loading). Dead load and prestressing force are the examples of permanent loading.

The exact mechanism of creep in concrete is still not fully understood. It is generally attributed to internal movement of absorbed water, viscous flow or sliding between the gel particles, moisture loss and the growth in micro-cracks.



$$\text{Creep coefficient } (\theta) = \frac{\text{Ultimate Creep Strain}}{\text{Instantaneous Elastic Strain}}$$

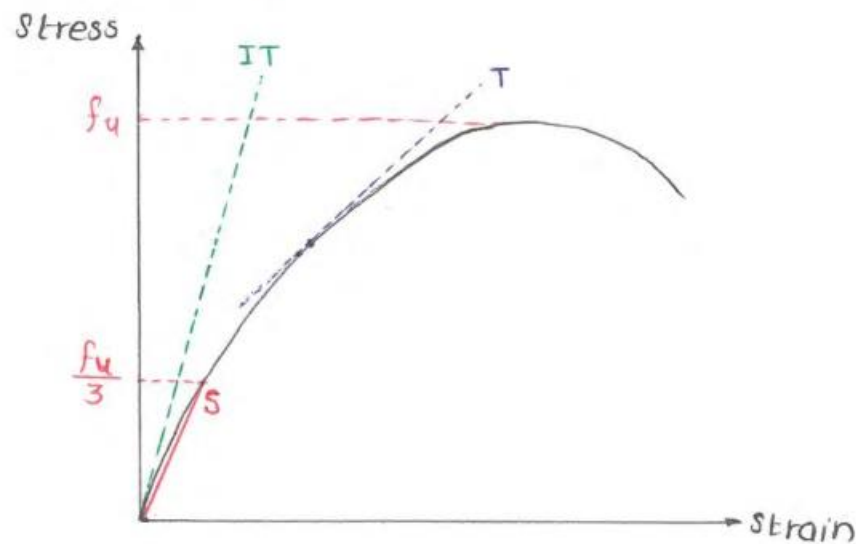
Age of concrete at the
time of loading θ

7 days	2.2
28 days	1.6
1 Year	1.1

*** Note:**

- Higher value of θ represents higher creep strain.
- Ultimate creep strain is more if load is applied at early age of concrete.

1.2.11 Modulus of Elasticity:



1. Initial Tangent Modulus (IT):

It is defined as slope of tangent drawn at a point of start of stress-strain diagram. This is also called as dynamic modulus of elasticity which is used for analysis due to dynamic loading. It is calculated using Resonance frequency test.

2. Secant Modulus (S):

It is defined as slope of line connecting point of start of stress-strain diagram to point with stress $\frac{1}{3}$ rd of

ultimate stress. It is also called as static modulus of elasticity. IS 456 provides standard formula for this modulus of elasticity.

$$E_c = 5000 \sqrt{f_{ck}} \text{ N/mm}^2$$

This is also called as short term modulus of elasticity and it is not incorporating effect of creep.

After effect of creep.

$$E_{ce} = \frac{E_c}{1+\theta} = \frac{5000 \sqrt{f_{ck}}}{1+\theta}$$

3. Tangent Modulus (T):

It is defined as slope of tangent drawn at any point of stress-strain diagram. It is used in incremental load analysis.

1.2.12 Acceptance of Concrete:

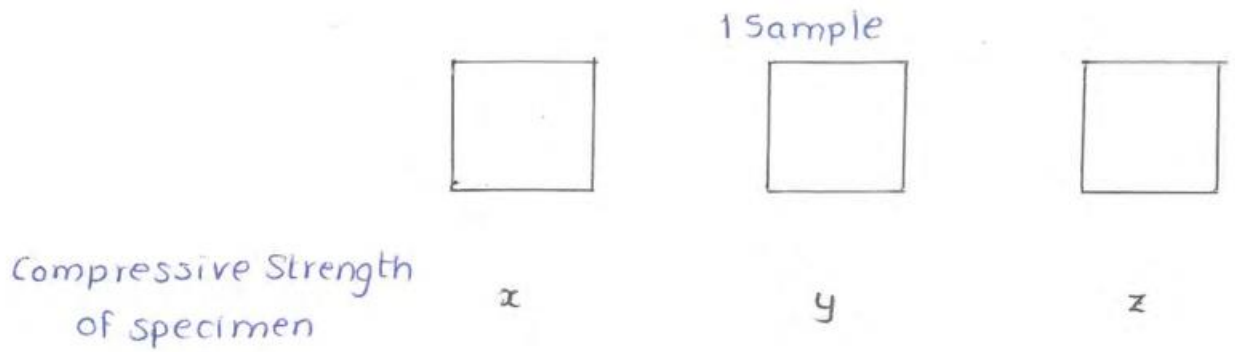
1.2.12.1 Acceptance Criteria of Sample:

- Specimen $\rightarrow$ 1 Cube
- Sample $\rightarrow$ Set of 3 cubes casted from same concrete at same time.

