SESSION: 2

ASSURING QUALITY AT CONSTRUCTION SITES

(CIVIL WORKS)

Organized by:

Construction Development Board, CDB

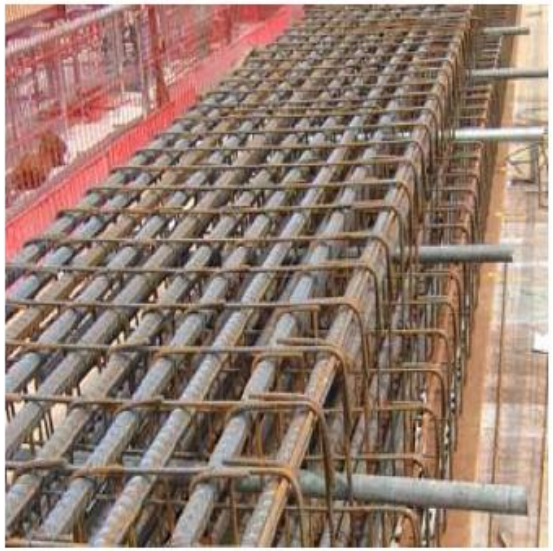
College of Science and Technology, CST

Karma Tempa

Part-1
Quality Assurance and Quality Control
In
Building Construction

QUALITY OF MATERIALS

BASIC PROPERTIES OF GOOD CONSTRUCTION MATERIALS



BRICKS and Brick Work

- Hard , free from cracks
- Give a metallic sound when hit by a hammer
- Should not break when dropped from a ht. of 1.5 m
- Min Strength - 3.5N/sq mm
- Soaked in water for about 1 hour before laying
- Laid not more than 1m ht a day

AGGREGATES -FINE AND COARSE

FINE AGGREGATE – SAND

Materials passing through 4.75 mm IS Sieve and entirely retained on 0.15mm sieve

Purpose

Prevent excessive shrinkage and cracking

Increase bulk and reduce cost

Improve strength

Properties

Sharp, gritty, free from dust and organic materials

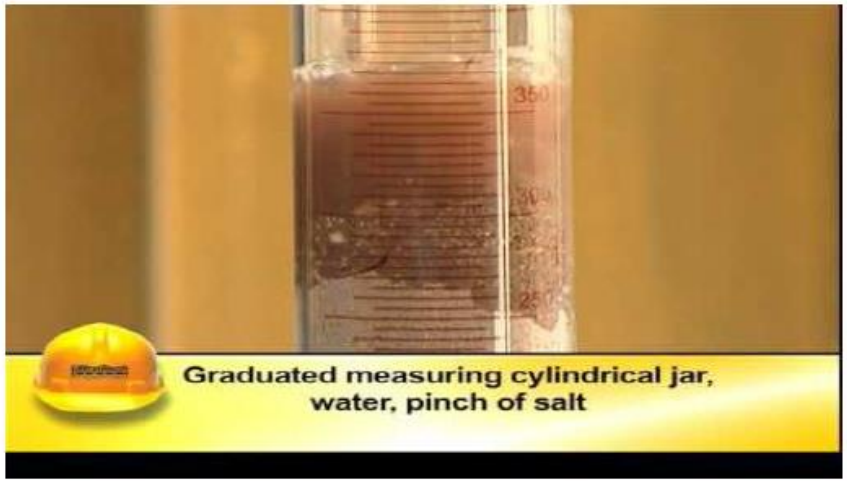
In natural river sand, the maximum quantity of silt shall not exceed 5%

