AIR-1 Notes

Pages: 350

RCC & Prestressed Concrete Structures

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AIR-1 ESE 2021

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RCC

CONTENT

Design of Concrete and Masonry Structures

[Pre → 15-20 ques.
Conventional → 100 + marks]

1) Footing
2) Column
3) Slab
4) Beam
5) Lintel
6) Water Tank
7) Staircase
8) Retaining wall.

⇒ RCC → IS 456:2000 [with amendment No.4, May 2013]
⇒ Steel → IS 800

1. Introduction

⇒ **Purpose of IS code:**

1) Ensure adequate structural stability by specifying minimum requirements (like minimum reinforcement)
2) Provides simple design tables and charts.
3) Ensure consistency among different designers.
4) Some legal validity.

→ SP-16, SP-24 and SP-34 [SP — Special publication]
- SP-16 → Design Tables
- SP-24 → explanatory code for IS 456-1978
- SP-34 → Reinforcement Detailing.

→ Plane and Reinforced Concrete [PCC and RCC]
- PCC → Plain Cement Concrete
- RCC → Reinforced Cement Concrete.

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→ It is a mixture of cement, Fine aggregate (sand), coarse aggregate (gravel) and water that results in a solid mass.

→ Sometimes admixtures are also used.

→ A concrete with no reinforcement is called as PCC.

→ PCC is generally used where significant tensile stress does not develop like in the construction of dam, levelling coarse of foundation etc.

→ Concrete is very strong in compression but weak in tension. It's tensile strength is approximately 1/10th of compressive strength.

NOTE: → Portable water shall be used in concrete and pH shall not be less than 6. Sea water shall not be used.

→ For most concrete work, nominal max. size of coarse aggregate is 20 mm.

Nominal size → Expected size

Actual size → Nominal ± tolerance.

→ **Reinforced concrete**

→ A concrete with reinforcement embedded in it. The embedded reinforcement makes the section capable of resisting higher tension.

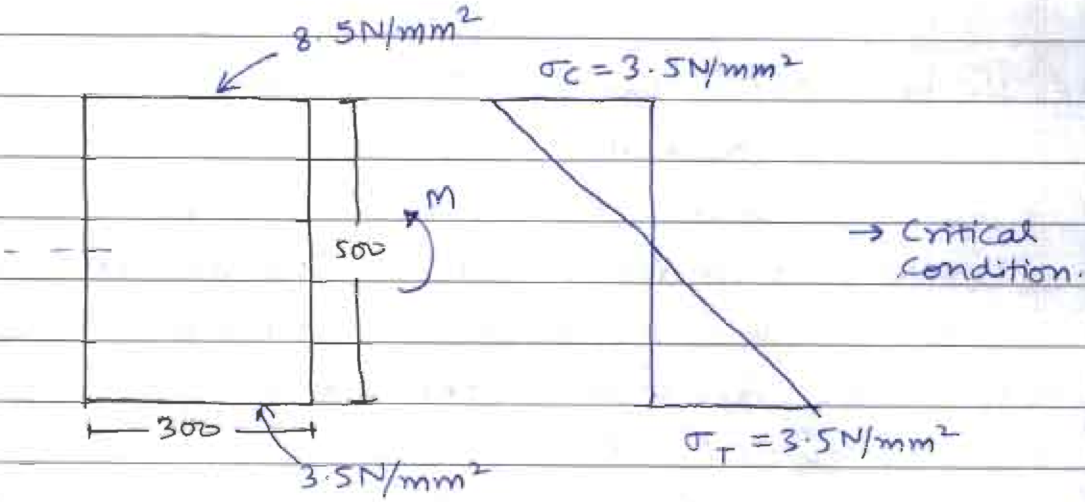
→ All of the tension is assumed to be taken off by the reinforcement (In cracked section analysis). without separating from concrete.

→ The bond between steel and surrounding concrete ensure strain compatibility i.e. the strain in steel is equal to the strain in surrounding concrete.

→ Reinforcement also impats ductility to the concrete which otherwise is a brittle material.

