Design of Concrete Structure

IS456:2000.

⇓

last amendment ④ IS456: May 2013

→ RCC and PCC Design;

1. Footing
2. Column
3. Beam
4. Slab
5. Lintels
6. Staircase
7. Water tank
8. Retaining wall

→ Prestressed Concrete;

→ Introduction
→ Analysis
→ Losses
→ Earthquake;

→ Why we refer IS: Code ?

i) Minimum Safety
ii) Simple design table
iii) Common Platform (different people come to a single point)
iv) Legal validity

→ P.C.C (Plain Cement Concrete) ;

→ It is a mixture of Cement, F.A, C.A & water that results in a solid mass.

→ It is generally used for mass Concreting work like construction of Gravity dam.

→ Concrete is very strong in Compression but weak in Tension. Its Tensile strength is approximately $\frac{1}{10}$th of the Compressive strength. [Lean Concrete → दुबला Concrete]

→ R.C.C (Reinforced Cement Concrete) ;

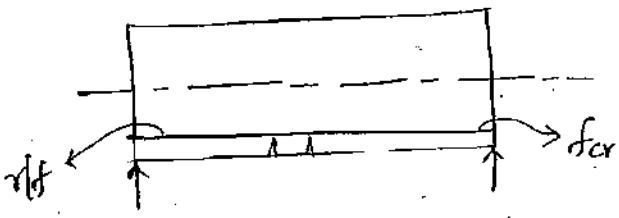
→ It is a concrete with reinforcement embeded in it. The embeded reinforcement makes the cross-section capable of resisting Tension.

→ All of the Tension is assumed to be takenup by the reinforcement without seperating from Concrete, i.e, ensuring strain compatibility.

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

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

→ Ductility means large deflection due to yielding of steel and ~~there~~ by giving Prior warning before impending collapse.



$$\text{Strain in concrete} = \frac{0.7\sqrt{f_{ck}}}{E_c \to 5000\sqrt{f_{ck}}} = 1.4\times10^{-4}$$

∴ strain in steel $= 1.4\times10^{-4}$

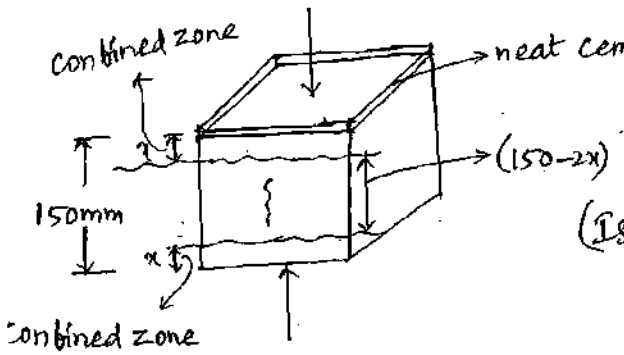
↳ Stress $= \varepsilon \times E_s$

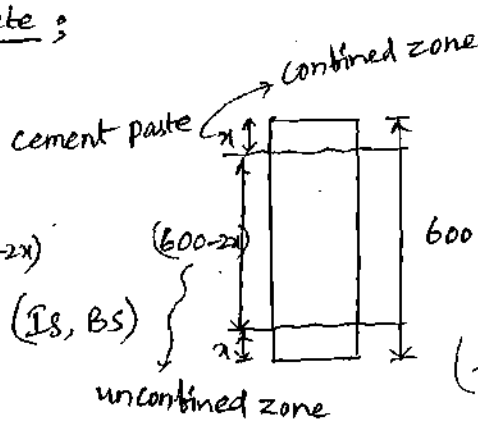
$= 1.4\times10^{-4} \times 2\times10^{5}$

$= 28$ MPa.

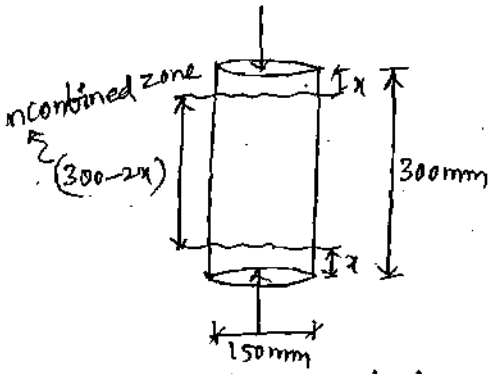
→ Crack width is limited to 0.3mm in general, 0.2mm for structure exposed to moisture or in contact with soil or ground water and 0.1mm for very severe and extreme weather condition.

