Compressive Strength of Concrete

Hardened Concrete - 1

G.Sivakumar
sivakumar@icomat.in
+91 9790 777000

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Compressive Strength of Concrete

R.C.C.Structures

- **Modern Day construction utilizes the efficiency of Reinforced Cement Concrete (R.C.C) to a great extent**
- **Technological Advances in R.C.C contribute to Construction of Mega and High Rise Structures across the Globe**

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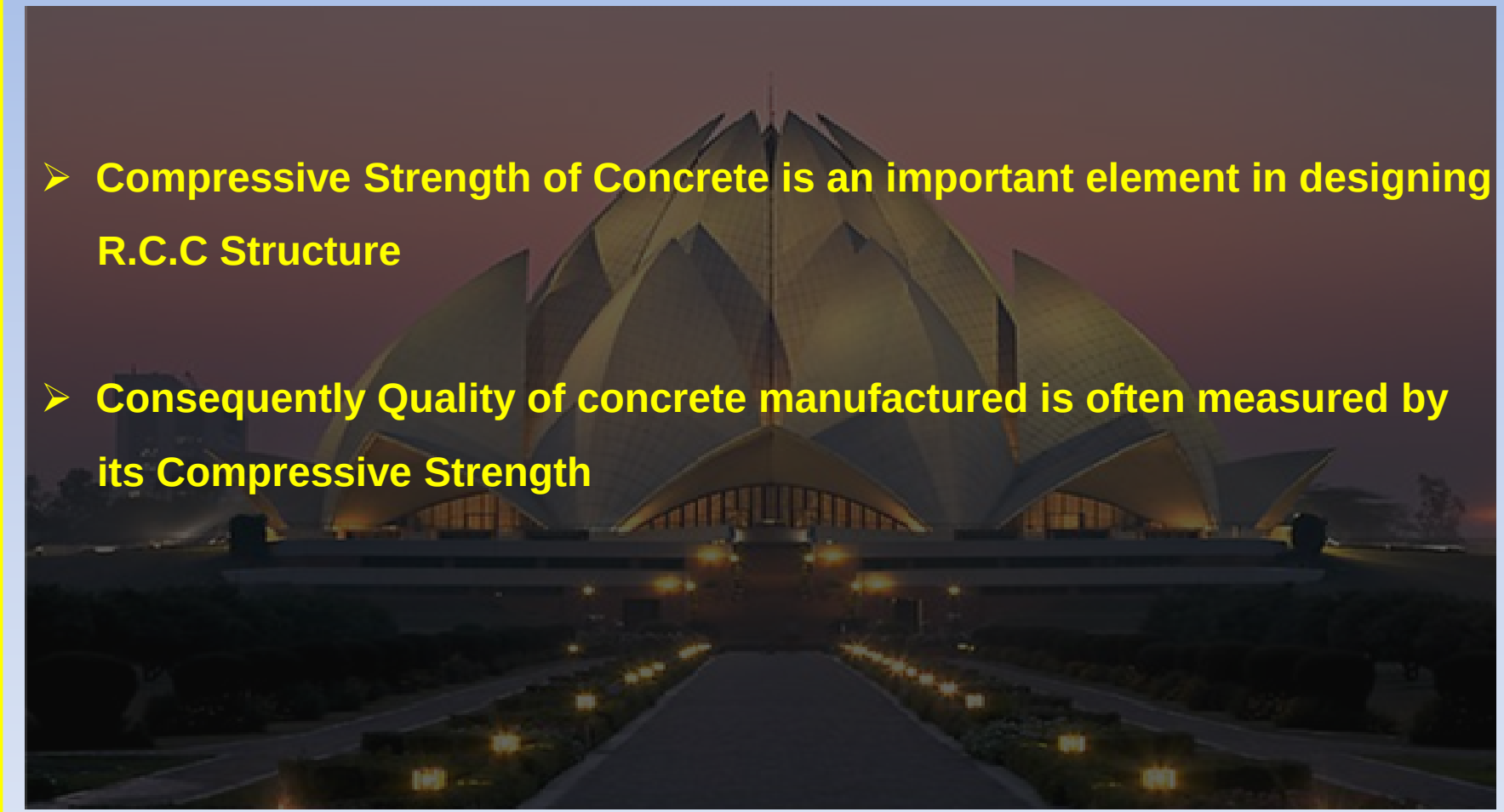
R.C.C.Structures



