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R.C.C

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Introduction to PCC and RCC

Complete Course on RCC - GATE & ESE

Amit Zarola · Lesson 1 · Feb 28, 2023

Reinforced Cement Concrete

- After determining the shear force, Bending moment, Axial force, Torsional moment, stress, strain, slope, deflection in the Strength of material and the Structural Analysis the design of structure is required.
- The Given Structure Can be designed as RCC structure, Prestressed Concrete Structure or steel Structure that depends upon the Purpose and requirements.
- In this Subject the design of RCC and Prestressed Concrete structures Shall be Studied.

Plain Cement Concrete and Reinforced Cement Concrete

Plain Cement Concrete (PCC) : →

- Concrete is a heterogeneous mixture of Cement, Sand, Coarse Aggregates, water and admixtures (if required)

Heterogeneous mixture : → when ingredients are not uniformly distributed

Homogeneous Mixture: → when ingredients are uniformly distributed.
for Ex.- Salted water

↳ Concrete is prepared in this style -

Coarse Aggregates (Gravels) + fine Aggregates (Sands) + Cement + Water

↳ Concrete is a brittle material which is good in compression and weak in tension.

↳ The tensile strength of Concrete is approximately one-tenth of it's compressive strength.

Reinforced Cement Concrete :→

↳ since Concrete is weak in tension, the reinforcement is provided in the tension zone to resist the significant tensile stresses this new Composite material is termed as Reinforced Cement Concrete (RCC).

↳ RCC was developed and first used by "Francois Coignet".

↳ Reinforcement Can be done with the help of Copper, Aluminum, Steel, Gold, Silver etc. These all the metals are ductile and good in Tension.

↳ But we choose Steel for Reinforcement. the reasons are as follows.

① The coeff. of Thermal expansion of steel is nearly equal to the Coeff of thermal expansion of the concrete.

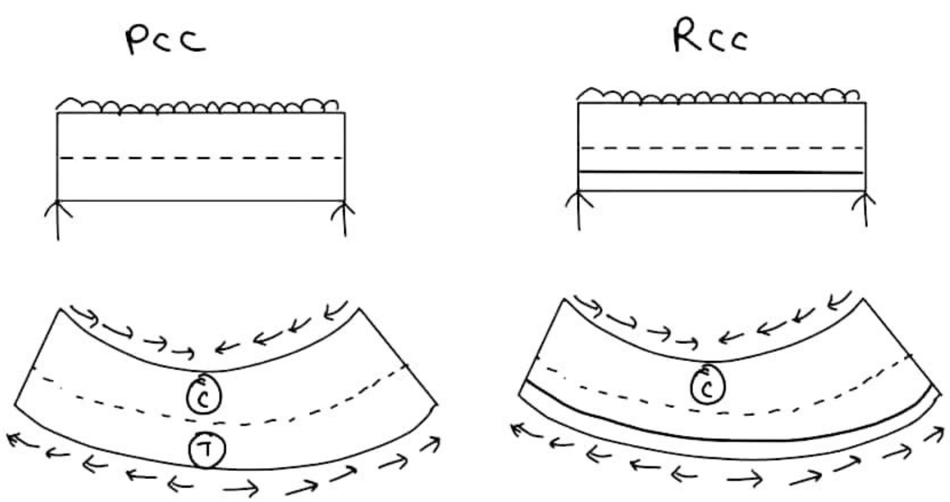
$\alpha_{Steel} = 12 \times 10^{-6} / °C$

$\alpha_{concrete} = 10 \times 10^{-6} / °C$

(2) The bond between Steel and the Surrounding Concrete ensures the Strain Compatibility i.e. the strain at any point in the steel is equal to that in the adjoining concrete

(3) Steel is good / Strong in tension and Compression as well which is required in Case of stress reversal [Cyclic loading]

(4) Steel is a ductile material which can impart some ductility to Concrete structure because Concrete is highly Brittle material.