→ Compressive strength of Concrete ;





$\left(\frac{l}{r} = \lambda\right)$ पे नहीं depend on this



→ Cylinder Compressive strength =
0.8 x Cube Compressive strength

i.e, $f_{cylinder} = 0.8 f_{cube}$

→ Compressive strength of Concrete is the most important property of concrete because all the other properties like Tensile strength, Bond strength, shear strength, density, impermeability, durability, modulus of Elasticity can be derived from Compressive strength.

→ Strength of Concrete in uniaxial compression is determined by loading the standard test cube (150 mm size) to failure in the compression testing machine. The test specimen is generally tested 28 days after casting and continuous curing.

→ The cube is always tested on sides that is the faces in touch with the mould

→ Confinement due to interaction between Plate and Cube.

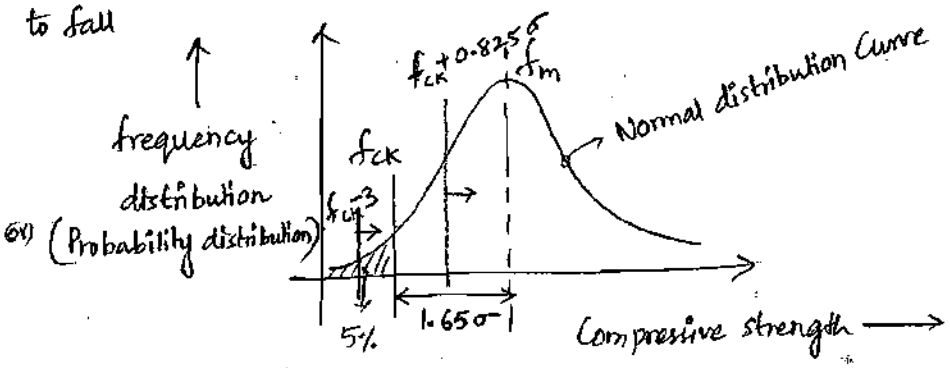
→ Grade of Concrete ;

Ordinary grade	M10, M15, M20
standard grade	M25 to M60
High strength Concrete	M65 and above

→ IS 456 : 2000, is not valid for Concrete grade above M60

→ Characteristic strength of Concrete ;

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



$$\frac{0.825\sigma}{\Uparrow} = \left(1 - \frac{1}{\sqrt{n}}\right) \times 1.65\sigma$$

$$= \left(1 - \frac{1}{\sqrt{4}}\right) \times 1.65\sigma$$

$$= 0.825\sigma$$

f_{ck} = characteristic strength

f_m = mean strength

→ $\boxed{f_m = f_{ck} + 1.65\sigma}$

where, σ → standard deviation

f_i → individual

f_m → mean

$$\boxed{\sigma = \sqrt{\frac{\sum_{i=1}^{N} (f_i - f_m)^2}{(N-1)}}} \quad ; \text{ valid for } N \geq 30$$

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

→ Acceptance Criteria ;

→ The Test result of the sample shall be the Average of the strength of 3 specimen. The individual variation shall not be more than ±15% of the average. if the variation is more, then the test result of the sample are invalid.

$0.85 f_{avg}$ ——— $1.15 f_{avg}$

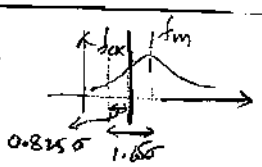
f_{c1}, f_{c2}, f_{c3}

→ Acceptance criteria for compressive strength ;

→ Concrete is considered to comply with the strength requirement when both of the following conditions are satisfied.

a) The mean strength of 4 non-overlapping consecutive test result comply with the [illegible] in the table below.