- **Compressive Strength of Concrete is an important element in designing R.C.C Structure**
- **Consequently Quality of concrete manufactured is often measured by its Compressive Strength**

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Characteristic Strength vs Design Strength

- Characteristic Strength = Grade of Concrete
- Defined as compressive strength of concrete specimen after 28 days of curing

  M25, M30, M35, M40, etc., ……
- Is Characteristic Strength = Design Strength ?
- No

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Characteristic Strength vs Design Strength

- **Design Strength = Target Mean Strength**

  = Characteristic Strength + Margin

<u>Target Mean Strength</u>

$$f'_{ck} = f_{ck} + 1.65 \times S \quad or \quad f_{ck} + 2.33 \times S$$

f'_{ck} = Target Mean Strength

f_{ck} = Characteristic compressive strength in 28 days

S = Standard Deviation

1.65 ➔ Not more 5% of the results falls below characteristic value

2.33 ➔ Not more 1% of the results falls below characteristic value

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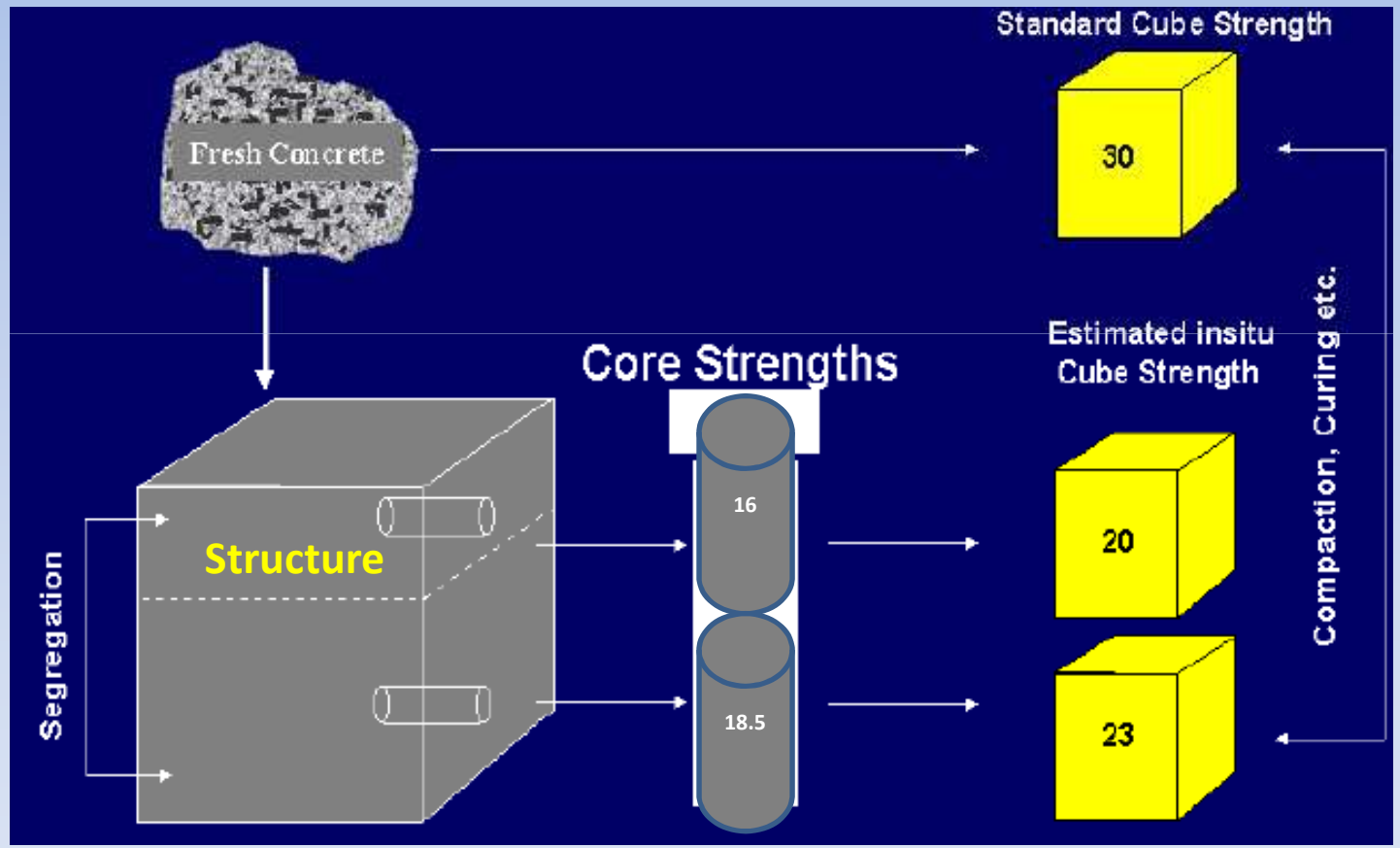
Labcrete vs Sitecrete Courtesy: Prof.Basheer, QUB, UK