DPP

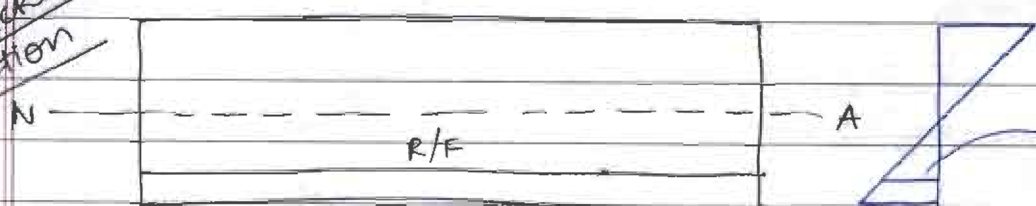
Q-1



$$MOR = 3.5 \times \frac{(300)(500)^3}{12 \times 250} = 43.75 \text{ kNm}.$$

→ MOR of the section (concrete) will be governed from the tension side.

Uncracked Section



$f_{st} = \varepsilon_s \cdot E_s$

$= \varepsilon_c \cdot E_s$

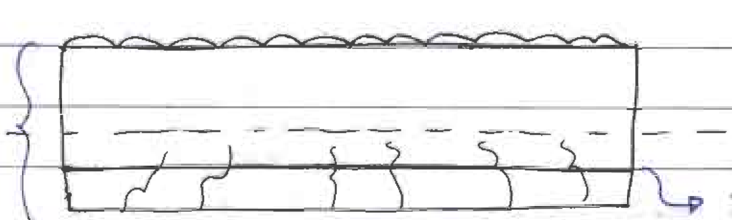
$= \frac{f_c}{E_c} E_s$

$f_c = 0.7\sqrt{f_{ck}}$, $E_c = 5000\sqrt{f_{ck}}$

So, $f_{st} = \frac{0.7}{5000} \times 2\times10^5 = 28 \text{ MPa}$

{ St → 250 ↳ 415 ↳ 500 }

Section becomes smaller



↳ 250MPa can be utilized

① ↳ gives sufficient warning before collapse [as compared to PCC]

DL on building ↑

→ Ductility means large deflection and this is due to yielding of steel. Ductile members give prior warning before impending collapse.

NOTE: We generally design cracked sections in RCC to use the higher permissible stress of steel.

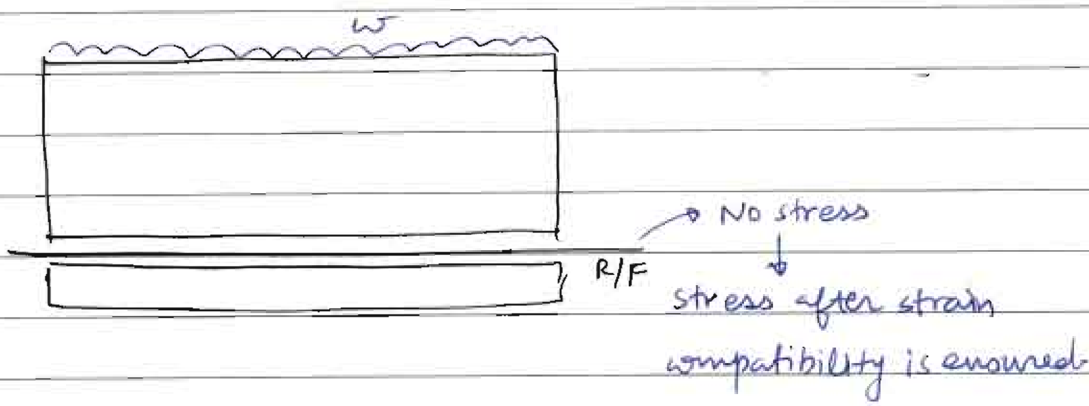
→ Also, the section size required will be less in cracked section compared to uncracked section. However, crack width shall not be high to avoid corrosion of reinforcement.

→ Permissible crack width as per code:

(a) In general → ≤ 0.3 mm

(b) Structure exposed to moisture or in contact with soil or ground water → ≤ 0.2 mm.

(c) Very severe and extreme weather condition → ≤ 0.1 mm.



→ **Compressive Strength of concrete**

→ The most important property of concrete and can be easily tested.

→ Many other properties like tensile strength, bond strength, shear strength, impermeability, durability, Modulus of Elasticity can be inferred from compressive strength.

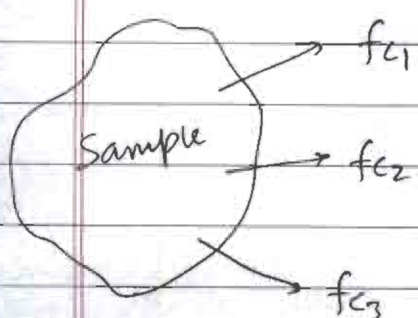
→ Strength of concrete in uniaxial compression is determined by loading the standard test cube [150 mm size] to failure in compression testing machine.

