CONSTRUCTION AND QUALITY CONTROL OF FLEXIBLE AND RIGID PAVEMENTS

Laboratory Tests on Cement, and Cement Concrete

National Rural Infrastructure Development Agency

Ministry of Rural Development

National Institute of Technology

Warangal, Hyderabad

Lecture-4

Laboratory Tests on Cement, and Cement Concrete

Which Cement to be used ???

Bogue's Compounds (Tornebohm)

Name of the Compound	Formula	Abbr. Formula
Tricalcium Silicate (Alite)	$3\ CaO.\ SiO_2$	C_3S
Dicalcium Silicate (Belite)	$2\ CaO.\ SiO_2$	C_2S
Tricalcium Aluminate (Celite)	$3\ CaO.\ Al_2O_3$	C_3A
Tetracalcium aluminoferrite (Felite)	$4\ CaO.\ Al_2O_3\ Fe_2O_3$	C_4AF

HYDRATION OF CEMENT

Hydration of C_3S

$$2C_3S + 6H \rightarrow C_3S_2H_3 + 3Ca(OH)_2$$

$$100 + 24 \rightarrow 75 + 49$$

Hydration of C_2S

$$2C_2S + 4H \rightarrow C_3S_2H_3 + Ca(OH)_2$$

$$100 + 21 \rightarrow 99 + 22$$

Calcium-Silicate–Hydrate

$C_3S_2H_3$ (C-S-H Gel)

Desirable

Calcium Hydroxide

$Ca(OH)_2$

Un Desirable

Hydration of C_3S

- Very Rigorous
- More Heat of Hydration
- More C_3S in High grade cements
- Responsible for Early Strength of concrete
- Quality & Quantity of C-S-H Gel is inferior / less
- More quantity of $Ca(OH)_2$

Hydration of C_2S

- Less Rigorous
- Less Heat of Hydration
- Less C_2S in High grade cements
- Responsible for Later Strength of concrete
- Quality & Quantity of C-S-H Gel is Superior / more
- Less quantity of $Ca(OH)_2$

Why $Ca(OH)_2$ Un Desirable?

$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

$CaCO_3$ Leaches out as white patches

High Grade OPC – Less Durable!!!

- High Grade Cement has more C_3S and less C_2S
- Quantity and Quality of C-S-H Gel produced by C_3S is Less
- Quantity of $Ca(OH)_2$ produced by C_3S is more
- C-S-H is desirable & $Ca(OH)_2$ is undesirable
- $Ca(OH)_2$ reacts with sulphates (present in soils) to form $CaSO_4$ – this $CaSO_4$ reacts with C_3A (in presence of water) – Calcium Sulpho Aluminate – Ettringite – Sulphate attack
- $Ca(OH)_2$ is alkaline- pH of 13 – prevents corrosion of steel

What is the solution?

Blended Cements (PPC)

$$Ca(OH)_2 + SiO_2 + H_2O \rightarrow C\text{-}S\text{-}H$$

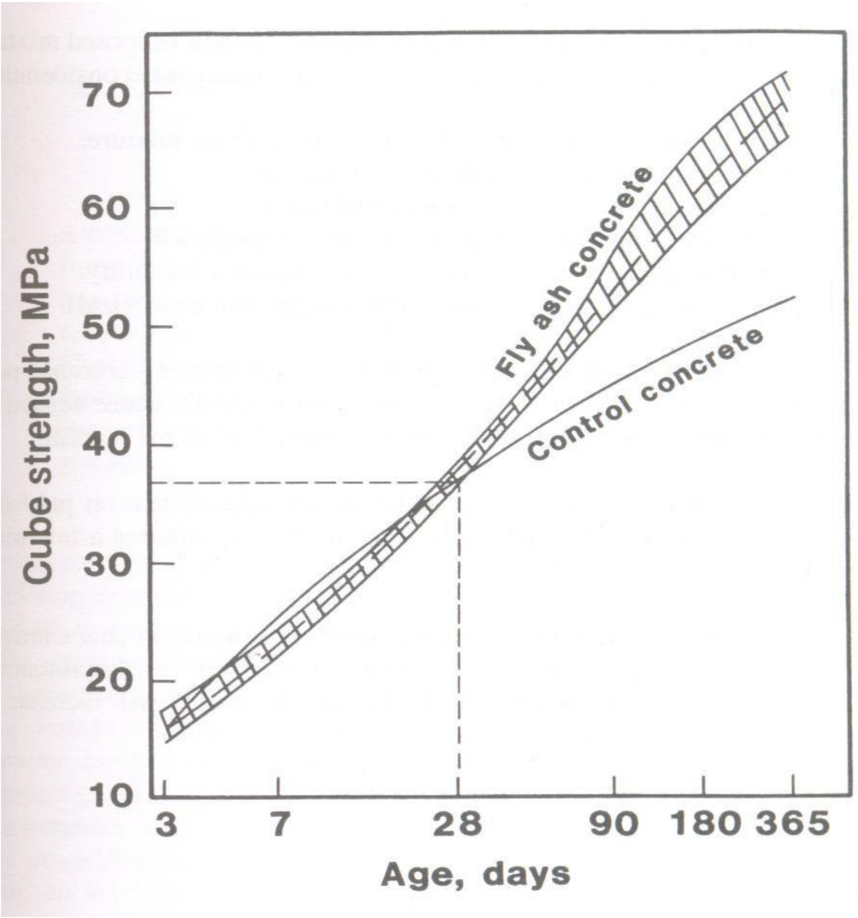
C-S-H much dense, Inert, impermeable, suitable for marine conditions.

Limitations - Low Early Strength,

Final strength is equal to more than OPC

This reaction is called as Pozzolanic Reaction

This SiO_2 comes from Pozzolanic materials – Natural or Artificial admixtures – Industrial wastes (Fly ash, GGBFS, SF, RHA etc.,)



BENEFITS OF BLENDED CEMENTS (PPC)

Improved Workability, Impermeability, Durability

Resistance against Alkali Aggregate Reaction, Sulphate Attack, Carbonation, Chloride Ion Penetration, Chemical attack

Low Heat of Hydration, Thermal Shrinkage, Leaching of $Ca(OH)_2$, Low cost, Low Shrinkage, Low Creep, Less vulnerable to cracking

Promotes use of industrial wastes – Eco friendly – Helps reduce pollution – Sustainability

Suitable for marine construction, underground construction

Portland Pozzolana Cement – IS 1489 (Part-1) 2015 – Flyash based
Portland Pozzolana Cement – IS 1489 (Part – 2) 2015 - Calcined Clay based
Portland Slag Cement – IS 455 - 1989

Water Requirement for Hydration of Cement

- C_3S requires 24% water & C_2S required 21% water – Average 23%
- 23% water is required for chemical reaction – BOUND WATER
- Some water is imbibed in Gel pores – GEL WATER
- About 15% water is required to fill up the Gel Pores – GEL WATER
- 38% Water is required for complete reaction & occupy the Gel Pores.
- If water is less than 38% - complete hydration is not possible – High Strength Concrete (HSC)
- If water is more than 38% - Gel will be less dense – Undesirable –Increase Permeability - Prone to early deterioration
- Lower water content – Gel will be more dense – Impermeable – Most Desirable – Unhydrated particles of cement if any (in HSC) will hydrate at a later age and fill the cracks – Hence improved durability

Ordinary Portland Cement Specification – IS 269 - 2015

- Table – 1 – Performance Improvers; Table – 2 – Chemical Requirements for OPC

Table 3 Physical Requirements for Ordinary Portland Cement

(*Clause* 7)

Sl No.	Characteristic	Requirement					Method of Test, Ref to
		OPC 33	OPC 43	OPC 43S	OPC 53	OPC 53S	
(1)	(2)	(3)	(3)	(3)	(3)	(3)	(4)
i)	Fineness, m^2/kg, *Min*	225	225	370	225	370	IS 4031 (Part 2)
ii)	Soundness:						IS 4031 (Part 3)
	a) By Le-Chatelier method, mm, *Max*	10 (*see* Note 1)	10 (*see* Note 1)	5 (*see* Note 1)	10 (*see* Note 1)	5 (*see* Note 1)	
	b) By autoclave test method, percent, *Max*	0.8 (*see* Note 1)	0.8 (*see* Note 1)	0.8 (*see* Note 1)	0.8 (*see* Note 1)	0.8 (*see* Note 1)	
iii)	Setting time:						IS 4031 (Part 5)
	a) Initial, min, *Min*	30 (*see* Note 2)	30 (*see* Note 2)	60 (*see* Note 2)	30 (*see* Note 2)	60 (*see* Note 2)	
	b) Final, min, *Max*	600 (*see* Note 2)	600 (*see* Note 2)	600 (*see* Note 2)	600 (*see* Note 2)	600 (*see* Note 2)	
iv)	Compressive strength, MPa (*see* Note 4):						IS 4031 (Part 6)
	a) 72 ± 1 h, *Min*	16	23	23	27	27	
	b) 168 ± 2 h, *Min*	22	33	37.5	37	37.5	
	c) 672 ± 4 h, *Min*	33	43	43	53	53	
	Max	48	58	–	–	–	
v)	Transverse strength (optional)	*See* Notes 3 and 4	*See* Notes 3 and 4	*See* Notes 3 and 4	*See* Notes 3 and 4	*See* Notes 3 and 4	IS 4031 (Part 8)

