MADE EASY

Civil Engineering

Toppers Handwritten Notes

RCC

By-Vivek Gupta Sir

MADE EASY

India's Best Institute for IES, GATE & PSUs

RCC & PSC

Class Notes

(Last Updated On

Vivek Gupta (Ex. IES)

CONTENT

A very special thanks

to

Sagar Jagannath Mahurkar

(Pune Batch)

for

Systematic & Exquisite

Class Notes

CHAPTER 1

Basic Concepts

CONTENTS

1. Basic Concepts

1.1 Introduction:

Structural Engineering

- Analysis (SOM, SA)
  - Equilibrium
  - Compatibility
  - Energy
- Design (RCC, PSC, Steel)
  - Safety
  - Serviceability
  - Durability
  - Economy
  - Asthetic

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 asthetic 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: Monolythic casting of beam and slab designed as T-section.

v) Asthetic: 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:

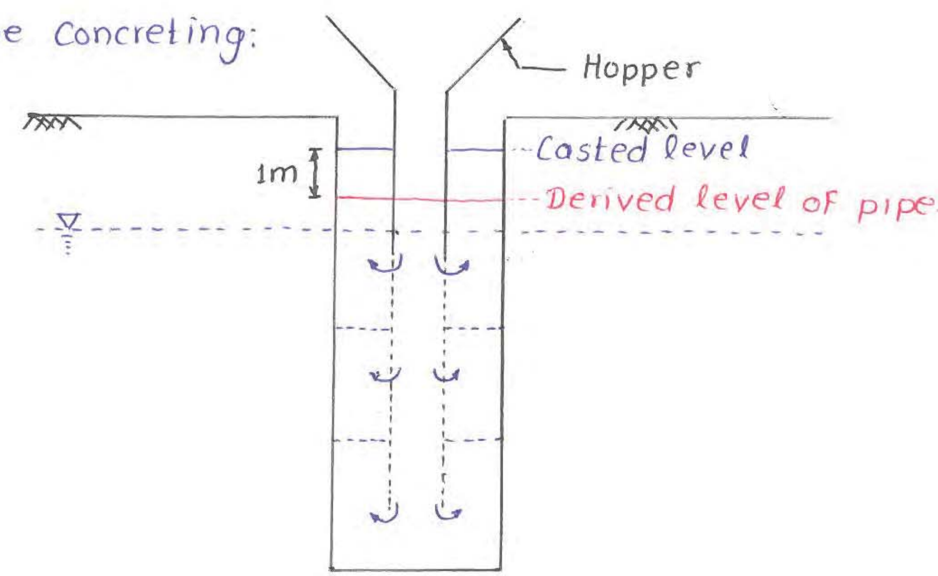
- Based on calculation as per IS10262 (2009)
- Proportioning must be by weight.
- Quantity of water is also fixed.
- Design mix is allowed for M10 to M100.

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
2. Compacting factor Test
3. Vee-bee Test
4. Flow Test

1.2.3 Hardened Concrete:

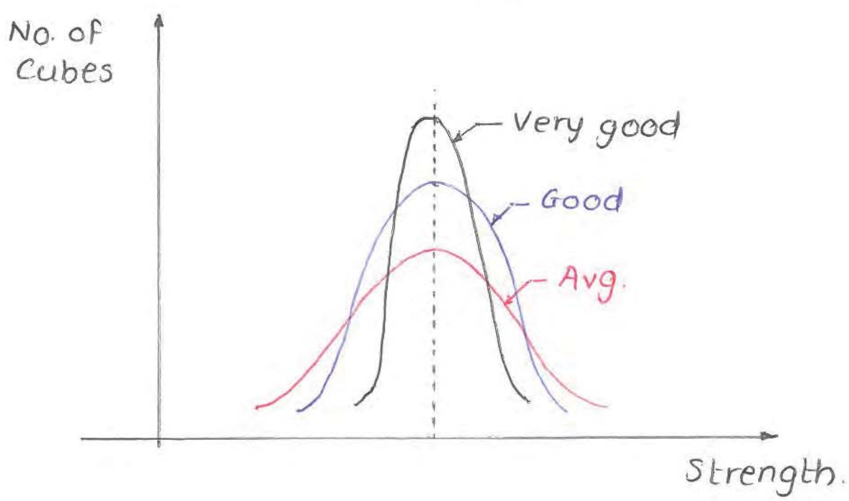
After final setting time, concrete is assumed to be hard and it keeps on gaining strength for very long time [1 to 5 years]