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Sampling and Testing of Cube Specimen

- 150mm X 150mm X 150mm – IS, BS EN, SS
- 100mm X 100mm X 100mm (for MSA<20mm) – IS, BS EN, SS

- Sampling as per IS 1199:1959 & IS 4926:2003
- Making Cube Specimen as per IS 516:1959
- Curing Cube Specimen as per IS 516:1959
- Testing Cube Specimen as per IS 516:1959

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Cube Mould Preparation – Fixing & Oiling

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Cube Mould Preparation – Ensuring Shape

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Sampling Sufficient volume (0.03 cum for 6 cubes) to get consistent results

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Filling and Compaction in 3 Equal layers with minimum of 35 strokes

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Cube Specimen Identification Marking

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De-moulding specimens

- It must be ensured that concrete has attained hardened state before de-moulding
- De-moulding shall be done with utmost care to prevent any damage, external and internal, to the specimen
- One day old specimen is like a “New Born Baby”

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Loosening Base Plate

Lifting from Base Plate

Loosening Site Plates

Lifting Moulds gently

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Curing to prevent loss of moisture

- The test specimen shall be stored at the site in a place free from vibration, under damp matting, sacks or other similar material for 24 hours ± ½ hour from the time of adding the water to the other ingredients

- Lifting and leading shall be done with proper care to avoid impact on specimen

- The specimen shall be stored in water at a temperature of 27° ± 2℃ until the time of test

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Curing to prevent loss of moisture

Curing specimen in water at a temperature of 27°± 2° C until the time of test

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Transportation of test specimens

- Avoid loss of moisture and deviations from the required temperature at all stages of transport, by, for example,

  packing the hardened test specimens in wet sand or wet sawdust or wet cloths, or sealed in plastic bags containing water

- Avoid vibration to specimen while lifting and transportation

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Handle with Care

Cube Care

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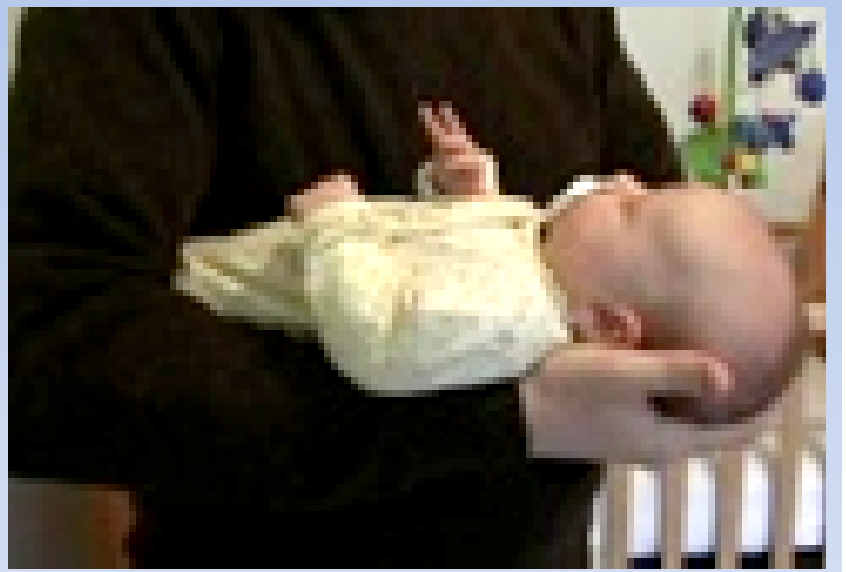
Baby Care