→ The test specimen is generally tested 28 days after casting and continuous curing.

→ Cube is always tested on sides i.e. faces in touch with mold are in contact with the platen (small plate) of the machine

→ ~~The~~ Three specimen of the sample are taken to report the strength and compressive strength is average of 3 specimen

→ Individual variation shall not be more than ±15% of the average. If the variation is more, the test result of the sample are invalid.



f_{c_i} → specimen strength.

$$\text{Sample strength } (f_{c,avg}) = \frac{f_{c_1} + f_{c_2} + f_{c_3}}{3}$$

$$\frac{f_{c,avg} - f_{c_i}}{f_{c,avg}} \times 100 \leq 15\%$$

$$\boxed{0.85\, f_{sample} \leq f_{specimen} \leq 1.15 \times f_{sample}}$$

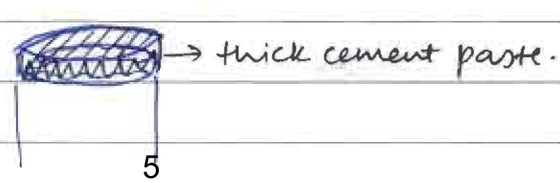
* Why 3 samples → concrete is a non-homogeneous material.

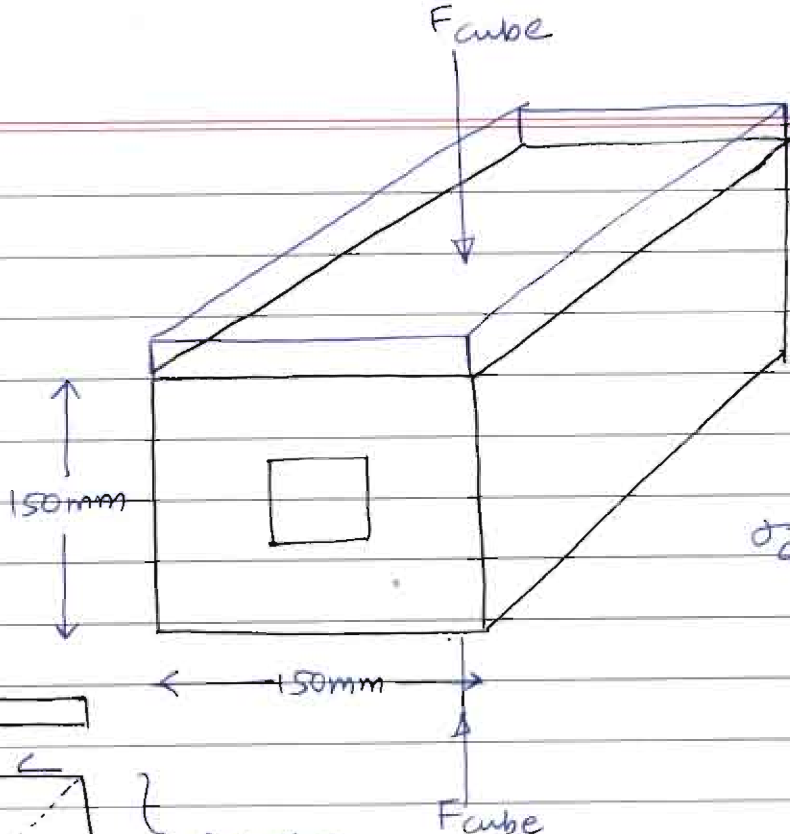
⇒ Comparison of strength of cube (IS456) and cylinder (IS516)

→ Standard cube size → 150mm

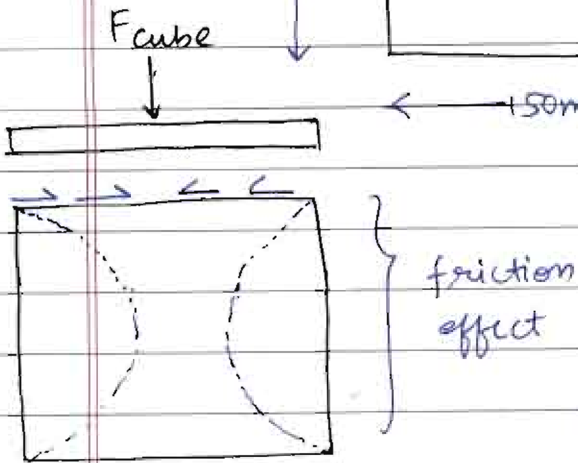
→ Standard cylinder size → 150 mm dia X 300mm height.