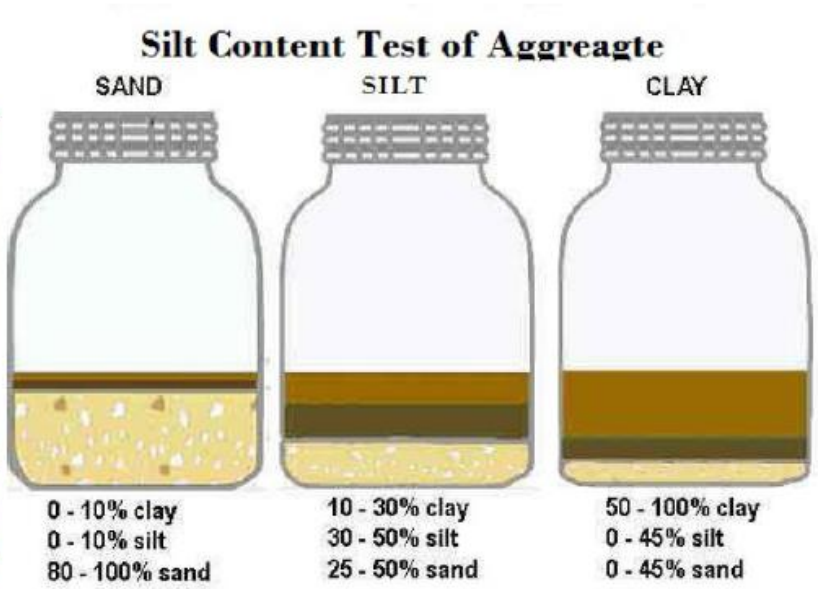
Sieve analysis test of Sand

Luwalaga John Groover

Quality of materials - sand

- In natural river sand, the maximum quantity of silt shall not exceed 5%
- In crushed sand, the amount of clay, fine silt and fine dust should not be more than 10%





Un-wanted substances in sand

TABLE 4 FINE AGGREGATES

(Clause 4.3)

IS Sieve Designation	Percentage Passing for			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10 mm	100	100	100	100
4·75 mm	90-100	90-100	90-100	95-100
2·36 mm	60-95	75-100	85-100	95-100
1·18 mm	30-70	55-90	75-100	90-100
600 micron	15-34	35-59	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15

NOTE 3 — Where concrete of high strength and good durability is required, fine aggregate conforming to any one of the four grading zones may be used, but the concrete mix should be properly designed. As the fine aggregate grading becomes progressively finer, that is, from Grading Zones I to IV, the ratio of fine aggregate to coarse aggregate should be progressively reduced. The most suitable fine to coarse ratio to be used for any particular mix will, however, depend upon the actual grading, particle shape and surface texture of both fine and coarse aggregates.

NOTE 4 — It is recommended that fine aggregate conforming to Grading Zone IV should not be used in reinforced concrete unless tests have been made to ascertain the suitability of proposed mix proportions.

AGGREGATES -FINE AND COARSE

COARSE – STONE GRAVELS

Materials passing through 63mm I.S Sieve and retained on 4.75mm

Grading of Coarse Aggregate

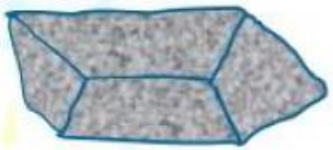
I.S. Sieve Designation	%age passing for graded aggregate of nominal size			
	40 mm	20 mm	16 mm	12.5 mm
80 mm	100	-	-	-
63 mm	-	-	-	-
40 mm	95 to 100	100	-	-
20 mm	30 to 70	95 to 100	100	100
16 mm	-	-	90 to 100	-
12.5 mm	-	-	-	90 to 100
10 mm	10 to 35	25 to 55	30 to 70	40 to 85
4.75 mm	0 to 5	0 to 10	0 to 10	0 to 10
2.36 mm	-	-	-	-

Portion of structure	The Nominal largest size of coarse aggregates	
	River Aggregates	Crushed Aggregates
Column, Beam, Slab, Wall	20,25 mm	20 mm
Footing	20,25,40 mm	20,25,40 mm

SHAPE OF AGGREGATES

Particle Shape and Surface Texture

- Important for compaction, deformation resistance, workability, binder requirement of bituminous mixes and workability in PCC