Note :→ The tensile stress occur in the Concrete due to

(a) Direct pull (Direct Tension)
(b) Bending (Flexural Tension)
(c) Shear (Diagonal Tension)
(d) Change in Temperature
(e) Shrinkage of Concrete

Grade of Concrete

Group	Grade Designation	Specific characteristic Compressive strength (N/mm^2)
Ordinary Concrete [M10 - M20]	M10	10 N/mm^2
	M15	15 N/mm^2
	M20	20 N/mm^2
Standard Concrete [M25-M60]	M25	25 N/mm^2
	M30	30 "
	M35	35 "
	M40	40 "
	M45	45 "
	M50	50 "
	M55	55 "
	M60	60 "
High strength Concrete [M65- M100]	M65	65 N/mm^2
	M70	70 "
	M75	75 "
	M80	80 "
	M85	85 "
	M90	90 "
	M95	95 "
	M100	100 "

Note :→ In the designation of concrete mix, M Stands for "Mix" and the number refers to the characteristic compressive strength of 150 mm cube at 28 days of curing expressed in N/mm^2. ($1\ N/mm^2 = 1\ MPa$)

Note :→ for concrete of grade above M60, the design parameters given by IS Code Shall not be applicable, In

Such cases design parameters are obtained from the experimental results and literature.

Note: → There is a very normal gain in compressive strength beyond the age of 28 days. That depends upon the grade, environmental conditions, type of cement and curing.

Note: → The design should be based on 28 days characteristic strength of concrete unless there is evidence to justify a higher strength for a particular structure due to age.

Note: → The cubes testing can be done in 3 days, 7 days and 14 days to ensure that the following minimum strength is achieved

3 days strength - 45% of specified 28 days strength

7 days strength - 60% of specified 28 days strength

14 days strength - 85% of specified 28 days strength

Note: → for mixing and curing purpose, use of sea water is not recommended.

Note: → The pH value of water shall not be less than 6.

Note: → Aggregate used in the preparation of concrete must not absorbe the water more than 10% by weight/mass.

Note: → permissible (or maximum) limits for solids in the water are given below:

Solids	Permissible limit (max value)
organic matter	200 mg/l
Inorganic matter	3000 mg/l
Sulphates (as SO_3)	400 mg/l

Chlorides (as Cl)	2000 mg/l (500 mg/l for RCC work)
Suspended matter	2000 mg/l

IS Code Recommendations

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Minimum grade of concrete for durability requirements

Exposure	Minimum Grade of Concrete	
	PCC	RCC
Mild	—	M20
Moderate	M15	M25
Sever	M20	M30
Very Sever	M20	M35
Extreme	M25	M40

Maximum w/c ratio for durability requirements

Exposure	Maximum water Cement ratio	
	PCC	RCC
Mild	0.6	0.55
Moderate	0.6	0.50
Sever	0.5	0.45
very sever	0.45	0.45
Extreme	0.40	0.40

↳ minimum grade of concrete for PCC under mild exposure condition is not specified.

↳ minimum grade of concrete (IS 456 : 2000)

for RCC work = M20

for PCC work = M15

↳ Maximum w/c ratio (IS 456 : 2000)

for RCC work = 0.55

for PCC work = 0.60

Note :→ As per IS13920 code the minimum grade of concrete shall be M25 for the buildings

(i) which are more than 15m in height in the Zones III, IV & V.

(ii) But grade of the concrete should not be less than required/specified by IS456:2000 based on exposure condition.

Note :→ for concrete of grade M30 and above the rate of increase of compressive strength with age shall be based on actual investigation/observation.

Note :→ for concrete in sea or exposed to sea coast the minimum grade of concrete shall be M30 for RCC work and M20 for PCC work.

Note :→ The maximum Nominal size of aggregate shall not be greater than $\frac{1}{4}^{th}$ of the minimum thickness of the member.

(The size of aggregates greater than 40 mm are also permitted)

Note :→ Exposure conditions are classified in following 5 levels of severity.

Table 3 Environmental Exposure Conditions

(Clauses 8.2.2.1 and 35.3.2)

S.No.	Environment	Exposure Conditions
(1)	(2)	(3)
(i)	Mild	Concrete surfaces protected against weather or aggressive conditions, except those situated in coastal area.
(ii)	Moderate	Concrete surfaces sheltered from severe rain or freezing whilst wet
		Concrete exposed to condensation and rain
		Concrete continuously under water
		Concrete in contact or buried under non-aggressive soil/ground water
		Concrete surfaces sheltered from saturated salt air in coastal area
(iii)	Severe	Concrete surfaces exposed to severe rain, alternate wetting and drying or occasional freezing whilst wet or severe condensation.
		Concrete completely immersed in sea water
		Concrete exposed to coastal environment
(iv)	Very severe	Concrete surfaces exposed to sea water spray, corrosive fumes or severe freezing conditions whilst wet
		Concrete in contact with or buried under aggressive sub-soil/ground water.
(v)	Extreme	Surface of members in tidal zone
		Members in direct contact with liquid/solid aggressive chemicals

Compressive Strength of Concrete [IS516 : 1959]

↳ Compressive strength of Concrete is determined by testing the hardened Concrete in the Compression Testing machine.