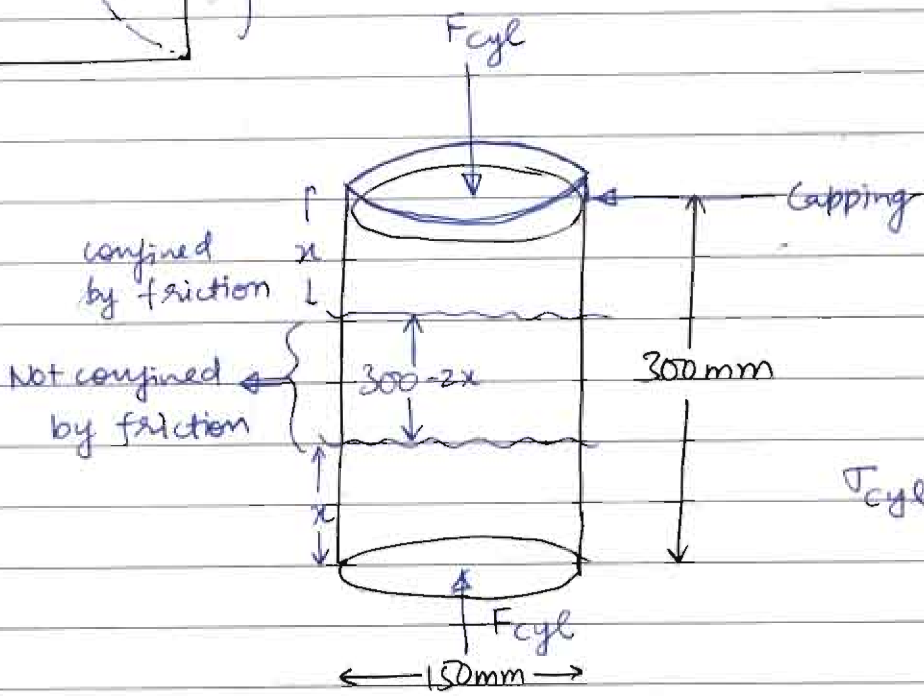
→ Cube tested without capping (neat cement paste) and cylinder tested with capping.





$$\sigma_{cube} = \frac{F_{cube}}{(150)^2}$$





$$\sigma_{cyl} = \frac{F_{cyl}}{\frac{\pi}{4}(150)^2}$$

$$\sigma_{cube} > \sigma_{cylinder}$$

$$\sigma_{cylinder} = 0.8 \times \sigma_{cube}$$

→ $\sigma_{cylinder}$ is closer to the practical value as there is generally no confinement practically.

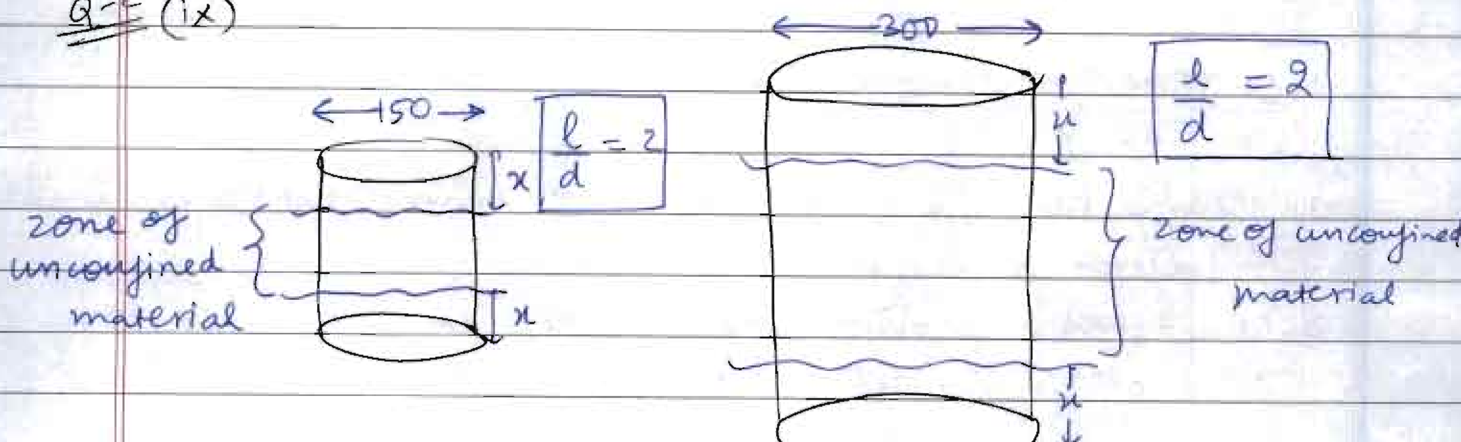
→ The restraining effect of the platens (because of friction) of the testing machine extends over the entire height of a cube. but ~~leads~~ leaves unaffected a part of test cylinder.