DETAILS OF IS 4031 (ALL PARTS)

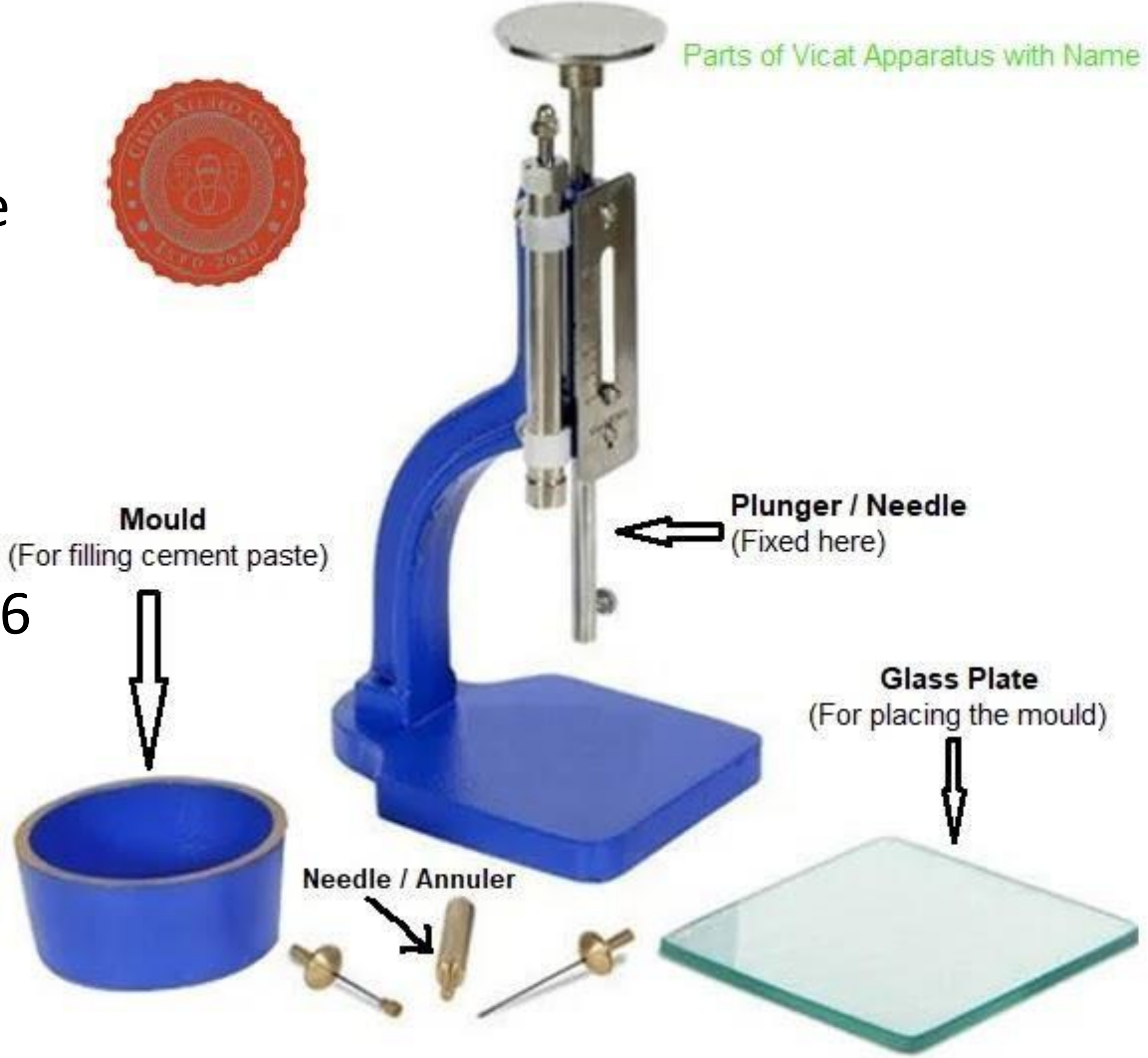
- PART 1 DETERMINATION OF FINENESS BY DRY SIEVING
- PART 2 DETERMINATION OF FINENESS BY BLAINE AIR PERMEABILITY METHOD
- PART 3 DETERMINATION OF SOUNDNESS
- PART 4 DETERMINATION OF CONSISTENCY OF STANDARD CEMENT PASTE
- PART 5 DETERMINATION OF INITIAL AND FINAL SETTING TIMES
- PART 6 DETERMINATION OF COMPRESSIVE STRENGTH OF HYDRAULIC CEMENT OTHER THAN MASONRY CEMENT
- PART 7 DETERMINATION OF COMPRESSIVE STRENGTH OF MASONRY CEMENT
- PART 8 DETERMINATION OF TRANSVERSE AND COMPRESSIVE STRENGTH OF PLASTIC MORTAR USING PRISM
- PART 9 DETERMINATION OF HEAT OF HYDRATION
- PART 10 DETERMINATION OF DRYING SHRINKAGE
- PART 11 DETERMINATION OF DENSITY
- PART 12 DETERMINATION OF AIR CONTENT OF HYDRAULIC CEMENT MORTAR
- PART 13 MEASUREMENT OF WATER RETENTIVITY OF MASONRY CEMENT
- PART 14 DETERMINATION OF FALSE SET
- PART 15 DETERMINATION OF FINENESS BY WET SIEVING

Testing of cement in Laboratory

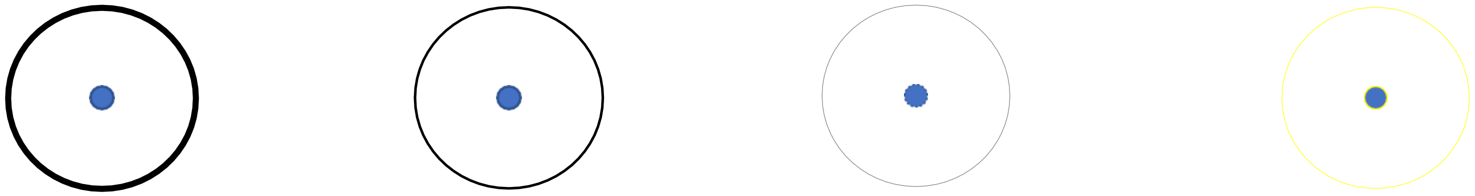
- Standard Consistency of Cement (If water required is P)
- Initial & Final Setting time (Amount of water required is 0.85P)
- Specific Gravity of cement
- Compressive Strength of Cement (Amount of water (0.25P+3)% of (wt of cement + Sand)
- Fineness of Cement
- Soundness of Cement (Amount of water 0.75P)

Standard Consistency of Cement

- Amount of water required for preparing the standard cement paste.
- The result of this test will be required for the following THREE TESTS
- Initial Setting Time & Final Setting Time
- Compressive Strength of Cement
- Soundness Test
- IS Code for Vicat's Apparatus – IS 5513 – 1996
- IS Code for Determination of Consistency of Standard Cement Paste – IS 4031 (Part -4) 1988
- IS Code for Determination of Initial & Final Setting time – IS 4031 (Part 5) 1988



FINAL SETTING TIME



The period elapsing between the time when water is added to the cement and the time at which the needle makes an impression on the surface of test block while the attachment fails to do so shall be the final setting time.

COMPRESSIVE STRENGTH OF CEMENT – IS 4031 (PART 6)

- CEMENT + STANDARD SAND (IS 650)
- AMOUNT OF WATER (0.25P+3)% BY WT. OF CEMENT + SAND
- STANDARD SAND IS AVAILABLE @TAMILNADU MINERALS – TAMIN
- ENNORE SAND – ENNORE IS A BEACH NEAR CHENNAI
- CEMENT + SAND1(2mm to 1 mm) +SAND2 (1mm to 0.5 mm) +SAND3 (0.5 mm to 0.09 mm)= 200 GMS EACH
- TOTAL CEMENT + SAND = 800 gms
- Amount of water = (0.25P+3)% of 800 gms =
- Standard mixing – mould of 50 sq cm = 7.07 cm x 7.07 cm
- Curing and testing under standard conditions

AGGREGATES

- Concrete is TWO Phase material – Paste & Aggregates
- Paste – Cement + Water
- 70 TO 80% OF Concrete is aggregates
- Mostly Naturally available (In Future-Artificial Aggregates)
- Reduce Shrinkage in concrete
- Reduce cost
- Supposed to be INERT (Few Agg are not INERT – Alkali Agg Reaction)
- Important to know the properties of aggregates responsible for behavior in concrete

Issues to be Studied

- Classification
- Size
- Source
- Shape
- Strength
- Texture
- Sieve Analysis – Grading
- Moisture Content
- Specific Gravity and Bulk Density
- Thermal Properties
- Bulking Factor
- Soundness
- Cleanliness
- Chemical Properties