Angular

Rounded

Flaky

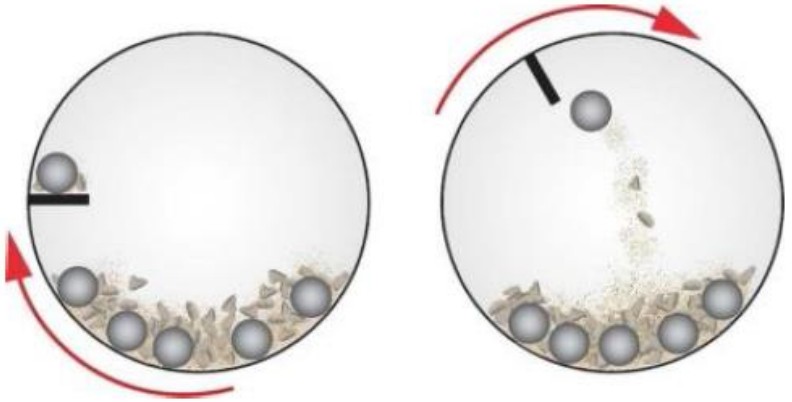
Elongated

Flaky & Elongated

IMPACT STRENGTH TEST

CRUSHING STRENGTH TEST

ABRASION TEST



RESULTS AND DISCUSSION

Aggregate Properties

Aggregate Test	Value (%)	Method
Aggregate Crushing Value (ACV)	42.57	BS 812 : Part 110 :1990
Aggregate Impact Value (AIV)	15.10	BS 812 :Part 112 : 1990
Flakiness Index (FI)	6.00	BS 812 :section 105.1 :1989
Elongation Index (EI)	42.00	BS 812 :Part 1: 1975
Los Angeles Abrasion Value (LAAV)	32.13	ASTM C: 131-81

CEMENT

CEMENT

ARTIFICIAL STONE

(LIME STONE + CLAY + Iron Ore) FLY ASH/SLAG GYPSUM

clinker *(3-5)%*

($CaCO_3$) (SiO_2) (Fe_2O_3 & Al) ($CaSO_4$)

HARDENS WHEN IN CONTACT WITH WATER AND BECOMES WATER RESISTANT THROUGH THE PROCEES OF *HYDRATION*

WHY THE NAME PORTLAND?

UPON SETTING IT RESEMBLES A LIMESTONE STONE FOUND IN A PLACE CALLED PORTLAND IN ENGLAND (COLOUR AND QUALITY SIMLILAR TO PORTLAND STONE)

TYPES OF CEMENT

BASED ON CONSTITUENT MATERIAL

- Ordinary Portland Cement
  (OPC) - Pure Lime stone + Clay and IronOre)
- Portland Pozzolona cement
  (PPC) – % Fly Ash, Residue of burned Coal from Thermal Power plants
- Portland Slag Cement
  (PSC) – % Slag from Blast furnace (Iron/steel)

BASED ON PROPERTIES

- Rapid Hardening Cement
  Higher C_3S and Finer clinker
  (Quick Setting)
- Low Heat Cement
  Higher C_2S
  (Mass concreting)
- Sulfate Resistance Cement
  Low C_3A and C_4AF
  (marine Environment, alternate wetting and drying)

Based on Strength

- Based on 28 days (Cube strength)
  - 33 Grade - 33MPa (IS -269)
  - 43 grade - 43MPa (IS - 8112)
  - 53 grade - 53Mpa (IS – 12269)

SETTING TIME

This test is to determine the time required for cement paste to harden.

Initial set can not be too early due to the requirement of mixing, conveying, placing and casting.

Final set can not be too late owing to the requirement of strength development.

Setting Time Test

Initial Setting Time : Not less than 30min

Final Setting Time : Not more than 600min

Physical Checks

- Lump free, cool to touch
- Greenish grey color
- When rubbed between fingers should feel smooth and not gritty
- A handful of cement thrown in a bucket filled with water should float for a while before finally settling down
- Used on "first in first out basis" but no later than 3 months from the manufacture date.

Storage and Strength of cement

Exposure to moisture looses strength.

Stored in a covered room with proper ventilation and free from moisture.

- Fresh - 100%
- After three months-reduces by 20%
- After 6 months by 30%
- After 12 months by 40%
- After 24 months by 50%
- With very excellent –air and moisture tight storage – can used after one year.