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Testing – Digital Equipment is preferred over Analog

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Testing – Loading Rate for 150 mm cube (140kg/cm^2/min or 5.25 N/Sec +/- 5%)

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Interpretation of Test Results

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IS 456 Interpretation of Test Results of Sample

- The test results of the sample shall be the average of the strength of three specimen
- The individual variation should not be more than 15% of the average.
- If more, the test results of the sample are invalid

Concrete shall be deemed to comply with the strength requirements when both the following condition are met:

- The mean strength determined from any group of four consecutive test results compiles with the appropriate limits in col 2 of Table 11
- Any individual test result complies with the appropriate limits in col 3 of Table 11.

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IS 456 Interpretation of Test Results of Sample

specified Grade	Mean of the Group of 4 Non-Overlapping Consecutive Test Results In N/mm2	Individual Test Results In N/mm2
(1)	(2)	(3)
M 20 or above	> fck + 0.825 X established SD (rounded off to nearest 0.5 N/ mm2) Or fck + 3 N/mm2, whichever is greater	> fck - 3 N/mm2

Only 5% results is expected to fall below "fck" when value of "k" used in design is 1.65
Only 1% results is expected to fall below "fck" when value of "k" used in design is 2.33

"fck actual" can be calculated when 30 or more results are available through
Mean Value – 1.65X k or Mean Value – 2.33 X k

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fck actual - Based on actual cube results

Date	Grade	OPC	Water	7 Days		Average	28 Days			Average
01.12.09	M25+	320	160	34.92	26.32	30.62	40.19	40.46	41.9	40.85
03.12.09	M25+	320	160	23.79	27.04	25.42	38	39.57	39.8	39.12
04.12.09	M25+	320	160	23.84	22.9	23.37	34.59	32.43	29.58	32.20
06.12.09	M25+	320	160	22.95	23.83	23.39	31.47	32.48	30.42	31.46
08.12.09	M25+	320	160	29.24	26.22	27.73	38.68	33.18	35.54	35.80
08.12.09	M25+	320	160	29.24	26.22	27.73	39.56	35.87	37.98	37.80
10.12.09	M25+	320	160	19.42	18.5	18.96	26.88	29.88	30.04	28.93
11.12.09	M25+	320	160	24.16	28.17	26.17	38.56	43.05	39.98	40.53
16.12.09	M25+	320	160	23.43	26.39	24.91	35.31	39.11	35.02	36.48
19.12.09	M25+	320	160	24.43	27.8	26.12	35.75	37.46	38.12	37.11
21.12.09	M25+	320	160	18.84	18.87	18.86	40.73	36.27	37.64	38.21
					SD	3.58			SD	3.85
					AVERAGE	24.84			AVERAGE	36.23

For illustration purpose

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f_{ck} actual – Based on actual cube results

- **f_{ck} actual = 36.23 – 2.33 * 3.85**

  = 27.25 MPa > 25 MPa

  hence OK

For illustration purpose

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Factors affecting Test Results

- Material – Parent Batch of the Sample (w/c, bleeding, segregation)

- Men – Mould Preparation, Sampling, Compaction, De-Moulding, Curing, Handling, Identification & Testing

- Machine – Capacity, Stability, Accuracy (Digital is Preferable), Hardness of Machine, Platens & Calibration