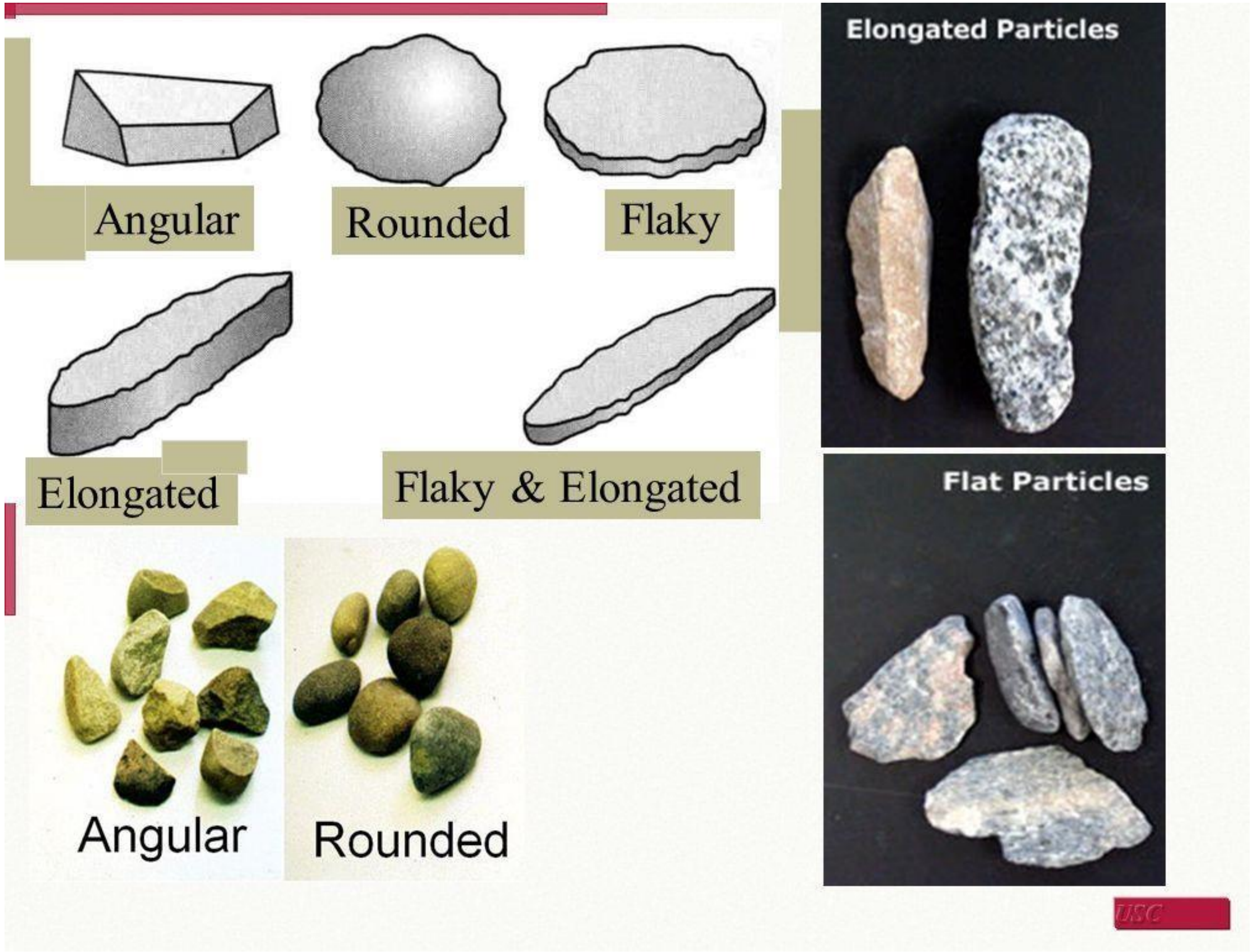
Classification of Aggregates

- Natural – River Sand, Gravel, Crushed Rock
- Artificial – Broken Brick, Air cooled Slag, Sintered Fly Ash, Bloated Clay, Shale, Construction & Demolished waste etc., (C & D Waste)
- Natural – Igneous rocks, Sedimentary rocks, Metamorphic rocks
- Igneous rocks – Solidification of molten rock – Granite, Basalt etc.,
- Sedimentary rocks – Deposition of weathered remains of rocks – Limestone, Clay, Sandstone, Shale etc.,
- Metamorphic rocks – Transformation of existing rock – Gneiss, Slate, Marble etc.,

Size of Aggregates

- Larger the size of aggregates – lower the consumption of cement, water, drying shrinkage – Higher Strength of Concrete
- Factors influencing – Thickness of section, Spacing of reinforcement, Clear cover, Mixing, handling & Placing techniques.
- Normally not more than 0.25 times thickness of the member
- < 4.75 mm – Fine aggregates, > 4.75 mm - Coarse Aggregates
- Maximum size of aggregate – 80 mm – Normally used in dams
- Size of aggregate is 5 mm less than the spacing of the reinforcement / Clear Cover
- For RCC normally – Nominal Size of aggregate shall be 20 mm.

SHAPE OF THE AGGREGATES



Shape of the aggregate

- Rounded – Water worn, River sands, Desert sands – Lower surface area - Better workability – No interlocking – Lower tensile strength – Satisfactory compressive strength
- Angular – Naturally irregular – more surface area – Lower workability – Better interlocking – better tensile strength - Desirable
- Flaky & Elongated – Not desirable – Not more than 40% (IS 383-2016)
- Quantification of Flakiness Index & Elongation Index
- IS 460-1985- Indian Standards For Test Seives
- ASTM – American Society for Testing Materials

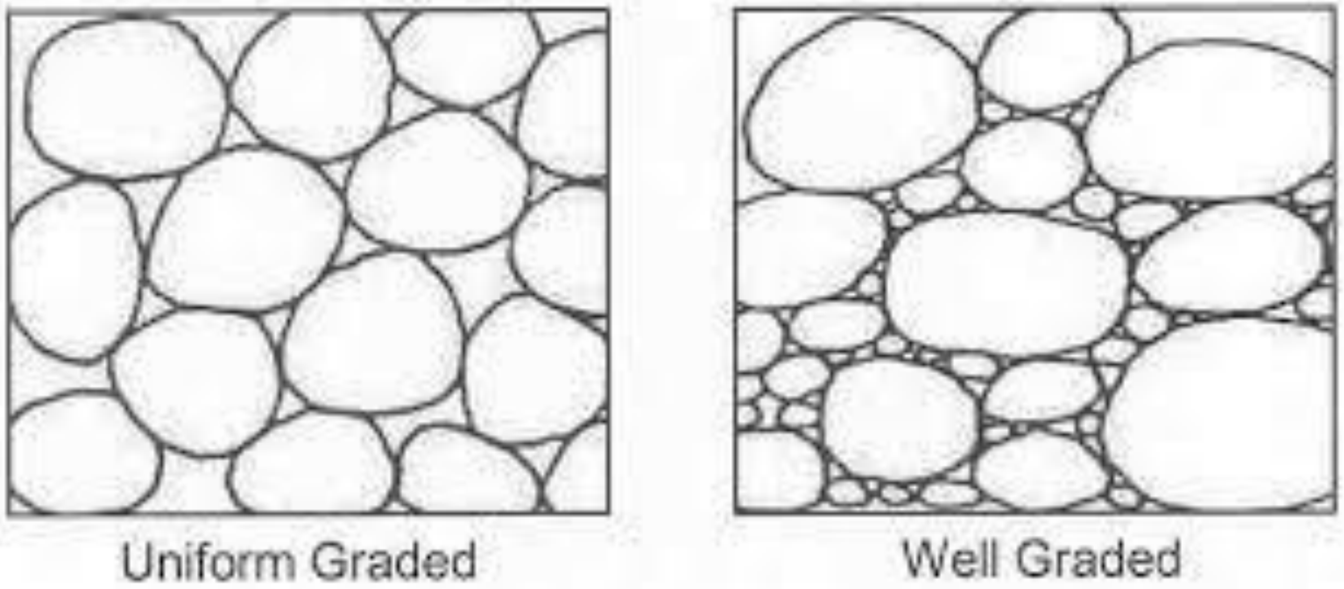
Texture of Aggregate

Rough Texture – More Friction – Requires more paste for workability

Smooth Texture – Less Friction – Requires less paste for workability

Rough Texture – Irregular shaped – desirable

Grading of Aggregate – Sieve Analysis



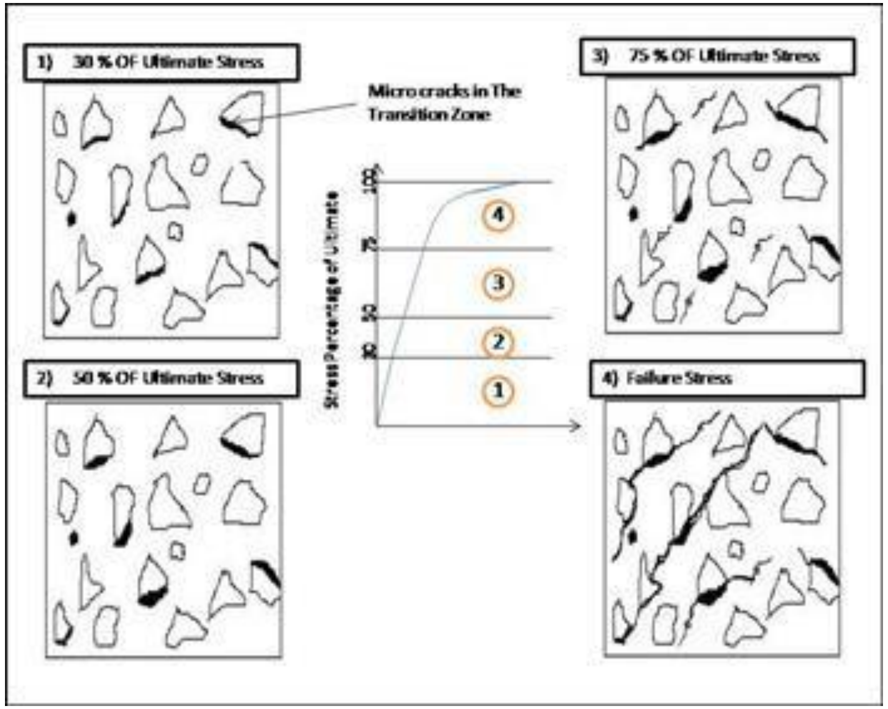
- Minimum Porosity of concrete – Topic active research
- Maximum strength
- Minimum permeability – Maximum durability
- Minimum consumption of cement – Improve durability
- Good workability – Good compactibility – Hence good strength & durability
- IS 383 – 2016