→ Due to restraining effect the strength differs and the cylinder fails at a early stress than the cube. and hence at the verge of failure, $\sigma_{cube} > \sigma_{cylinder}$

→ Cylinder strength is closer to the true uniaxial compressive strength of concrete and $f_{cylinder} = 0.8\, f_{cube}$.

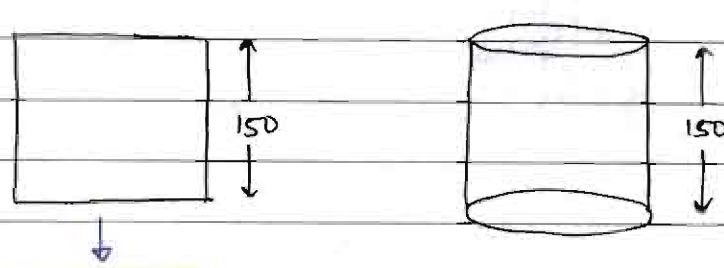
→ IS code uses cube compressive strength.

Q:- (ix)



Upto $h \cong 1.7D$ → friction effect is significant.

→



Cube will fail early due to stress concentrations.

→ **Grade of concrete**

As per IS code:

1. Ordinary Concrete → M10, M15, M20
2. Standard Concrete → M25 to M(60) 55
3. High-Strength concrete → M(65) 60 to M100

} IS code valid for these two

NOTE :→ M30 means characteristic compressive strength of 150 mm size cube at 28 days is 30 N/mm².

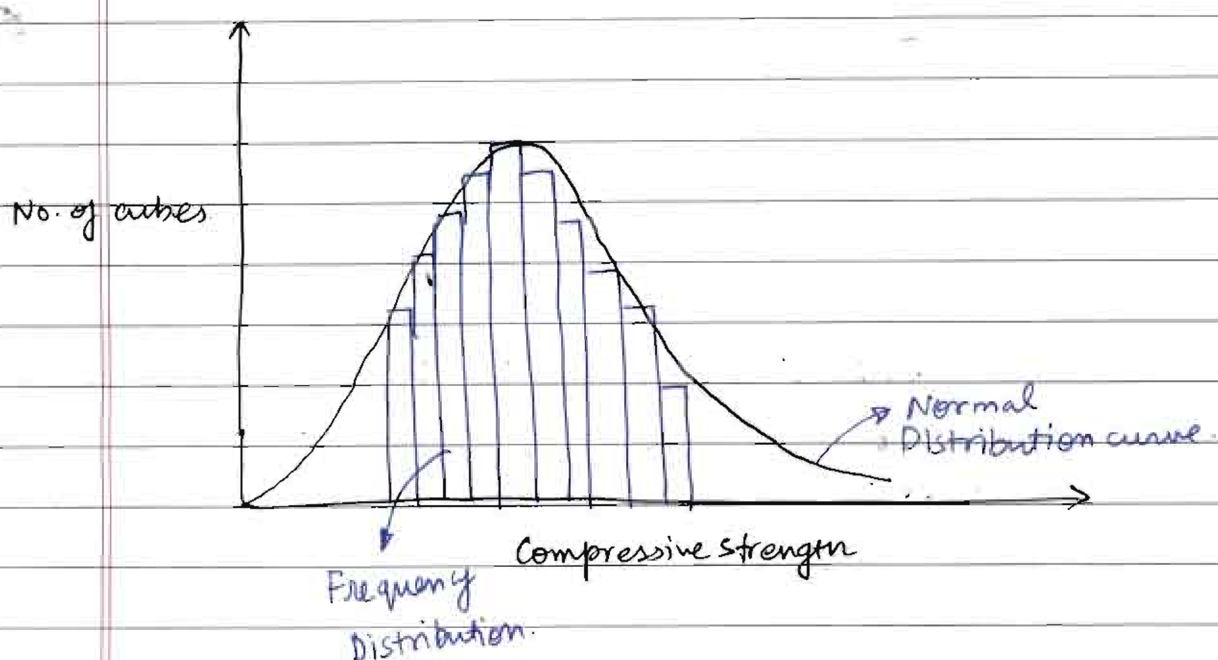
→ IS 456-2000 may not be applicable for concrete grade above M60.