SOUND PRACTICES AT SITE

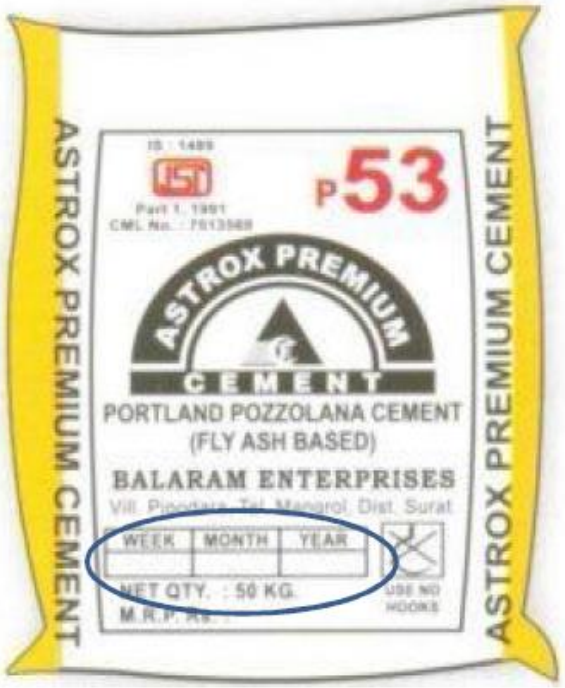
GOOD STORAGE : Accessible for inspection and identification, weather proof air tight and dry shed.

Should not come in contact with water or exposed to moisture.

When to reject cement:

Cement older than *3 months* from the date of manufacture must be retested.

Lumps inside the bag and hardened bags to be rejected.



Reinforcement Steel

Types of Rebars

- **Based on Manufacturing process**
  - 1- Plain Bar,
  - 2- Deformed bar
    - Cold Treated Bar – TOR (Twisted)
    - Hot Treated - TMT

- **Based on Grade (Strength)**
  - Fe 250 (Mild steel)
  - Fe 415 (HYSD)
  - Fe 500 (HYSD)

- **Based on Properties / Application**
  - Structural Steel : IS 2062
  - High strength steel bars and wires : IS1786
  - Electrical Steel
  - Mechanical Steel

LOOK FOR PROPER MARK

Test procedure to Verify TMT bars

1.Cut ‘small length samples’ from a few randomly selected TMT rebars of any lot, preferably in a cutting machine, if not, by hack-saw cutting.

2.Cross-sections of test samples shall be mirror finished with any suitable polishing device. An ideal polishing device is a unit with rpm of about 3000, wherein an emery sheet can be mounted on the rotating circular disc. Polishing of cross-sections shall be done for at least about 10 minutes.

3. The c/s shall be smeared (etched) with drops of 'Nitrol Solution. A synthesis of 10 % of Conc. Nitric Acid' and '90 % of Ethyl Alcohol'.

4. Soon after etching, two distinct phases (Shades) with uniform thickness are clearly visible on the c/s, if the rebars are 'Genuine TMT Rebars'.

If the two phases are not distinct, the rebars are either 'Substandard' or 'Fake' TMT rebars.

Note: It is essential that the c/s be examined soon after etching. In case of delay, etching to be redone

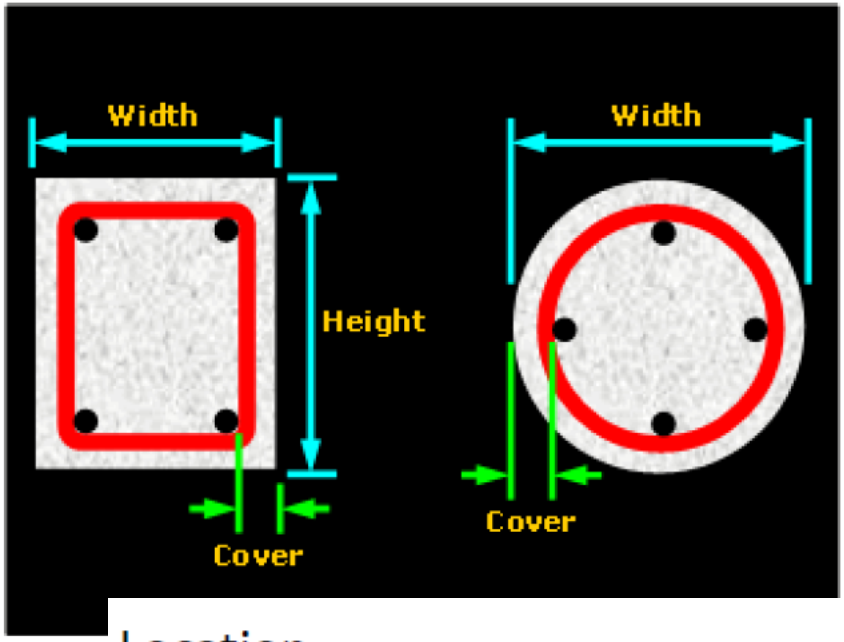
REINFORCEMENT STEEL

- Ensure that reinf. bars are free from rust/corrosion,

- Should not crack when bent beyond 90 deg.

