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REINFORCED CEMENT CONCRETE

-JASPAL SINGH
(Ex IES)

REINFORCED CEMENT CONCRETE.

Basic Concept

Structural Engineering

- Analysis
- Design

Analysis

{SOM, TOS & Aspects}
- Compatibility of structure
- Energy of structure
- Equilibrium of structure.

Design

{RCC, PSC, steel structure aspects}.
- Safety.
- Serviceability
- Durabity.
- Economic.
- Asthetic.

* Here, cct is concrete and R/f^n is reinforcement.

1. Safety.
A structure must be safe with sufficient f.o.s. for loading, that is expected to come on it during its design life.
Ex: Designing of beam.
Safety: It is made safe under tensile loading by providing adequate R/fⁿ.

2. Serviceability.
It signifies that structure should provide service for which it is constructed.
Ex: Doubly R/Fⁿ section instead of singly R/fⁿ section is more serviceable.

3. Durability.
A structure should be durable/sustain loading for which it is designed and should perform well within safety limit and serviceability limit.
– Durability without serviceability and less margin of safety is irrelevant.
Ex: By providing nominal cover, selecting specific type of material for construction.

4. Economy.
Design and construction of any structure should be economical without affecting safety, serviceability and durability.
Ex: Monolithic casting of beam and slab, using pozzolona in some proportion with cement.

5. Asthetic.
If large investment is done over design and construction of structure it should be asthetic (good in appearance).
Ex: By changing the geometry of the section like providing half round section instead of rectangular section

Plain and Reinforced concrete

1. Plain concrete (PCC)
It is a paste which is formed by addi-

tion of water in specified proportion in mixture of binding material (cement), fine aggregate and coarse aggregate and admixture if required.

- Cct is strong in compression, but weak in tension.

- Its tensile strength is increased by reinforcing it by fibres and is termed as R/f^{n} cement concrete.

- Its tensile strength is one tenth (approx) of its compressive strength.

- PCC is generally used in mass Concreting.
Ex : Dam, Small Pedestal etc.

2. <u>Reinforced Cement Concrete</u>
It is a cct with r/f^{n} embedded in it.
- The embedded r/f^{n} makes it capable of resisting tension also.
- Steel bars are generally used for RIf of Concrete.

- Steel bars are embedded in tension zone in Cct and relieves it of any tension and take all the tensile loading without seperating from the Cct.

- The bond between steel and surrounding ensures strain compatibility i.e, the strain at any particular point in steel and Cct would be same.

- R/f^{n} steel also imparts ductility to the cct which otherwise is brittle material.

- Here ductility means large deflection due to yielding of steel would be observed prior to the failure.

- Tensile stress in Cct arise due to
1. flexural tension.
2. Diagonal tension.
3. Shear.
4. Temperature difference.
5. Shrinkage effect.
6. Restrain to deformation.

– Under these condition R/f^{n} is to be provided across potential tensile crack.

Different grades of Concrete

Groups	Grade designation.	Specified characteristic compressive strength of 150 mm cube at 28 day
Ordinary concrete	M10	10
	M15 (10-20)	15
	M20	20
Standard Concrete	M25	25
	M30	30
	M 35	35
	M40 (25-60)	40
	M45	45
	M55	55
	M60	60
High strength Concrete	M65	65
	M70	70
	M 75	75
	M80	80
	M85	85
	M 90	90
	M95	95
	M 100	100.

NOTE : 1. In the designation of Cct mix 'M' refers to the mix and number to be specified characteristic compressive strength of 150 mm cube at 28 days expressed in N/mm^2.

2. for Cct of grade above M60, design parameter of IS 456 are not valid and for this Cct, further specilised literature or experimental result is to be concerned

3. Ordinary Cct is used for general RCC continued, standard Cct is used for pre stressed Cct structure and high strength Cct is used for high strength RCC structure.

Minimum grade of concrete to be used depends upon the exposure conditions in the anticipated life of the Cct, which governs its durability as follows.