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Simple Mistakes can reduce the strength of Concrete cubes

So

“Do it right the first time”

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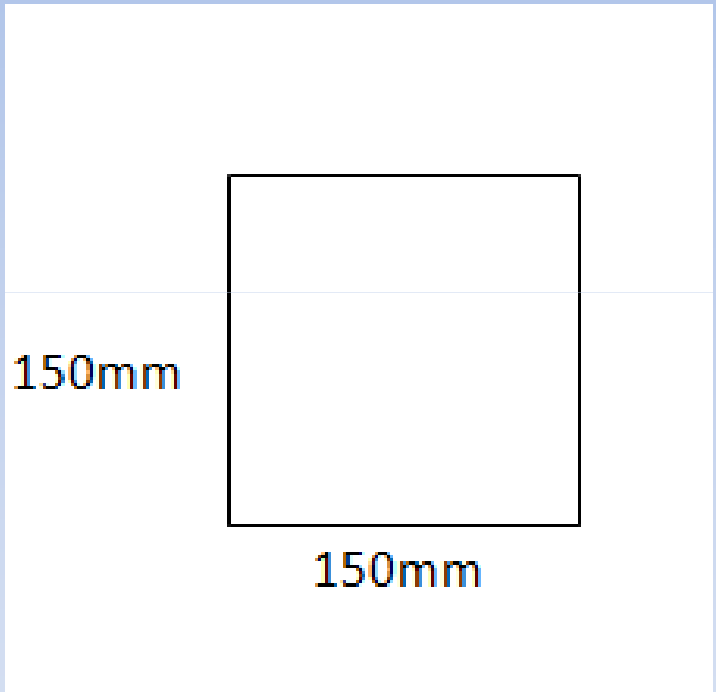
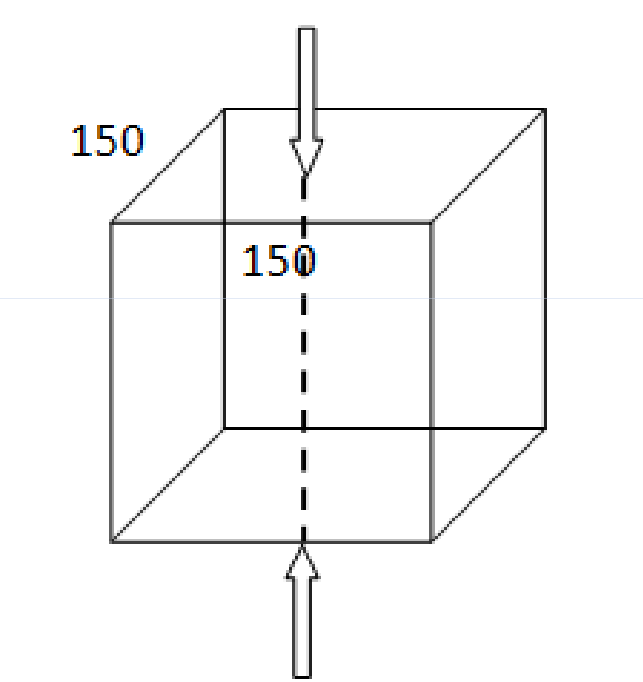
Simple Mistakes reduce the strength - Shape





Proper Shape ensures Equal Diagonal measurements and Uni-axial Loading

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Failure Pattern of Cube – BS EN 12390-3 : 2002

Explosive failure

NOTE All four exposed faces are cracked approximately equally, generally with little damage to faces in contact with the platens.