GRADING OF AGGREGATES

1. IS 460 Part 1- 1985 (Reaffirmed 1998) Specification for Test Sieves
2. IS 2386 (Part – I) – 1963 (Reaffirmed 2003) – Methods of test for aggregate for concrete – Particle size and shape
3. IS 383 – 1970 (Reaffirmed 2002) – Specifications for coarse and fine aggregate from natural sources for concrete
4. Fineness modulus is the parameter which indicates the fineness / coarseness of aggregates

FM of sand preferred for concrete – 3.2 to 3.5

Strength of Aggregate



Quantify the Strength IS 2386 (Part IV)

1. Aggregate Crushing Value
2. 10% fines value
3. Impact Strength of aggregate - Roads

If the paste is weaker than aggregate – cracking through the paste – Normal Strength Concrete – Strength Depends on strength of paste

If the paste is stronger than aggregate – cracking through the aggregate – High Strength Concrete – Strength Depends on the Strength of Aggregate

For Roads – Stronger aggregates
For Buildings – Lesser Strength of aggregates is required

Strength of Aggregate as per IS 383-2016

- Aggregate Crushing Value for aggregates to be used for Roads – 30 Percent (Maximum)
- Aggregate Impact Value for aggregates to be used for Roads – 30 Percent (Maximum)
- Aggregate Abrasion Value (Los Angeles machine) – 30 Percent (Maximum)

WHAT IS WORKABILITY?

- Workability for concrete – EASE WITH WHICH THE CONCRETE CAN BE WORKED WITH
- WORKING OF CONCRETE – EASE WITH WHICH THE CONCRETE CAN BE MIXED, TRANSPORTED, PLACED, COMPACTED & FINISHED
- THIN MEMBER – SLAB , PAVEMENT, STAIR CASE – LOW WORKABILITY
- BEAM COLUMN JOINT – REINFORCEMENT IS CONGESTED – VERY HIGH WORKABILITY – SELF COMPACTED CONCRETE
- BEAM – NORMAL WORKABILITY
- THEORETICAL WATER REQUIRED FOR COMPLETE HYDRATION OF CEMENT IS 0.38 (0.23 BOUND WATER + 0.15 GEL WATER)
- LESS THAN 0.38 – SOME CEMENT REMAINS UNHYDRATED – HIGH STRENGTH CONCRETE
- MORE THAN 0.38 – GEL IS MORE DILUTE AND HAS PORES – REDUCE DURABILITY
- MORTAR / CONCRETE – FA & CA – WILL REQUIRE MORE WATER FOR LUBRATION

FACTORS INFLUENCING WORKABILITY

- WATER / CEMENT RATIO – MORE W/C RATIO – MORE WORKABILITY – NORMAL STRENGTH CONCRETE
- HIGH STRENGTH CONCRETE – LESS W/C RATIO – LESS WORKABILITY – ADMIXTURES (PLASTICISER / SUPER PLASTICISER) TO IMPROVE WORKABILITY
- SHAPE OF AGGREGATE – ROUNDED – LESS SURFACE AREA – MORE WORKABILITY FOR A GIVEN W/C RATIO
- ANGULAR AGGREGATE – MORE SURFACE AREA – LESS WORKABILITY FOR A GIVEN W/C RATIO

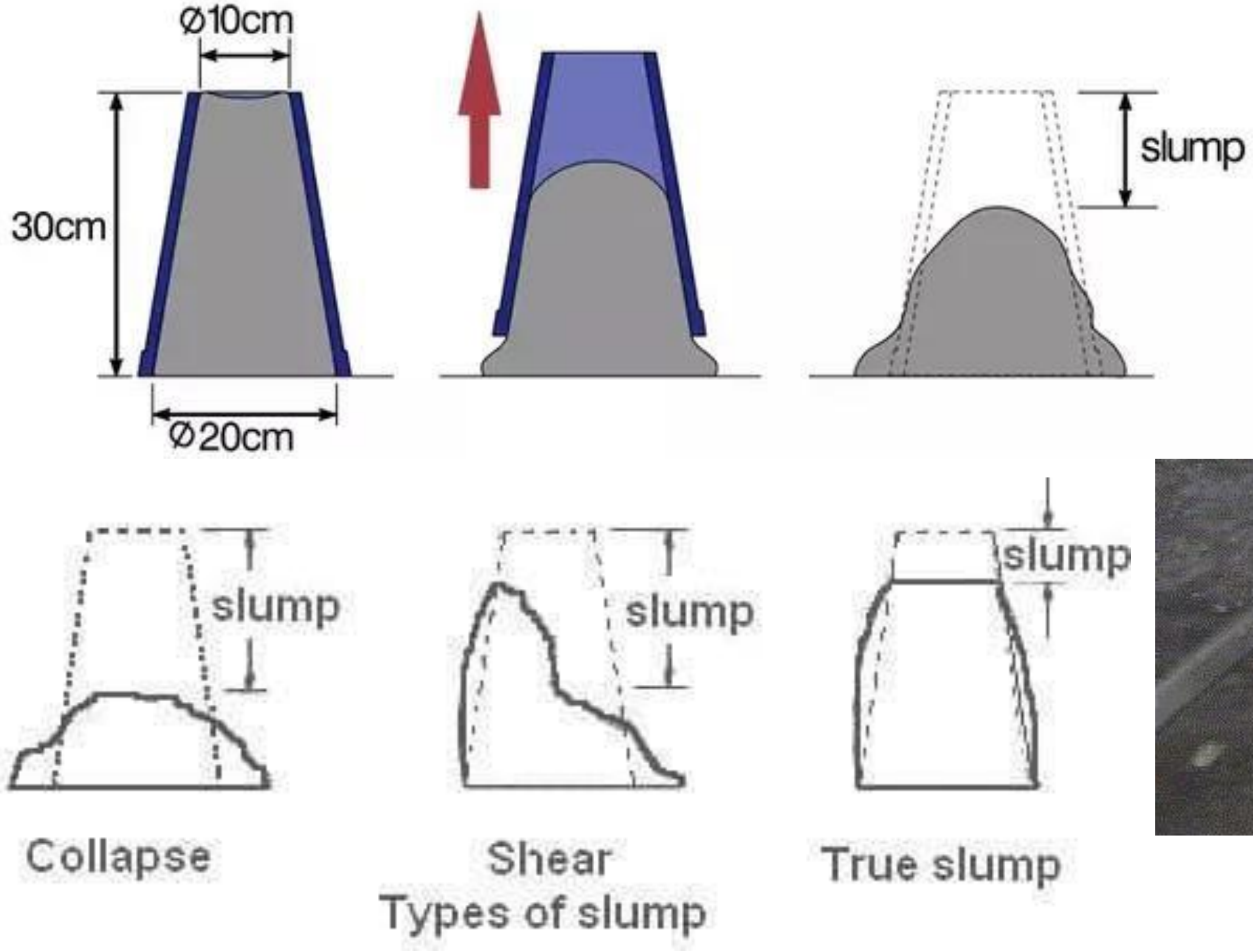
FACTORS INFLUENCING WORKABILITY

- SURFACE TEXTURE – ROUGH TEXTURE – MORE FRICTION – LESS WORKABILITY FOR A GIVEN W/C RATIO
- SMOOTH SURFACE TEXTURE – LESS FRICTION – MORE WORKABILITY FOR A GIVEN W/C RATIO
- GRADING OF AGGREGATE – WELL GRADED AGGREGATES – BETTER WORKABILITY – BETTER COHESIVITY
- POORLY GRADED AGGREGATE – POOR WORKABILITY – SEGGREGATE/ BLEEDING
- TYPE AND DOSAGE OF ADMIXTURES –
- BETTER WORKABILITY – BETTER COMPACTING – BETTER STRENGTH – BETTER FINISH - BETTER DURABILITY