⇒ Any individual test result also comply with the test result given below;

Specified Grade	Mean of 4 non-overlapping consecutive test result (MPa)	In individual test result (MPa)
M15 and above	$\geq f_{ck} + 0.825\sigma$ (or) $f_{ck} + 3$, whichever is greater 	$\geq (f_{ck} - 3)$

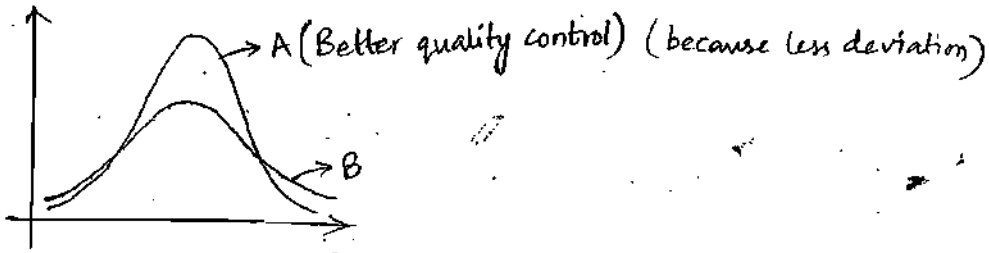
· Standard deviation;

→ Assume standard deviation as per IS: code when no data is available.

Grade of Concrete	σ (N/mm²)
M10, M15	3.5
M20, M25	4.0
M30 to M60	5.0

→ The standard deviation are valid for good quality of control of material.

⇒ For poor quality control this value shall be increased by 1 N/mm²



Q:- For a concrete work of 50m³, 4 samples are taken and the test results of the cube from each sample is given in the table below; check whether the concrete attains acceptance criteria for compressive strength. Grade of concrete is M25.

No. of sample	Specimen strength (MPa)
1	22, 28, 26
2	26, 24, 28
3	31, 33, 35
4	

Sol: As per IS: code we have to take 30 samples (i.e, 30×3 = 90 Specimen) for 50m³ concrete after that add +1 sample for each +50m³ (which is not economical)

No. of sample	Specimen strength (MPa)	f_{avg} (MPa)	$0.85 f_{avg}$ (MPa)	$1.15 f_{avg}$ (MPa)
1	22, 28, 26	25.33	21.53	29.13
2	26, 24, 28	26	22.10	29.90
3	31, 33, 35	33	28.05	37.97
4	32, 31, 33	32	27.20	36.80

(Hence we are taking 4 samples) & जो satisfy करता है।

$(f_{ck}-3)$ MPa
22
22
22
22

→ The test result is valid

→ the individual samples are O.K.

$\therefore$ Strength of concrete $= \frac{25.33+26+33+32}{4}$

$= 29.08$ MPa

refer max. of these two →

→ $f_{ck}+3 = 28$ MPa

→ $f_{ck}+0.825\sigma = 25+0.825\times 4 = 28.30$ MPa

$\therefore$ The average of 4 consecutive test result $= 29.08$ MPa > 28.30 MPa

→ The concrete can be accepted for compressive strength.

→ Exposure condition, Nominal Cover and Grade of Concrete ;

→ Exposure Condition ;

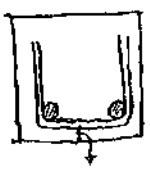
→ It is the general environment to which concrete will be exposed during its working life.

→ Nominal Cover ; (clear cover)

→ It is the design depth of concrete cover to all reinforcement, including links (stirrup)

It shall not be less than the diameter of bar

→ As per IS: code, 5 types of exposure conditions are there.



Nominal Cover/ clear Cover

Remember

Exposure Condition	Description	Nominal Cover (mm)	Minimum Grade of Concrete (RCC)	Minimum Grade of Concrete (PCC) ← Based on exposure condition
Mild	Table-3 Page-18 IS: 456-2000	20	M-20	—
Moderate		30	M-25	M-15
Severe		45	M-30	M-20
Very Severe		50	M-35	M-20
extreme		75	M-40	M-25

→ Nominal Cover is governed by;

i) Exposure Condition

ii) Stress in the reinforcement

iii) Fire resistance

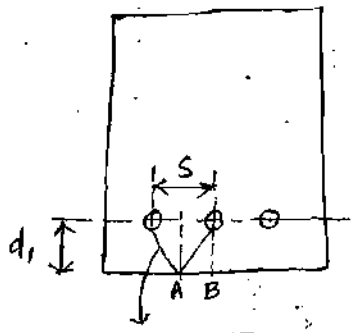
→ The above nominal cover criteria is valid for beam and slab.