Figure 1 — Satisfactory failures of cube specimens

Satisfactory failure Patterns

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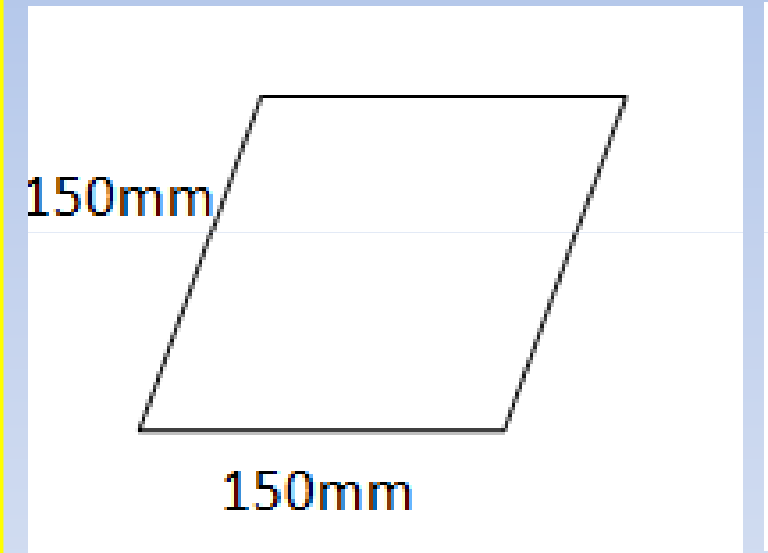
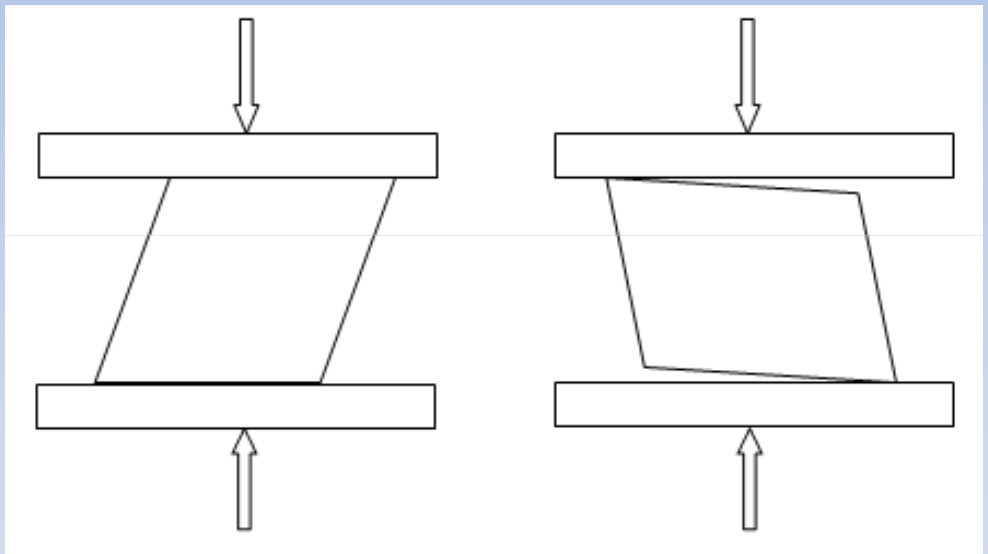
Simple Mistakes reduce the strength - Shape