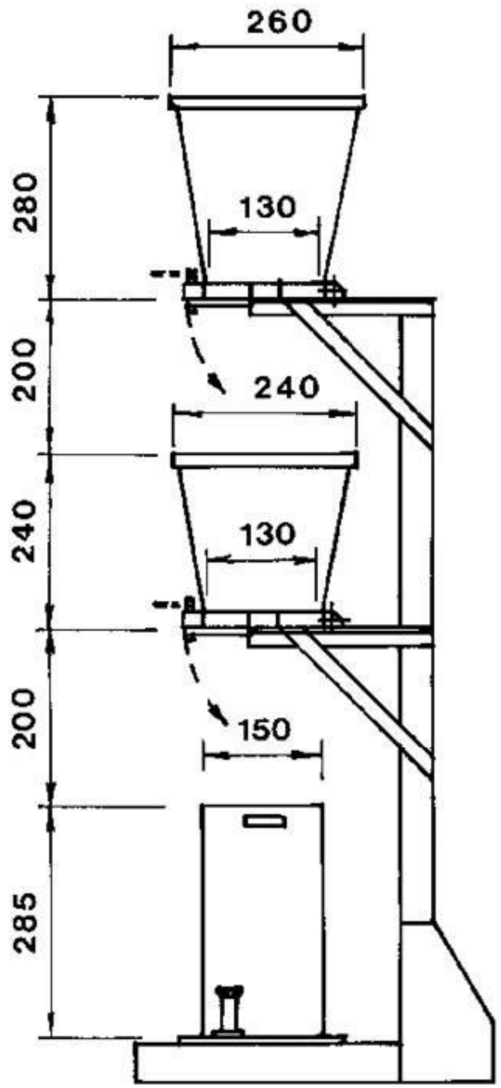
MEASUREMENT OF WORKABILITY

- SLUMP TEST – Rapid testing – suitable for site conditions
- COMPACTING FACTOR – Precise test – Suitable for all concretes
- VEE BEE CONSISTOMETER – Suitable for low workability concrete
- K-BALL TEST
- FLOW TEST – Very high workable concrete

SLUMP TEST – IS 1199



COMPACTING FACTOR TEST – IS 1199



RATIO OF PARTIALLY COMPACTED CONCRETE TO FULLY COMPACTED CONCRETE

IF THE CONCRETE IS WORKABLE IT WILL GET COMPACTED NORMALLY

VEE BEE DEGREE – VEE BEE CONSISTOMETER

- IS 1199
- Time in seconds to transform the shape of the concrete from the frustum of a cone to cylindrical shape is measured.
- Less Workability – more time
- More Workability – Less time

DISCUSSION

- WORKABILITY INCREASES WITH WATER CEMENT RATIO
- SLUMP INCREASES AS WORKABILITY INCREASES
- COMPACTING FACTOR INCREASES AS WORKABILITY INCREASES
- VEE DEGREE DECREASES WITH THE INCREASE OF WORKABILITY

Table 3.2. Suggested values of workability

Application	*Slump*	*Compaction Factor*	*Time in Vee-Bee*
1. Concreting of shallow sections with vibrations	—	0.75 – 0.80	10 – 20
2. Concreting of light reinforced sections with vibrators	—	0.80 – 0.85	5 – 10
3. Concreting of lightly reinforced sections without vibrations and heavily reinforced sections with vibrations	25 – 75 mm	0.85 – 0.92	2 – 5
4. Concreting of heavily reinforced sections without vibration	75 – 125 mm	More than 0.92	—

7 WORKABILITY OF CONCRETE

7.1 The concrete mix proportions chosen should be such that the concrete is of adequate workability for the placing conditions of the concrete and can properly be compacted with the means available. Suggested ranges of workability of concrete measured in accordance with IS 1199 are given below:

Placing Conditions	*Degree of Workability*	*Slump* (mm)
(1)	(2)	(3)
Blinding concrete; Shallow sections; Pavements using pavers	Very low	*See* **7.1.1**
Mass concrete; Lightly reinforced sections in slabs, beams, walls, columns; Floors; Hand placed pavements; Canal lining; Strip footings	Low	25-75
Heavily reinforced sections in slabs, beams, walls, columns; Slipform work; Pumped concrete	Medium	50-100 75-100
Trench fill; *In-situ* piling	High	100-150
Tremie concrete	Very high	*See* **7.1.2**

NOTE—For most of the placing conditions, internal vibrators (needle vibrators) are suitable. The diameter of the needle shall be determined based on the density and spacing of reinforcement bars and thickness of sections. For tremie concrete, vibrators are not required to be used (*see also* **13.3**).

Segregation & Bleeding of concrete

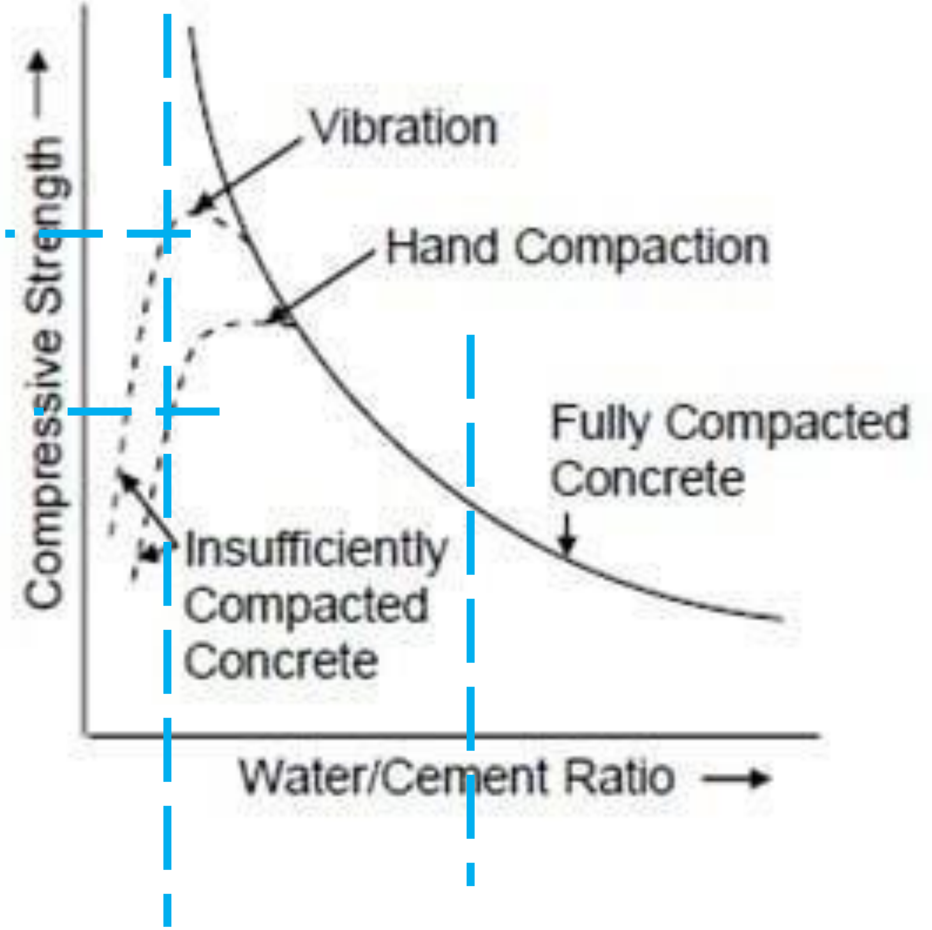
- When workability is very high – constituents of concrete tend to segregate.
- Very high w/c, improper grading of aggregates, Very high Specific Gravity of aggregates
- More vibration for highly workable concretes leads to segregation
- If the concrete is dropped from certain height
- If the concreting is done in hot sun – segregation of water - bleeding
- When the concrete segregates / bleeds and if the formwork is not leak proof – Honey combed concrete

Transportation of Concrete

- Manual transport – Rural areas – little concrete – When the concrete is dropped from height – segregation
- Cranes – For two or more floors – Trolleys and place the concrete
- Transit mixer – For more distances – Retarders to prevent setting of concrete during transit
- Conveyor belts – Industries/ casting yards
- For more heights – Concrete pumps – Self compacted concrete

Compaction of concrete

- Hand Compaction – Poking or Rodding - Crude method - Suitable for high workable concretes – Rural areas
- Plat form Vibrators – Suitable in prefabrication yards & laboratory
- Pan Vibrators – suitable for flat surfaces with shallow depths – Slabs, Pavements
- Needle Vibrators – suitable for compaction at depths – beams, columns – Diameter of needle depends on the spacing between the rebars and thickness of the member
- Shuttering Vibrators – Suitable for very low workable concrete – Effective – suitable for high strength concrete – Good finishing – Precast PSC elements
- Spinning – Centrifugal forces – Suitable for Hume pipes