↳ It is the ability of concrete to resist the gradual Compression load.

↳ The concrete Cube of size 150mm x 150mm x 150mm (if nominal size of aggregate exceeds 20mm) or 100mm x 100mm x 100mm (if largest nominal size of aggregate does not exceed 20 mm) is used for Testing.

↳ In the preparation of Concrete cube maximum nominal size of aggregate doesn't exceed 38 mm

↳ After filling the Concrete in the mould, the Mould is placed/stored where no vibration occurs and air has relative humidity of atleast 90 %. After the duration of 24 hours the cube is removed from the mould and immediately immersed into the fresh water at 27 ± 2 °c for 28 days.

↳ After 28 days concrete cubes are tested.

↳ The Concrete Cubes (Specimens) Can be tested in 3 days, 7 days, 14 days depending upon the requirements.

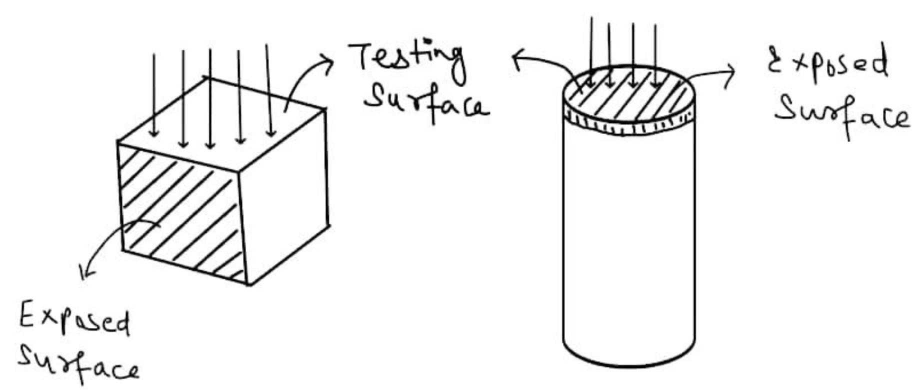
↳ In India Cubes are tested whereas in America Cylinders are tested.

↳ Cylinderical Test Specimens Can be used of Height to diameter ratio as 2:1 (H = 300 mm and D = 150 mm)

↳ Cylinders are cast and tested in the same Position whereas cubes are Cast in one direction and tested from the other direction.

↳ The cube does not require Capping whereas cylinder requires Capping.

↳ The strength of Capping material should be more than the strength of Concrete that means Capping must not fail before the Concrete fails.



↳ Capping can be done by

(i) Neat Cement Paste (After 4 hours of Casting)

(ii) Cement Mortar (After Completion of Casting)

(iii) Sulphur (Just prior to testing)

(iv) Hard Plaster (Just prior to testing, not the ordinary plaster like POP)

↳ Rate of application of loading is kept $14\ N/mm^2/min$ upto failure.

↳ Compressive strength of concrete is reported or expressed nearest to $0.5\ N/mm^2$.

↳ Results obtained in this test are comparatively more than actual due to restraining effect of the steel plates on the concrete specimens.

Cube size (mm)	100	150	200	300
Relative strength to 150mm cube	1.05	1	0.95	0.87

↳ The restraing effect of the plates of the testing machine extends over the entire height of the cube (H = 150mm) but leaves unaffected a part of test cylinder because of greaty height (H = 300mm). Therefore the strength of the cube comes out to be different from the concrete cylinder.

↳ Normaly, cylinder strength = 0.8 × cube strength

$$f_c = 0.8 f_{ck}$$

$$f_{ck} = 1.25 f_c$$

f_{ck} → Cube strength , f_c → Cylinder strength

Note :→ Because of the effect of the selenderness the cylinder strength ($\frac{H}{D} = 2:1$) comes out to be smaller than the cube strength ($\frac{H}{D} = 1:1$)