→ minimum Grade of Plain Concrete under mild exposure is not specified.

→ for main reinforcement upto 12mm dia. & mild exposure, nominal cover may be reduced by 5mm

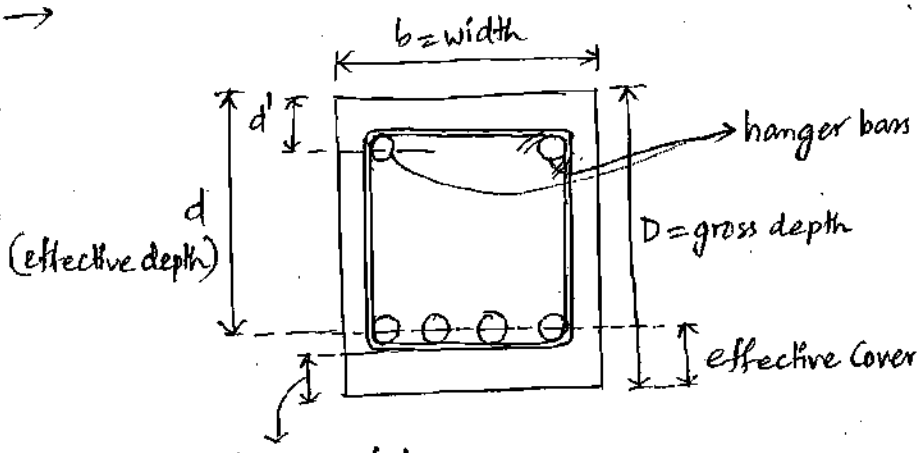
Actual concrete cover shall not deviate from the required nominal cover by +10mm and 0mm (i.e, No tolerance on -ve side)

For exposure condition severe and very serere, nominal cover may be reduced by 5mm when the grade of concrete is M35 and above



crack width = $\sqrt{\left(\frac{S}{2}\right)^2 + d_1^2}$

→



$$d = D - \text{effective Cover}$$

→ effective Cover = distance between Centroid of tensile r/f to the extreme tensile fibre

d' = distance between extreme compressive fibre to the centroid of compressive r/f.

→ Concrete Mix design ;

→ Design of concrete mix involves economical selection of relative proportion of various ingradients of concrete.

→ The concrete shall satisfy strength criteria and durability criteria in the hardened state and workability criteria in the plastic stage (or) Green stage (fresh concrete).

→ Normally concrete is classified as ;

a) Nominal mix Concrete

b) Design mix Concrete

a) Nominal Mix Concrete ;

→ It is permitted only upto M20 grade of concrete.

→ Design mix concrete is preferred over Nominal mix.

→ Nominal mix generally contains higher cement volume compare to same grade of Design mix.

→ Proportioning of Nominal mix as per IS: code ; (*) No need to remember

Grade of Concrete	(FA+CA) in 50kg Cement (kg)	Ratio of FA & CA (by weight)	water content per 50kg cement
M5	800	Generally 1:2 can vary from 1:1.5 to 1:2.5	60
M7.5	625		45
M10	480		34
M15	330		32
M20	250		30

Ex: Calculate Proportion for M15

Sol: Cement = 50kg

FA+CA = 330kg

FA : CA = 1:2

→ $FA = \frac{330}{3} \times 1 = 110kg$

→ $CA = \frac{330}{3} \times 2 = 220kg$

∴ Cement : FA : CA = 50 : 110 : 220 = 1 : 2.2 : 4.4

→ $\frac{W}{C} = \frac{32}{50} = 0.64$

→ Nominal Mix ; (Concluded) ⇓

M5 — 1:5:10

M7.5 — 1:4:8

M10 — 1:3:6

M15 — 1:2:4

M20 — 1:1.5:3