Biggest Problem with Steel

Cover in RCC Works



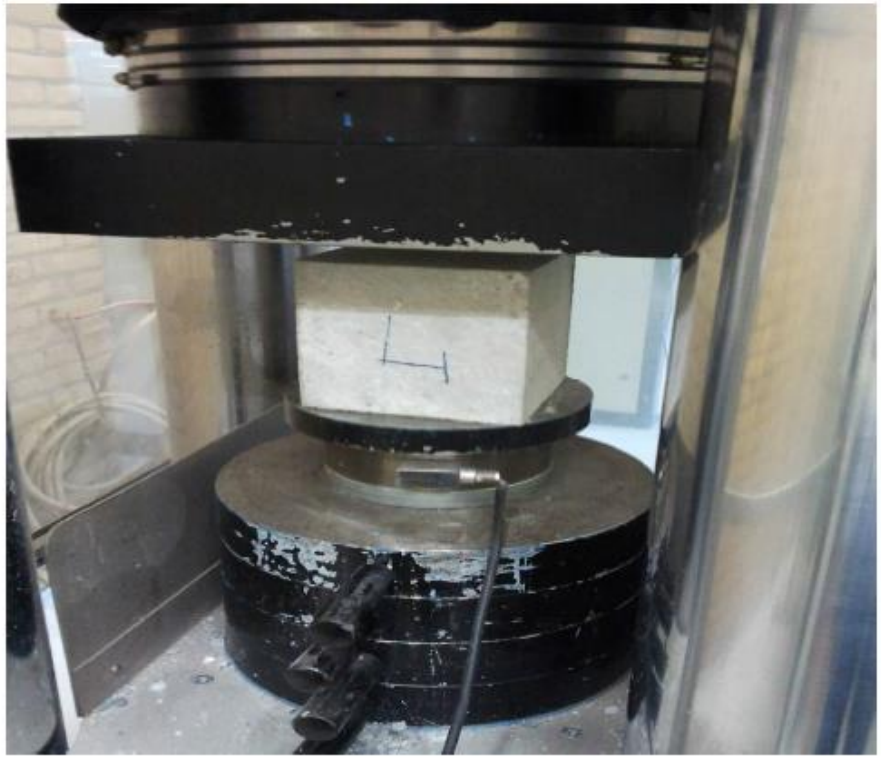
Location	Clear Cover
Slabs	20 mm
Beams - main reinforcement	30 mm
Beams – stirrups	20 mm
Columns – main reinforcement	40 mm
Column – ties	20 mm
Footings	75 mm

COVER BLOCKS

	20 / 25 mm	Slab, Wall
	20 mm	Slab
	L-40 mm	Column
	30 / 40 mm	Raft Foundation
	20 / 25 / 40 / 50 mm	Beam, Raft, Heavy Slab

CUBE STRENTH TEST

- 3 Cubes = average result should give the design strength (M20)
- None of the result should vary by more than 15%
- To be tested for every new mass concreting
- Where ever material source or preparation method is changed



Percentage strength of concrete at various ages:

The strength of concrete increases with age. Table shows the strength of concrete at different ages in comparison with the strength at 28 days after casting.

Age	Strength per cent
1 day	16%
3 days	40%
7 days	65%
14 days	90%
28 days	99%

Compressive strength of different grades of concrete at 7 and 28 days

Grade of Concrete	Minimum compressive strength N/mm^2 at 7 days	Specified characteristic compressive strength (N/mm^2) at 28 days
M15	10	15
M20	13.5	20
M25	17	25
M30	20	30
M35	23.5	35
M40	27	40
M45	30	45

Water cement ratio

Check on water cement ratio

- A large quantity of water is highly injurious for concrete as well as steel.
- More water means lesser strength and lesser life of concrete
- Excessive water can corrode steel reinforcement

Amount of Cement, Sand, Aggregate and Water in Different Grades of Concrete				
Mix	Ratio	Cement in Kgs	Sand in Kgs	Water in Litres
M5	1:5:10	141.00	785.00	70.50
M7.5	1:4:8	174.00	773.00	87.00
M10	1:3:6	226.00	753.60	113.00
M15	1:2:4	322.00 (www.civilread.com)	717.80	161.00
M20	1:1.5:3	403.20	672.00	201.60
M25	1:1:2	565.00	565.00	282.50
M30	1:1:3	452.00	452.00	226.00

The above values are approximate values and may change according to the presence of moisture content in the constituents.