Exposure	Min grade of Cct (PCC)	Min grade of Cct (RCC)
Mild	—	M20
Moderate	M15	M25
Severe	M20	M30
Very severe	M20	M35
Extreme	M25	M40

NOTE: Minimum grade of plain Cct for mild exposure condition is not specified.

REMARK: Minimum grade of Cct (IS 456).
RCC M20
PCC M15

Min grade of Cct (structural) shall be M20 but M25 for building (IS 13920).
a) More than 15 m in height in seismic zone III IV V.
b) But not less than that required by IS 456 based on exposure condition.

— Minimum grade of Cct to be used in prestressed Cct (PSC) work.
A. Pre tensioned M40
B. Post tensioned M30

— There is normally gain of strength beyond 28 days the extent of which depends upon the grade and type of cement, curing and environmental condition.

— The design should be based upon 28 days characteristics strength of Cct, unless there is evidence of justify higher str for a particular structure due to age.

— for Cct of grade M_{30} and above, the rate of increase of compressive strength with age shall be based on actual observation.

- for Cct of grade lower than specified before, it may be used for plain cct works, lean cct works, simple foundation, foundation for masonary wall or other simple or temporary RCC construction.

Compressive Strength of Concrete

It is the ability of the Cct to resist the gradual compressive load.

It is most important property of Cct as other properties like tensile strength, shear strength, bond strength, impermeability, durability can be inferred from the compressive strength only (by empirical relationship).

- Compressive strength can be measured by standard test on Cct cube (or cylinder) specimen.

- Strength of cct in uniaxial compression is determined by loading standard cube of 150 mm to failure in compression testing machine.

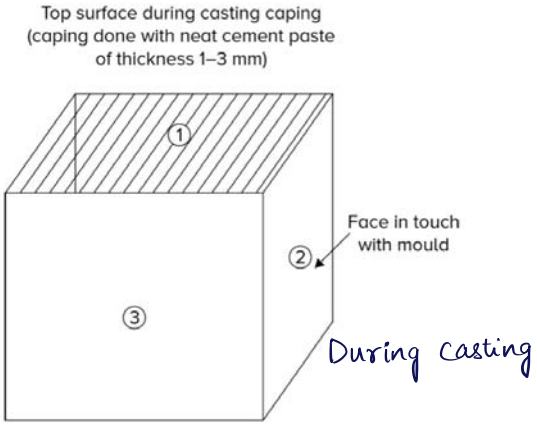
- The test specimen in general is tested after 28 days of casting and continous curing. (In order to find the rate of gain of strength, it can be tested at the age of 3 days or 7 days).

- Cube is always tested on sides i.e., face in touch with mould.

- Strength of cube is expressed to nearest of $0.5\ N/mm^2$.

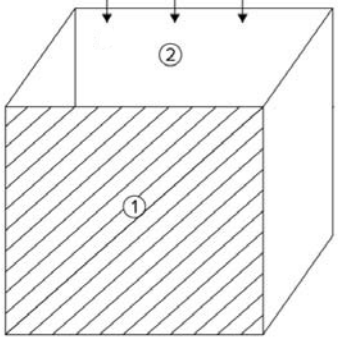
- As per IS 456 1 sample, must consist of 3 specimen cube.

- To report strength of cube sample average of 3 specimen must be taken such that individual variation should not be more than ± 15 %.