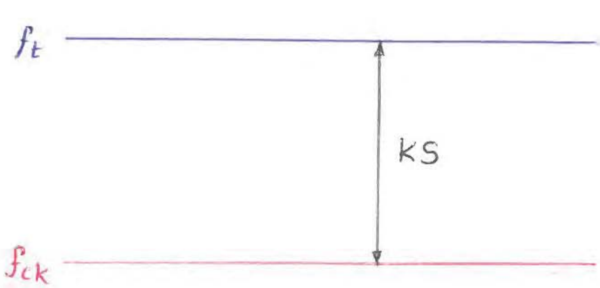
a) Compressive Strength of Cube:

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

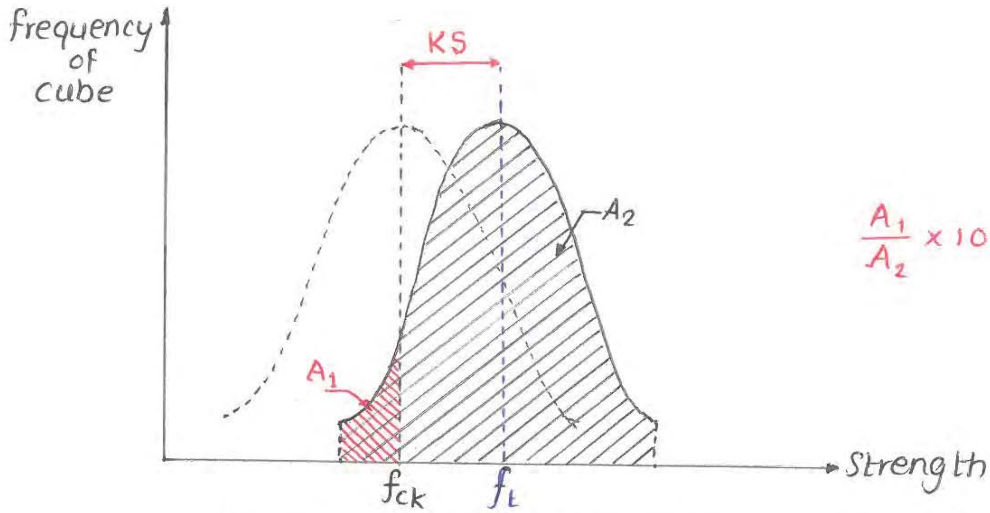
b) Characteristic Compressive Strength of Cube:

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





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



$\frac{A_1}{A_2} \times 100 \leq 5\%$

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

$$\Rightarrow f_{ck} = 25 \text{ N/mm}^2$$

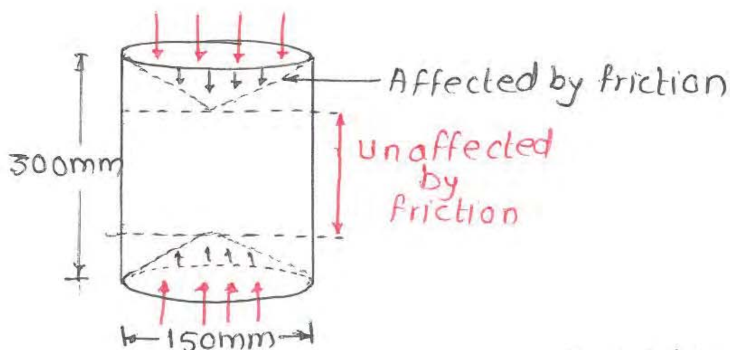
c) Characteristic Compressive Strength of Concrete:

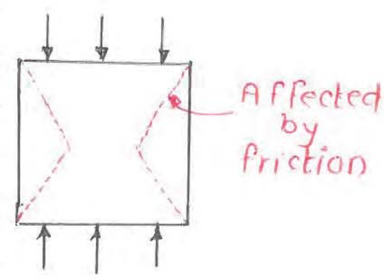
It is obtained by dividing characteristic compressive strength of cube by a factor 1.5 to account for variation in shape of concrete [other than cube] and variation in loading condition [other than uniaxial compression].