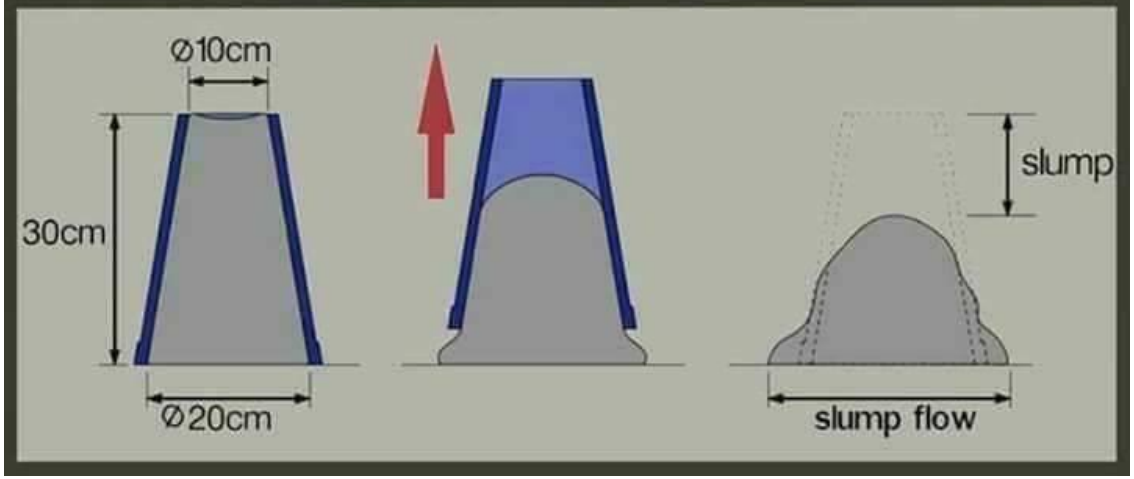
For more Details visit: www.civilread.com

Concrete Workability

- **How To improve the workability of concrete**
  - increase water/cement ratio
  - increase size of aggregate
  - use well-rounded and smooth aggregate instead of irregular shape
  - increase the mixing time
  - increase the mixing temperature
  - use non-porous and saturated aggregate
  - with addition of air-entraining mixtures