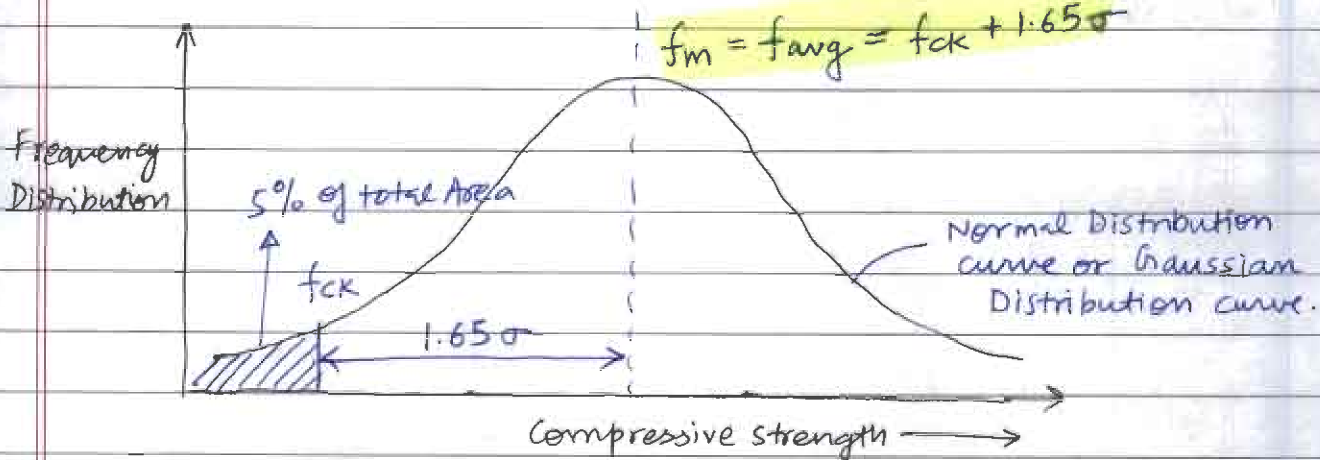
→ M5, M7.5 is known as Lean concrete.

→ **Characteristic strength of concrete**

→ When a large no. of test result of concrete cube are plotted it follows a normal distribution curve.

→ Characteristic strength is the strength below which not more than 5% of the test result are expected to fall.





$\sigma \rightarrow$ Standard Deviation.

→ Minimum sample required for standard deviation calculation is 30 and no. of specimen req. = 30×3 = 90.

$$\sigma = \sqrt{\frac{\sum_{i=1}^{N} (f_i - f_m)^2}{N-1}} \qquad N \geq 30$$

→ Concrete is designated by characteristic cube strength at 28 days.

NOTE: Cement Hydrates and gains strength over a long period of time and hence strength of concrete increases with time.
→ However, this increase in strength is not considered as per IS 456 : 2000.

✗ IS456-1978	→ 7 days	− $0.7 f_{ck}$
	→ 28 days	− f_{ck}
	→ 6 months	− $1.2 f_{ck}$

Q- The frequency distribution of the compressive strength of 100 samples is as follows. Calculate f_{ck}, f_m, σ and K where

$f_m = f_{ck} + K\sigma$

No. of samples	Compressive strength (N/mm^2)
2	10
3	14
9	16
11	18
14	20
15	22
21	24
11	26
9	28
3	30
2	32

→ Let us take $f_{ck} = 15 N/mm^2$.