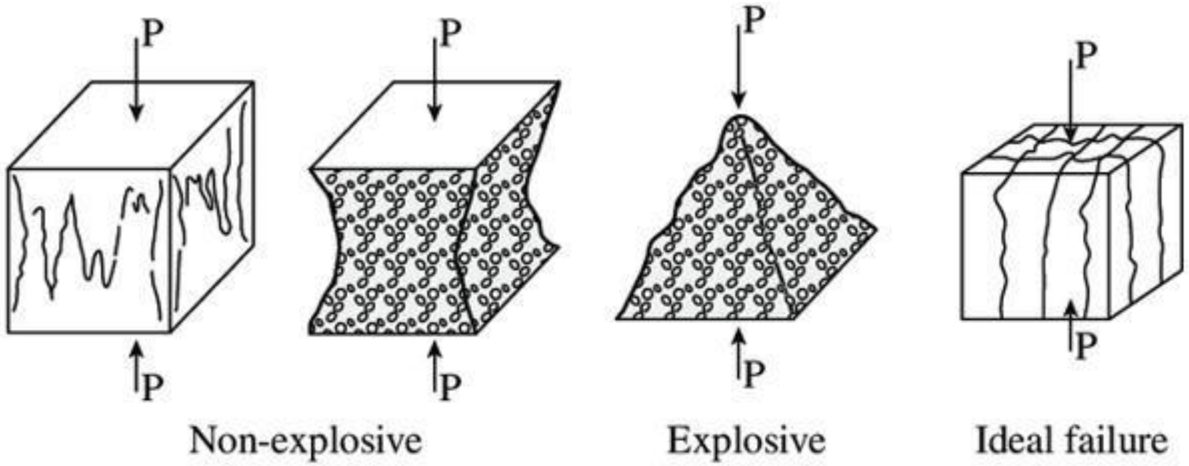
Testing of Hardened Concrete

- IS 516 – 2019 – Draft code
- IS 516 – 1959
- Destructive Testing & Non Destructive Testing
- Non Destructive Testing for human beings – X-ray, MRI, BLOOD PRESSURE, temperature by thermometer
- Partial Destructive Testing for human beings – blood testing , biopsy,
- For already constructed building – Non destructive testing or partially destructive testing

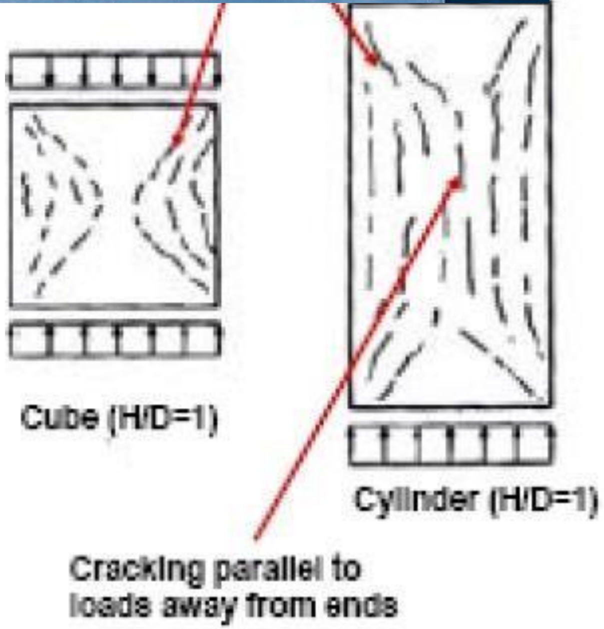
Destructive Testing of hardened concrete

- Concrete is strong in compression – Compressive Strength – as per IS 516 – 150 mm x 150 mm x 150 mm or 100 mm x 100 mm x 100 mm
- Compressive strength as per ACI – Cylinder of 150 mm dia & 300 mm height.
- Tensile strength – Indirect method – (1) Split tensile strength or (2) Modulus of rupture