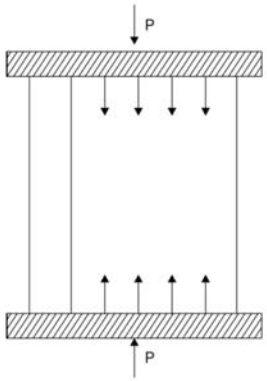


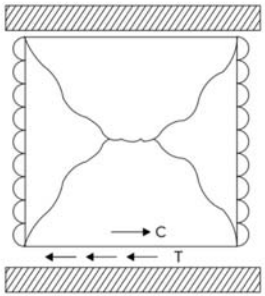
During casting

Loading applied on face in touch with mould



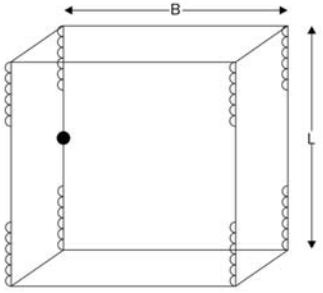
During Testing



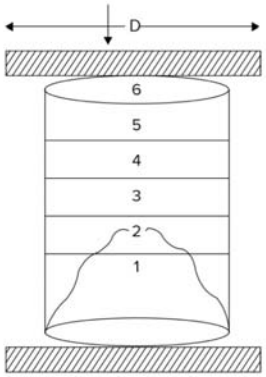


Cube size (mm)
relative strength to
150 mm cubes

100	150	200	300
1.05	1	0.95	0.87



Prismoidal



Cylinder

NOTE :

Relative strength of prism of different (L/B) ratio.

L/B ratio	0.5	1.0	2.0	3.0	4.0	5.5
Relative strength (150 mm cube)	1.5	1	0.8	0.72	0.68	0.6

Strength c_y = 0.8 S_{cu}

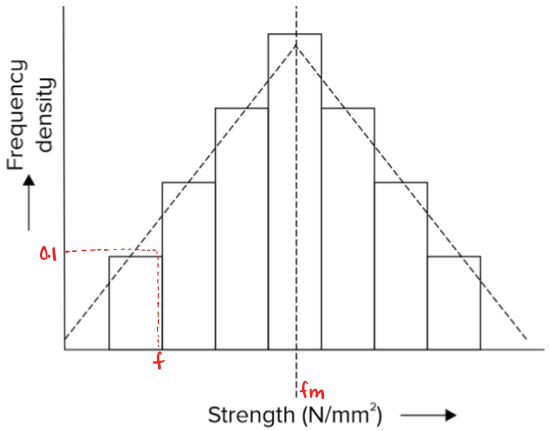
S_{cu} = 1.25 c_y.

Characteristics compressive strength of concrete

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

- Cct is designated by characteristics strength of cube at 28 days.
- As cement paste hydrates for infinite time continously (long period). Hence, we need to specify the strength for some particular time.

Variation in Strength

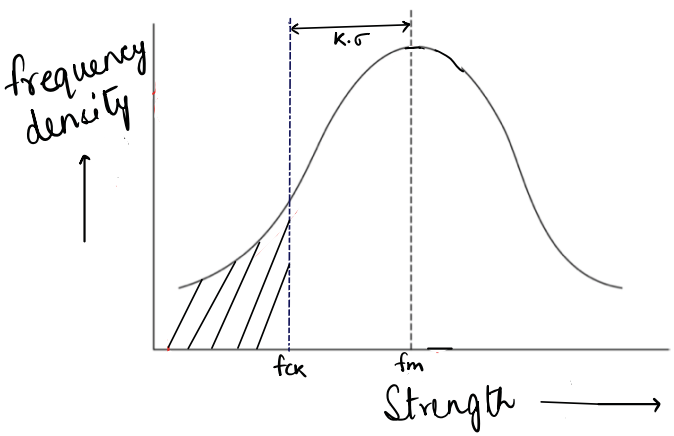


frequency density

No. of sample in an interval.
Total no. of sample.

- If the number of samples are increased indefinately the histogram becomes frequency distribution curve.

- for most of the engineering material, this curve is symmetric about mean and such a curve is termed as normal probability distribution curve / Gaussian curve / Bell curve.



Mean of observation (strength) $= \frac{\Sigma X_i}{n} = \frac{\Sigma f}{n}$
(f_m)

Deviation of observation (strength) $= f - f_m$

Standard deviation of observation

$$\sigma = \sqrt{\frac{\Sigma (f - f_m)^2}{n \text{ or } (n-1)}}$$

NOTE: When standard deviation of entire sample can be computed than N is used, but if standard deviation of certain portion of sample is computed then N-1 is used, hence for ex

$$\sigma = \sqrt{\frac{\Sigma (f - f_m)^2}{n - 1}}$$

- Spread of standard deviation is measure of quality control.

- If σ is large (more strength variation), hence poorer is the quality control.

- If standard deviation is small (less - strength variation), hence better is the quality control.