$$f_m = \frac{\Sigma f_i n_i}{\Sigma n_i} = 22.1 N/mm^2$$

$$\sigma = \sqrt{\frac{\Sigma (f_i - f_m)^2 \cdot n_i}{N-1}} = 4.507$$

$$f_m = f_{ck} + k\sigma$$

$$k = \frac{f_m - f_{ck}}{\sigma} = 1.575$$

⇒ Compressive strength of concrete in structure

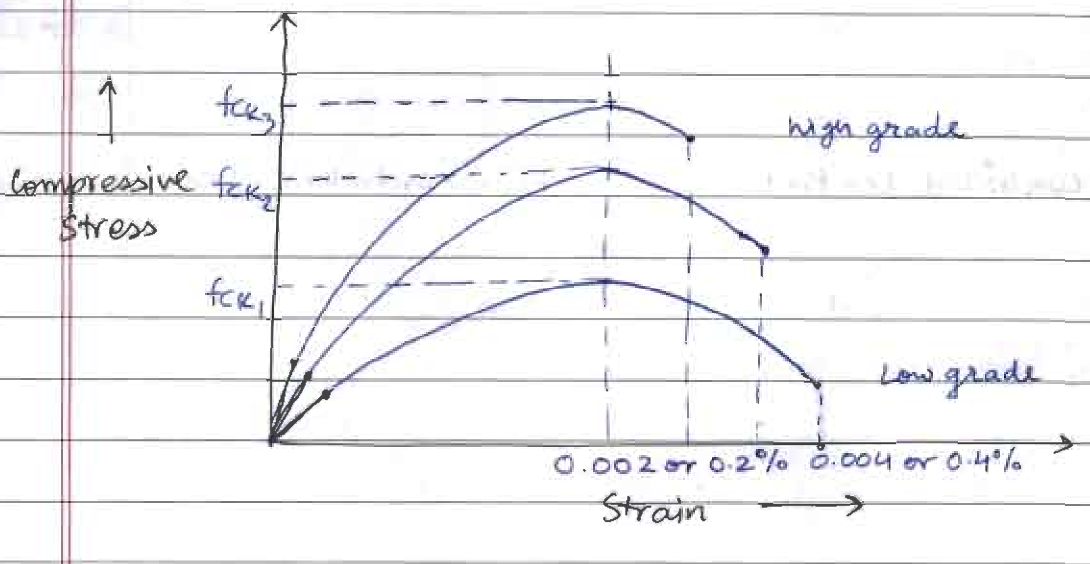
→ It is not equal to the strength obtained from the compression test of cube due to many factors like duration of loading, size of member [size effect], multiaxial state of stress and strain gradient.

→ Strength decreases with increase in size however after a certain value, it is almost constant.

→ Compressive strength of concrete in structure $= 0.85\, f_{cylinder}$
$= 0.85 \times 0.8\, f_{cube}$
$= 0.68\, f_{cube}$
$\simeq 0.67\, f_{ck}$ [IS code]

→ Due to size effect, actual strength available of concrete in structure $= 0.67\, f_{ck}$

⇒ Stress-Strain curve of concrete in compression



→ Curve is generally linear upto 1/3 to 1/2 of peak stress.

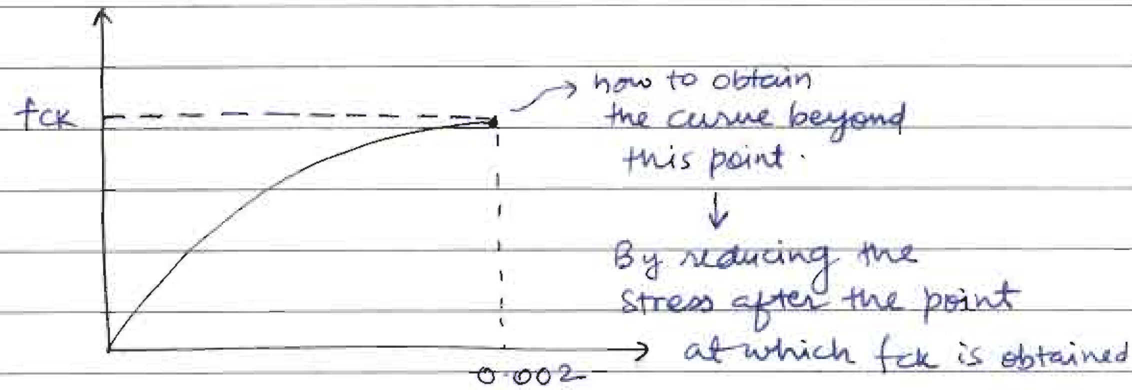
→ Maximum compressive stress reaches at a strain of 0.002

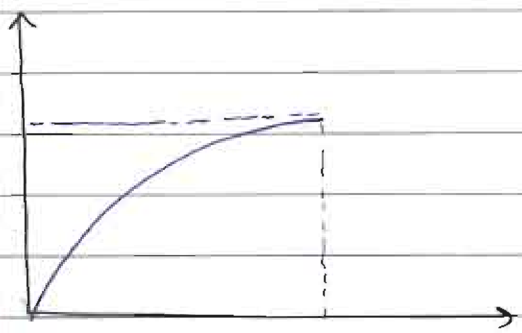
→ Stress at 0.002 (0.2%) strain is called compressive strength of concrete.