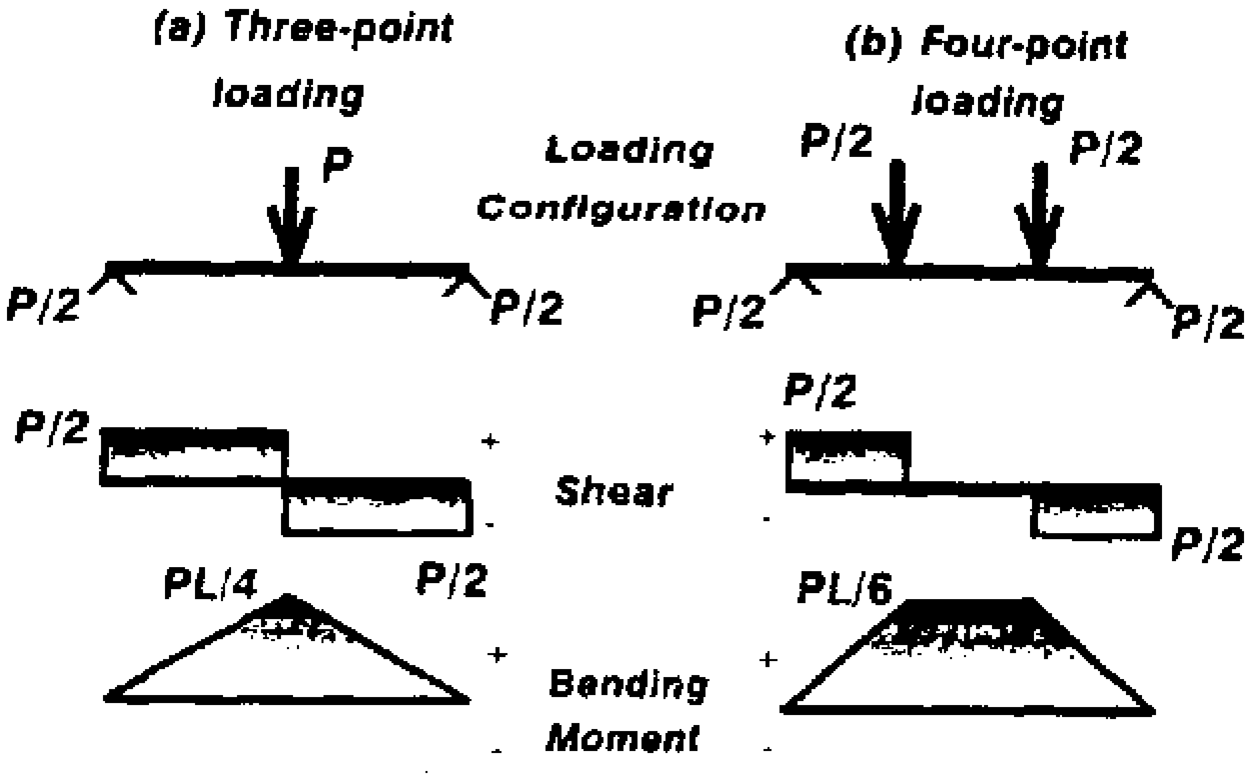

Compression Testing Machine
15 cm Cube Mould
Concrete Cube



COMPRESSIVE STRENGTH = P/A



Flexural Strength – Modulus of Rupture



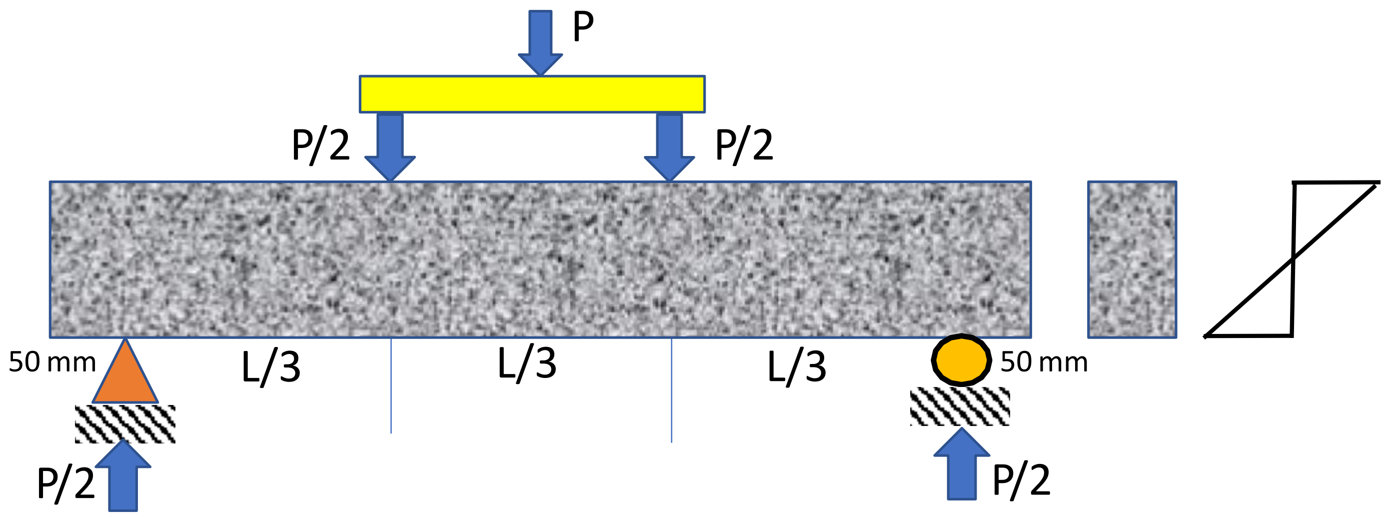
CONCEPT OF PURE BENDING

Theory of Bending -

$$\frac{M}{I} = \frac{f}{y} = \frac{E}{R}$$

Bending Stress -

$$f = \frac{My}{I} = \frac{M}{Z}$$



Size of the specimen as per IS 516

100 mm x 100 mm x 500 mm OR

150 mm x 150 mm x 700 mm

$I = BD^3/12 = D^4/12$, $y = D/2$

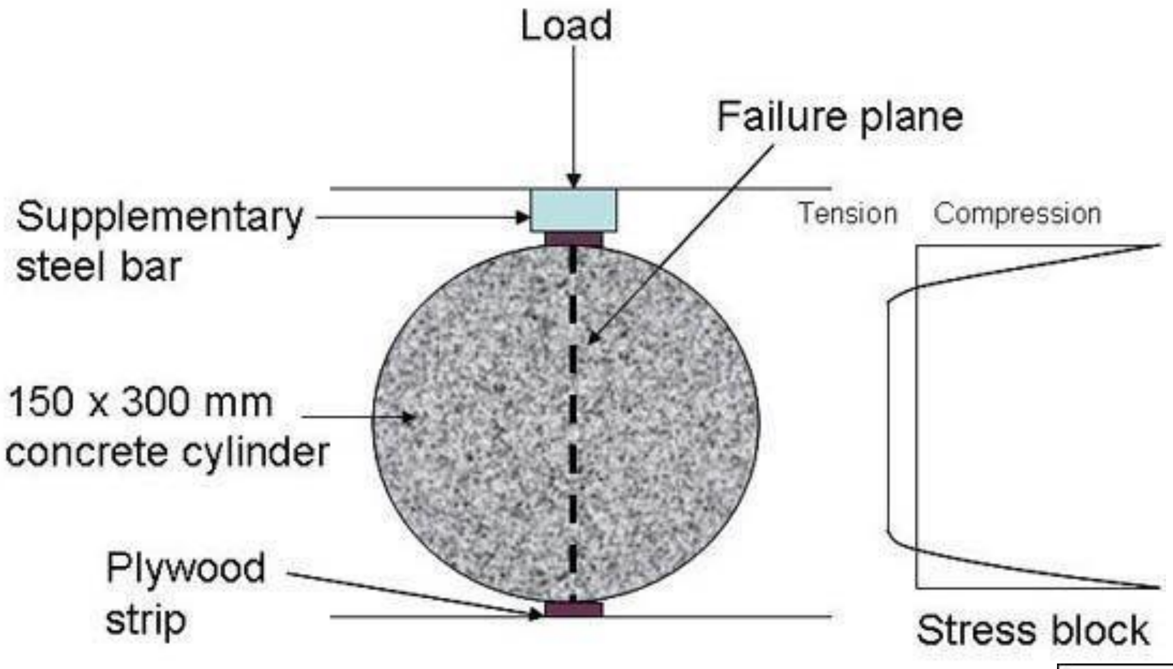
$Z = BD^2/6 = D^3/6$

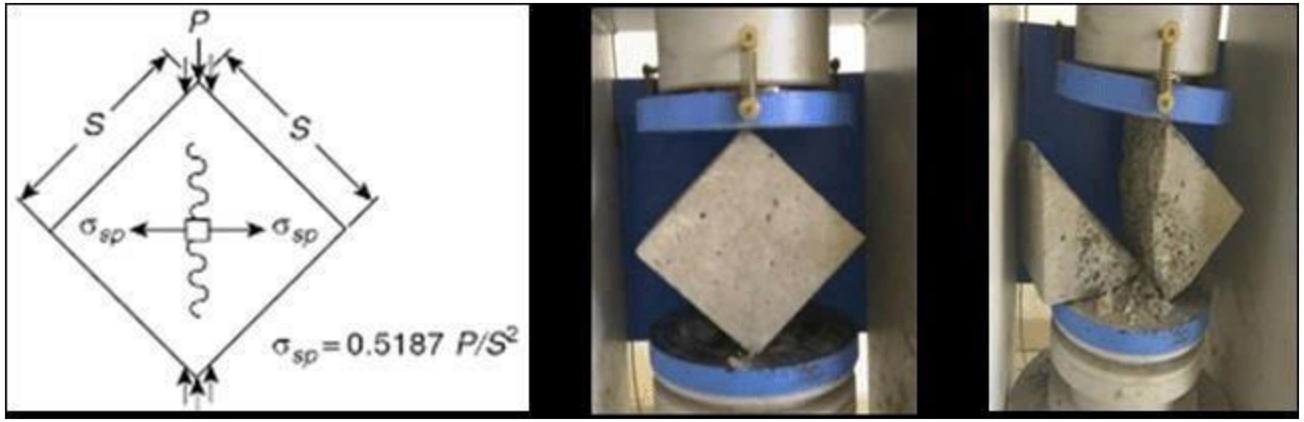
When the Crack occurs in middle third portion M =PL/6 - $f = \frac{My}{I} = \frac{PL}{D^3}$

When the Crack occurs at 'a' from support M =Pa/2 -$f = \frac{My}{I} = \frac{Pa}{2}\left(\frac{6}{D^3}\right) = \frac{3Pa}{D^3}$

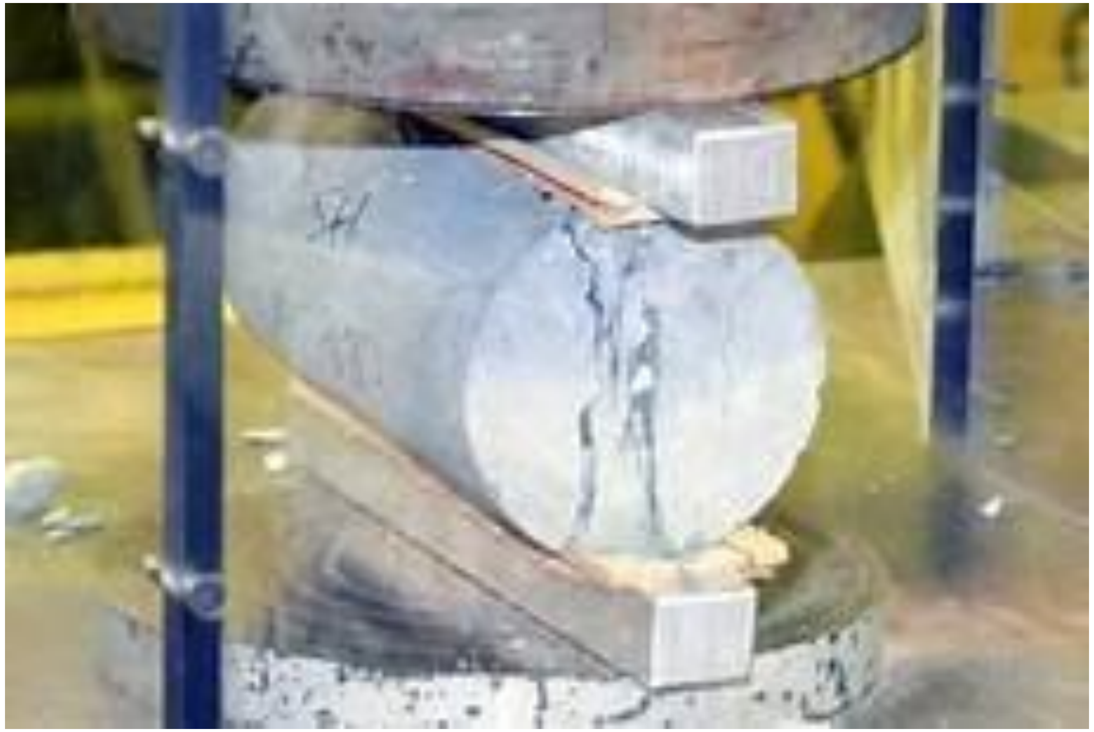
When a is less than 170 mm (for 150 mm specimens) or 110 mm (for 100 mm specimens) the results shall be discarded