Quantity of Concrete

No. of Sample

1 - 5 m ³	1
6 - 15 m ³	2
16 - 30 m ³	3
31 - 50 m ³	4
51 - above	4 + 1 sample for each additional 50 m ³ .



Compressive strength of Sample = $\frac{x+y+z}{3}$

Sample is acceptable only if compressive strength of no individual specimen (x,y,z) is falling beyond $\pm 15\%$ of compressive strength of sample $\left(\frac{x+y+z}{3}\right)$

1.2.12-2 Acceptance Criteria of Concrete

Day	Day 1	Day 2	Day 3	Day 4
Quantity	20m ³	35m ³	25m ³	20m ³
No. of Sample	3	4	3	3
Sample Number.	1 [*] 2 3 4	5 [*] 6 [*] 7 [*] 8	9 10 11	12 13

V = 100m³

Avg. of 4 consecutive and non-overlapping $\geq$ Maximum $\left\{ \begin{array}{l} \bullet f_{ck} + (0.825 \times \text{Standard deviation}) \\ \bullet f_{ck} + 3 \end{array} \right.$

In addition to above criteria, compressive strength of no individual sample (1 to 13) should be less than $f_{ck} - 3$

1.2.13 Testing of Hardened Concrete:

a) Destructive Testing:

Sample used for destructive testing can not be reused for service.

1. Load Test:

Used in precast construction.

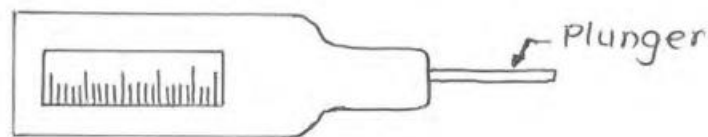
2. Core cut Test:

Used in road construction.

b) Non-destructive Testing.

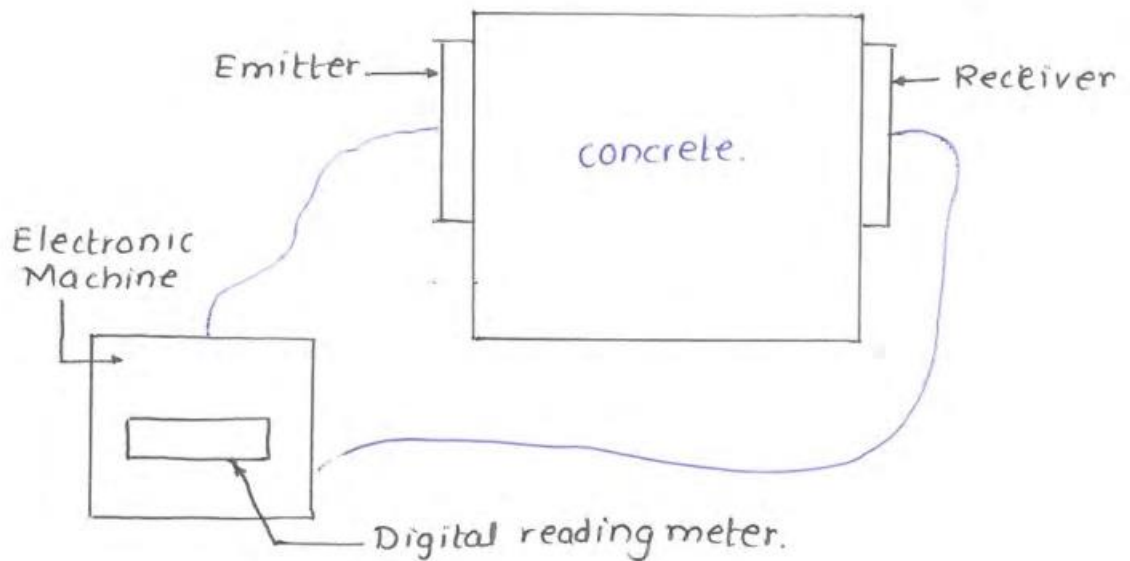
Sample used for NDT can be reused for service.

1. Rebound Hammer Test:



- Plunger of this apparatus is pressed against surface of concrete.
- Energy rebounded from concrete surface gives idea about strength of concrete.
- Reading meter installed with this apparatus gives a value which is multiplied by a factor to get a compressive strength of concrete.
- This method of testing is vague because plunger pressed against mortar and aggregate gives different values.
- This test gives idea about surface of concrete only.

2. Ultrasonic Pulse Velocity Test:



- This is an electronic method in which emitter and receiver are connected on opposite surfaces of concrete.
- Time taken by ultrasonic waves to travel through concrete is measured.
- If time is less then concrete is dense - It means quality is good.
- This method is also used to detect cracking in RCC structure and to determine dynamic modulus of elasticity.

1.2.14 Concrete Mix Design:

Step 1: Calculate target mean strength

$$f_t = f_{ck} + K \cdot S$$

Where, $K = 1.65$ (for 5% of definition)

S = Standard deviation that depends on quality control.