→ The strain at failure is in between 0.003 to 0.005 for usual grade of concrete.

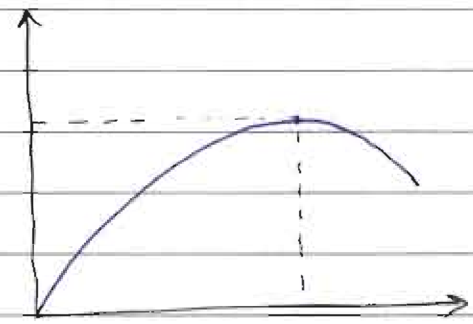
→ The higher the concrete grade, steeper is the initial portion and sharper is the peak of the stress-strain curve i.e not flat at top.

→ Low grade concrete is more ductile than high grade concrete. However, in RCC structure ductility of concrete is not considered.





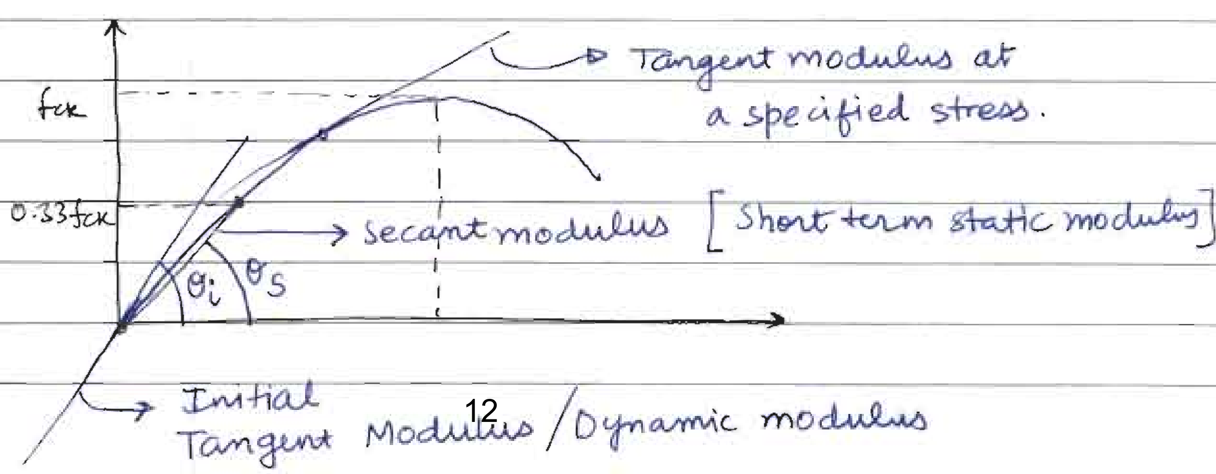
Stress controlled Loading



Strain controlled Loading.

→ To obtain the descending part of the curve, the applied load shall be strain controlled.

⇒ Modulus of Elasticity and poisson's ratio



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⇒ 3 types of modulus:

1) Initial Tangent modus / Dynamic modulus (E_{cd})

→ Slope of tangent at origin of stress-strain curve. (corresponds to a small instaneous strain).

→ Can be used for dynamic load cases (earthquake, wind) or very short period loading like (impact loading in which long term effect of creep and shrinkage can be neglected)

→ Can be obtained by NDT [Electrodynamic method, Resonance frequency method] (NDT → Non ~~Descriptive~~ Destructive Testing)

2) Secant modulus (E_c)

→ Slope of line drawn from origin to a specified stress level, here it is $0.33 f_{ck}$.

→ As per IS code, $E_c = 5000\sqrt{f_{ck}}$, where f_{ck} - characteristic compressive strength
(E_c ↓ MPa, f_{ck} ↓ MPa)

[± 20% variation permissible]

→ E_c is used to calculate instantaneous elastic deformation for structure analysed using linear static analysis.

→ E_c does not take into account long term effect of creep and shrinkage and hence called as short term static modulus.

3) Tangent Modulus (E_t)

→ Slope at any particular point on the curve.

→ It applies to changes in load from a particular load level.

NOTE:

→ E_c increases with increase in grade of concrete.

→ IS code uses Secant modulus / short term static modulus.

→ Generally dynamic modulus ≥ short term static modulus.

→ Modulus of Elasticity is primarily influenced by the elastic properties of aggregate and to a lesser extent by the conditions of curing, ageing of concrete, the mix propostion