* 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 spacimen. (Cube, cylinder, prism, etc)

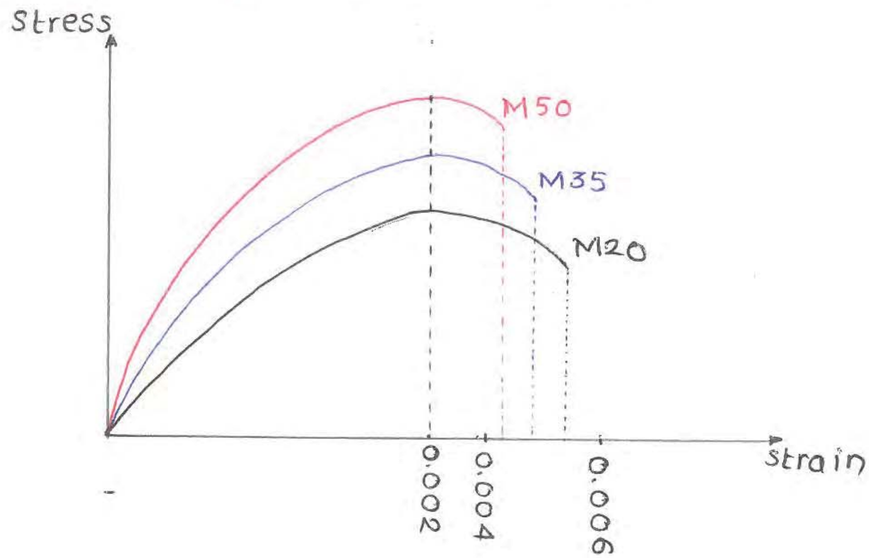
$$f_{cube} \approx 1.25\ f_{cylinder}$$

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

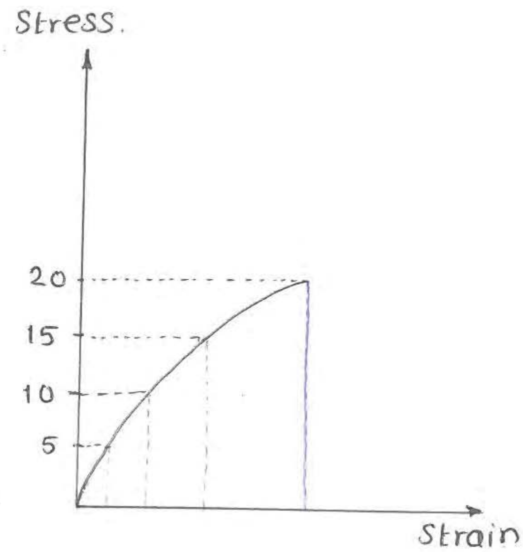
* Note:-

- 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.

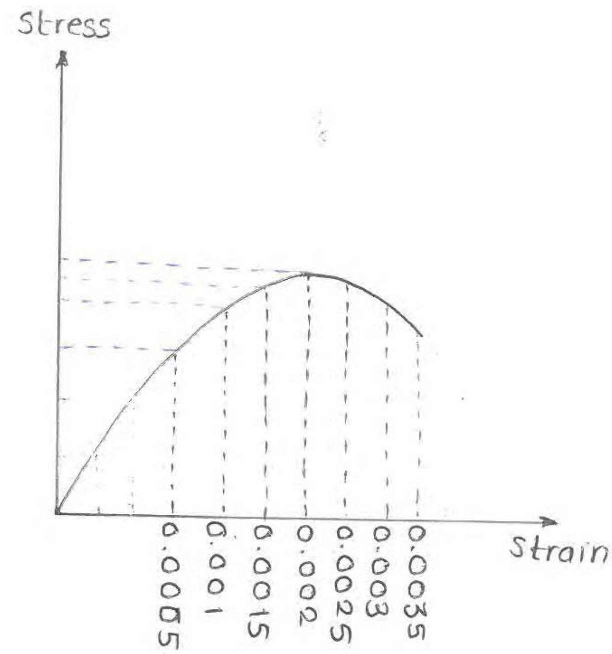
1.2.5 Stress-Strain diagram of Concrete under