Skew Shape resulting in Un-equal Diagonal measurements and eccentric loading

Eccentricity could pull strength down by 4 MPa or more

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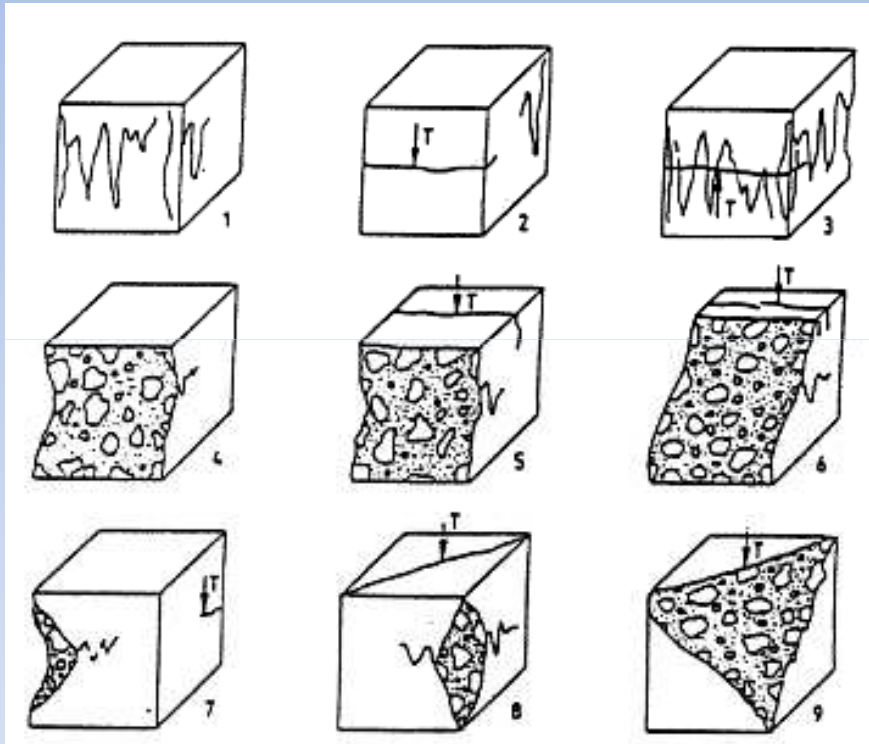
Failure Pattern of Cube – BS EN 12390-3 : 2002



NOTE T = tensile crack

Figure 2 — Some unsatisfactory failures of cube specimens

Eccentricity could pull strength down by 4 MPa or more

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Simple Mistakes reduce the strength - Poor Early Curing

Poor Early Curing will affect 28 day cube results

Cube specimen can loose internal moisture easily when exposed, due to larger surface area

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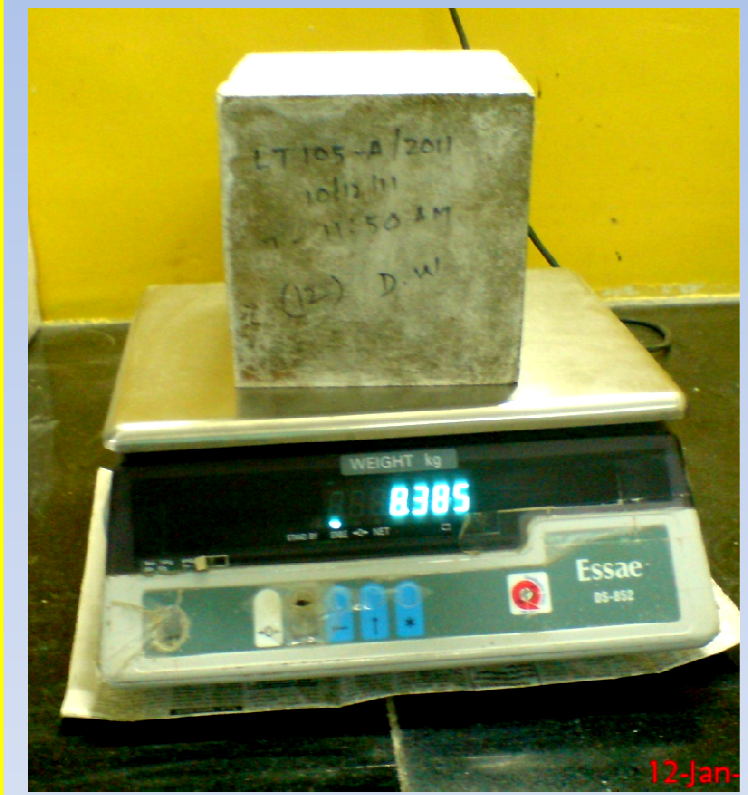
Simple Mistakes reduce the strength – Poor Compaction



Concrete Density in kg/cum	Volume of 150mm size cube	Corresponding Weight of cube in kg
2400	0.003375	8.100
2425	0.003375	8.184
2450	0.003375	8.269
2475	0.003375	8.353
2500	0.003375	8.438

Verifying Cube Weight to ensure Compacted Concrete Density

Low cube weight could be an indication of Poor Compaction

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Thank You

G.Sivakumar
sivakumar@icomat.in
+91 9790 777000

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