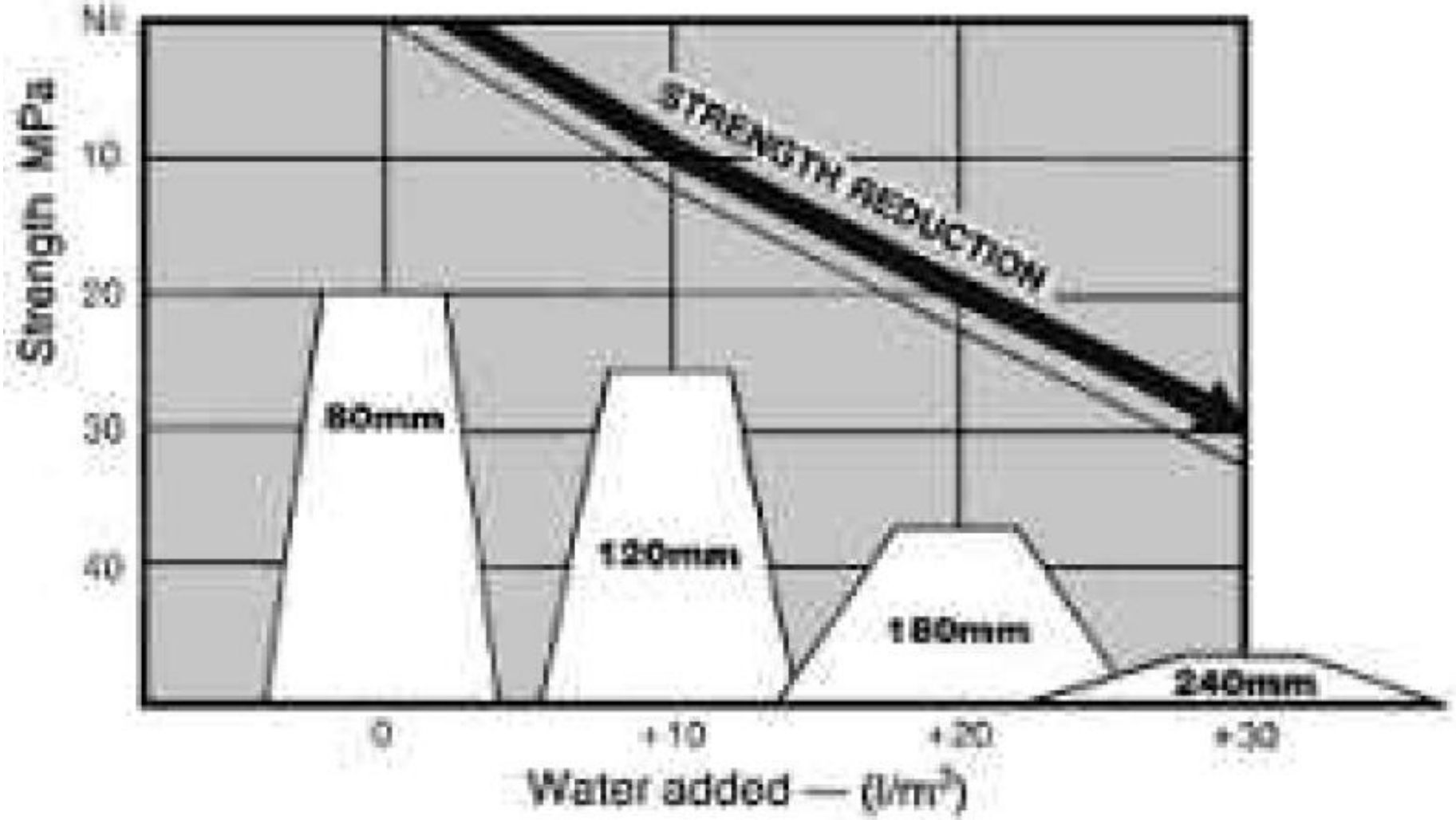
An on site simple test for determining workability is the SLUMP TEST.

SLUMP TEST



SLUMP TEST

	Work	SLUMP (in mm) Vibrators Used	Not used
1.	Mass concrete in R.C.C. foundation footings, and retaining walls.	10-25	80
2.	Beams slabs and columns simply reinforced.	25-40	100-125
3.	Thin R.C.C. section or section with congested steel.	40-50	125 -150


Nil
10
20
30
40
Strength MPa
STRENGTH REDUCTION
80mm
120mm
180mm
240mm
0
+10
+20
+30
Water added — (l/m³)

Hand mixing

- Shall be done on smooth, clean and water tight platform
- Measured qty of sand and Aggregate spread evenly
- Cement shall be dumped on the sand and distributed evenly
- Mixed with spade over over again
- spread out and measured qty of aggregates shall be added.
- A hollow shall be made in the middle of the mixed pile
- ¾ of the total quantity of water required shall be added while the material is turned in towards the centre with spades. Then add rest of the water and mix continuously until a uniform colour and consistency is obtained

Machine Mixing sequence:

Coarse aggregate should be placed in the hopper first followed by sand and cement.

A small proportion of water should be added in the drum prior to the addition of the dry materials in it.

Machine mixing time – minimum 2 minutes

POURING

Ensure that concrete is not dropped for heights > 1m

Concrete Segregation

- **Definition**
  - Segregation is when the coarse and fine aggregate, and cement paste, **become separated**. Segregation may happen when the concrete is mixed, transported, placed or compacted

  - Segregation makes the concrete
    - WEAKER,
    - LESS DURABLE,
    - and will leave A POOR SURFACE FINISH ^_*