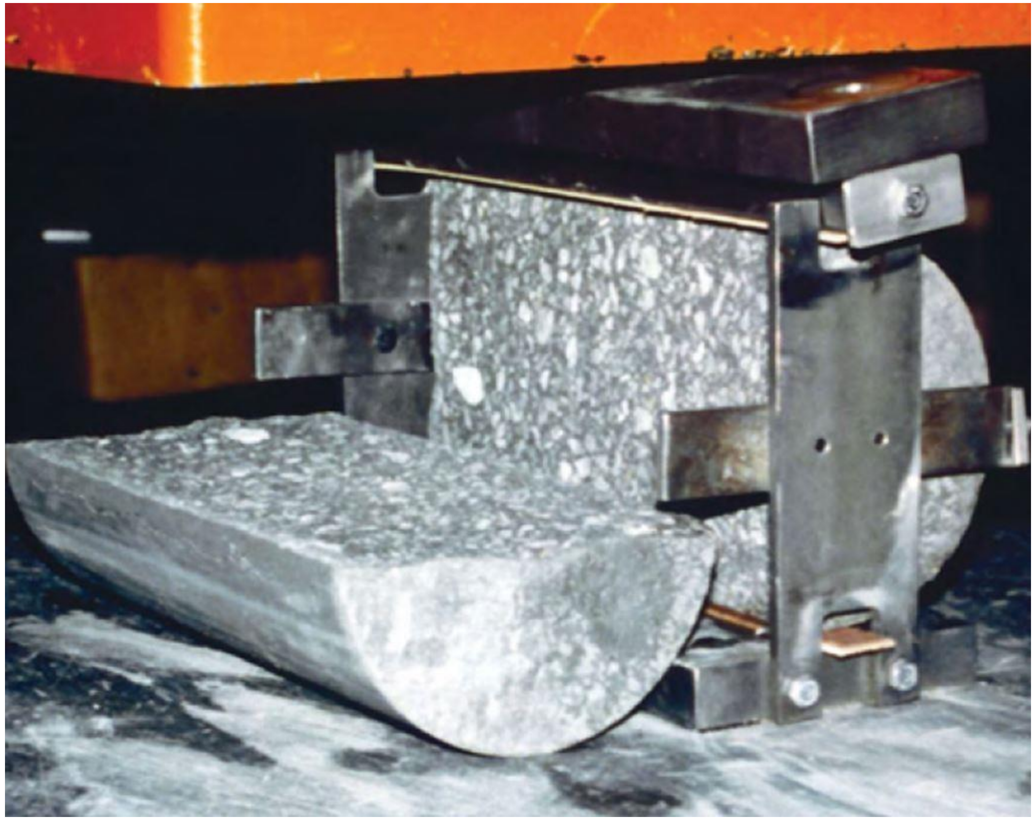
Split Tensile Strength





CYLINDER 150 mm DIA
& 300 mm HEIGHT





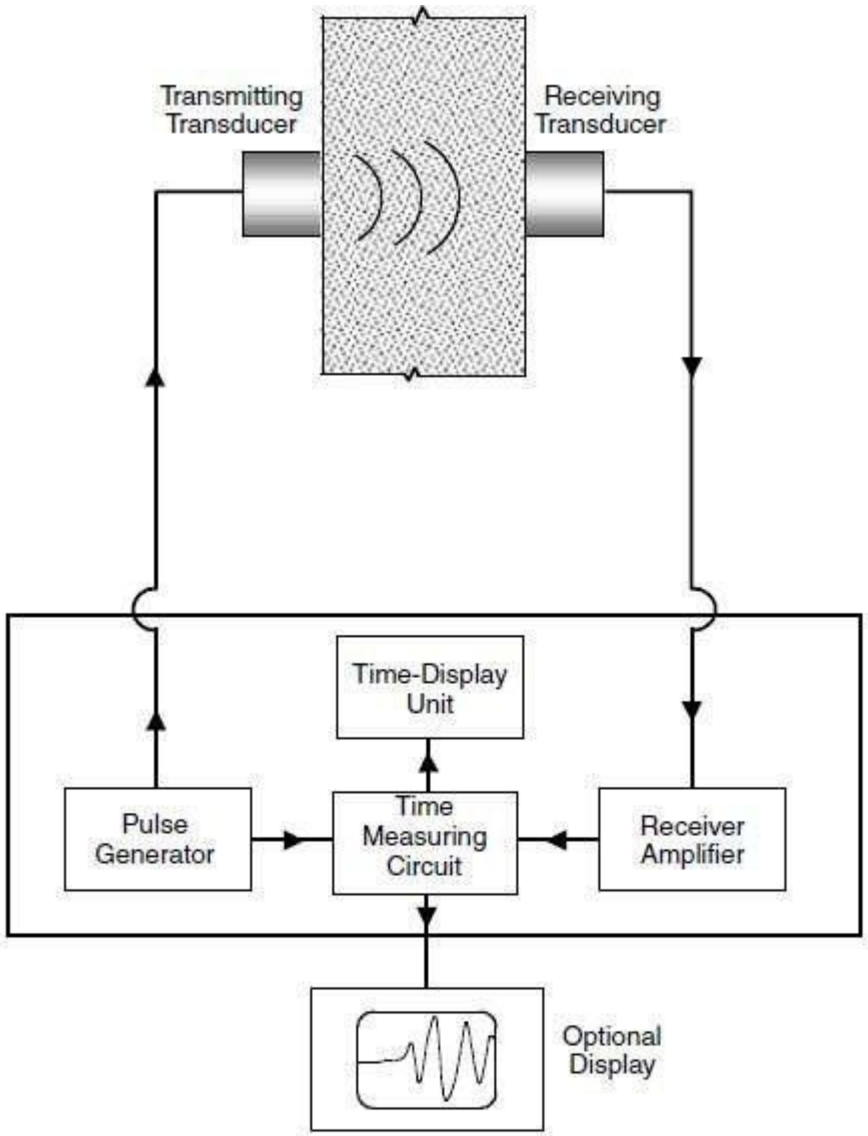
SPLIT TENSILE STRENGTH = $2P/\pi LD$

L=300 mm, D=150 mm

Testing by partial destruction – core samples

- This is preferred for constructed & finished structure/ road/bridge
- Sample is extracted by core cutting
- Sample is cylindrical shape of different H/D ratio
- Capping is done and tested in compression.
- Correction factor using Fig. 1 (Pg. No. 13) of IS 516-1959
- Corrected cylinder strength is multiplied by 5/4 to equivalent cube strength
- H/D ratio of the core is 1.6 – Compressive strength for core is 22 MPa
- Corrected cylindrical strength = 0.95 x 22 = 20.9 MPa
- Equivalent cube strength = (5/4) 20.9 = 26.125 MPa.

REBOUND HAMMER TEST



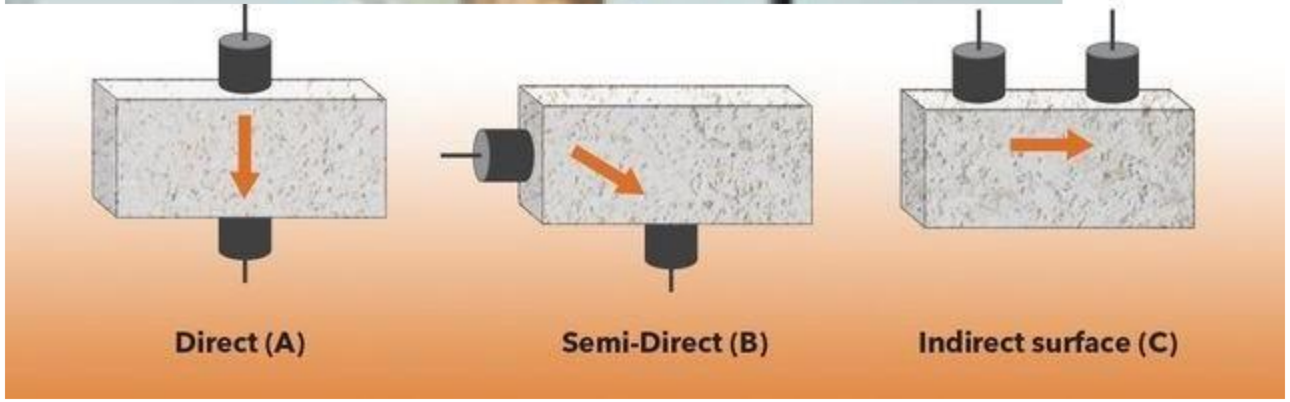
ULTRASONIC PULSE VELOCITY TEST
IS 516 (Part 5/Sec 1) 2018

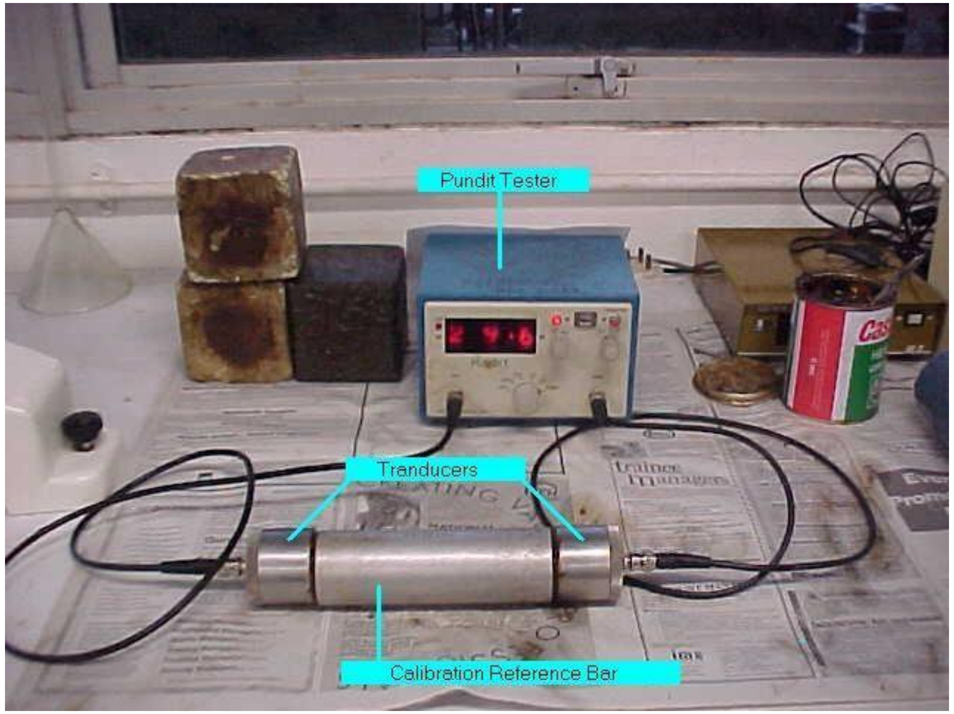
Time in micro seconds & Distance in mm – Velocity in mm/μ sec = km/sec

Higher Velocity is obtained when the quality of concrete in terms of homogeneity, density and uniformity is good – Indirect measure of strength

Lower Velocity means more voids, less density, honey combed concrete or existence of cracks

Calibration curves for a particular type of aggregate and cement is to be established. Calibration curves are not universally valid





Pulse Velocity (km/second)	Concrete Quality (Grading)
Above 4.5	Excellent
3.5 to 4.5	Good
3.0 to 3.5	Medium
Below 3.0	Doubtful