- 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:

M - 25

Mix → M ; 25 → Characteristic compressive strength (N/mm^2)

M5 - M20 ⟶ Nominal Mix

M10 - M100 ⟶ Design Mix [as per ammendment ④]

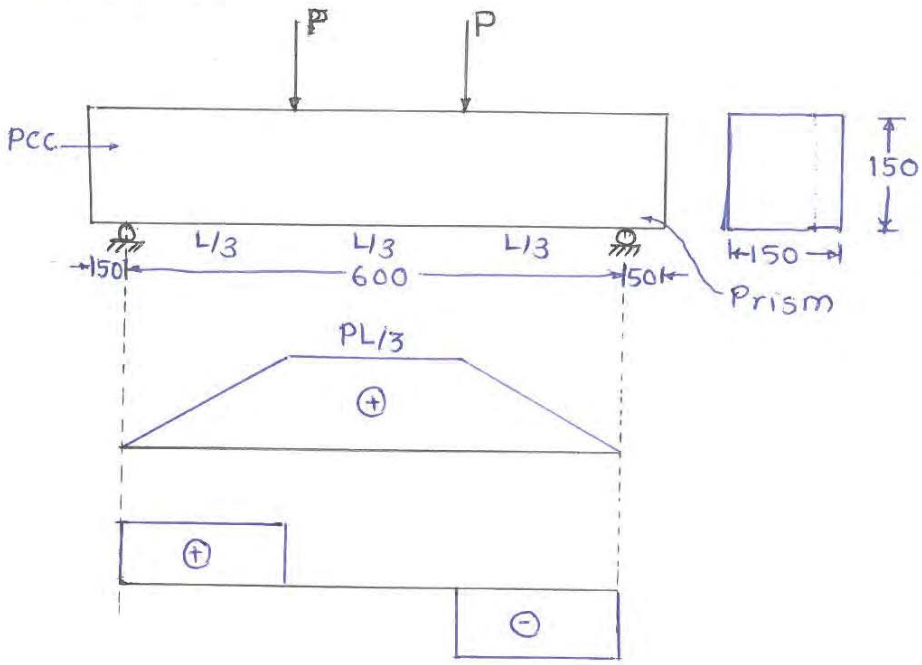
1.2.7 Tensile Strength of Concrete:

- 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-homogenity 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.

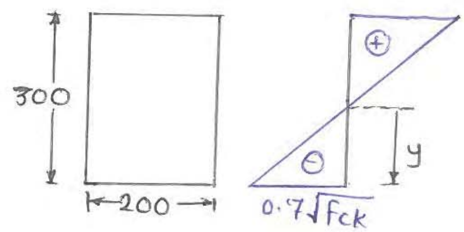
- IS 456 provides standard formula for flexure tensile Strength/Modulus of Rupture

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

Ex. A PCC beam of section size 200 x 300 mm is made up of M30 concrete. Calculate cracking moment of section.

⇒

By Flexure Formula.



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

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

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

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

$$I = 450 \times 10^6 \, mm^4$$

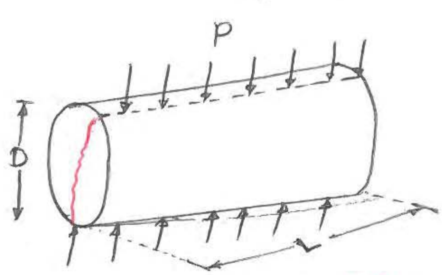
$$y = D/2 = 150 \, mm$$

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

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

3. Cylinder Split Test:

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



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

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