Segregation of Concrete

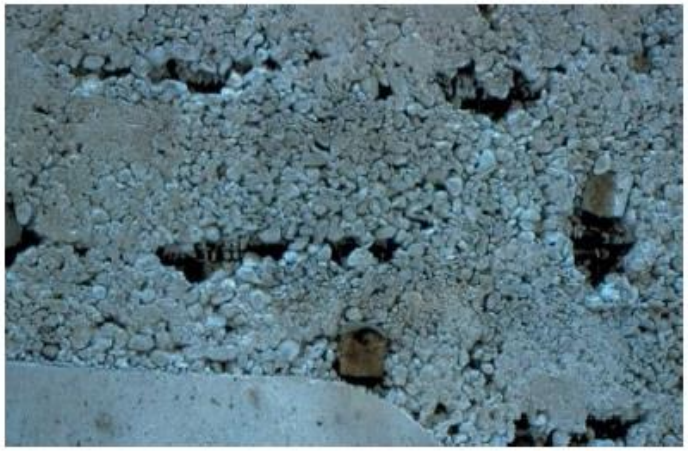
COMPACTION

Both under-compaction as well as over-compaction are bad for concrete.

- Under-compaction for formation of honeycomb
- Over-compaction or excessive use of vibrator causes bleeding/segregation of concrete

COMPACTION

- Needle vibrator may be used for about 5-10 sec only at each location



Striping of formworks

Type of formwork	Minimum period before striking formwork
Vertical formwork to columns, walls and beams	16 – 24 h
Soffit formwork to slabs (props to be refixed immediately after removal of formwork)	3 days
Soffit formwork to beams (props to be refixed immediately after removal of formwork)	7 days
Props to slabs spanning upto 4.5 m	7 days
Props to slabs spanning over 4.5 m	14 days
Props to beams and arches spanning upto 6 m	14 days
Props to beams and arches spanning over 6 m	21 days

CURING

All concrete works must be cured – cold weather included

In order to prevent loss of moisture from the recently placed concrete, concrete has to be cured for a min of 10-14 days from the date of placing the concrete.

Checklist for assuring quality

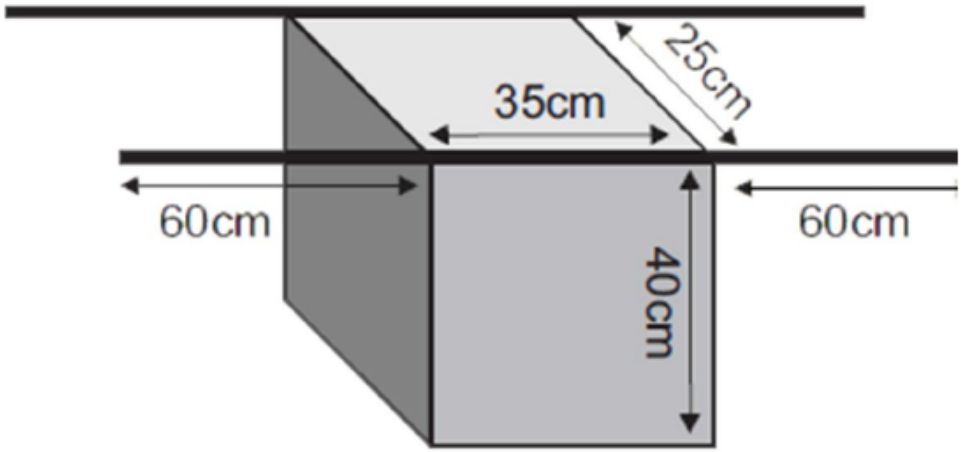
Never spray dry cement on a wet surface to take up excess water. This can form a paste that will break off easily.

Measurement box

- In the case of volume batching, the commonly used dimension of measurement box is:
  - L = 35 cm
  - B = 25 cm
  - D = 40 cm

- The volume of measurement box (25x35x40) = (0.035 cum) which is the volume of 1 bag of cement and it is not equal to one cft !

- In the case of mix design, the measurement differs



Simple ways to Assure Quality

- Timely Supervision
- Use of Approved materials
- Proper storage and stacking
- Basic field testing
- Adherence to Specification
- Proper Planning

Certificate of Approval

This is to certify that Product brand named

is approved for use
in the construction industry of Bhutan

Date of Issue: Valid until:

Certificate No.:

Convener **Director**
SQCA

Standards & Quality Control Authority
Ministry of Works & Human Settlement
Royal Government of Bhutan

End of Session-02

Thank you