K.S. School of Engineering & Management

15, Mallasandra, Off Kanakapura Road
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Department of Civil Engineering

IV Semester

Building Material Testing Laboratory

(Code: BCVL404)

Academic Year: 2024-25

Laboratory Manual/Observation Book

Name of the Student :

University Seat No :

K S SCHOOL OF ENGINEERING AND MANAGEMENT

Holiday Village Road, Vajarahalli Village, Mallasandra, off, Kanakapura Rd, Bengaluru, Karnataka 560109

VISION

To impart quality education in engineering and management to meet technological business and societal needs through holistic education and research.

MISSION

K. S. School of Engineering and Management shall,

- Establish state-of-art infrastructure to facilitate effective dissemination of technical and managerial knowledge.
- Provide comprehensive educational experience through a combination of curricular and experiential learning, strengthened by industry-institute interaction.
- Pursue socially relevant research and disseminate knowledge.
- Inculcate leadership skills and foster entrepreneurial spirit among students.

DEPARTMENT OF CIVIL ENGINEERING

VISION

- To emerge as one of the leading Civil Engineering Department by producing competent and quality ethical engineers with strong foot hold in the areas of Infrastructure development and research.

MISSION

- Provide industry oriented academic training with strong fundamentals and applied skills.
- Engage in research activities in Civil Engineering and allied fields and inculcate the desired perception and value system in the students.

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Experiment No. 1

Sieve Analysis of Fine Aggregates

Aim: To determine the fineness modulus and grain size distribution of the given fine aggregate.

Apparatus: Indian standard test sieves, Weighing balance, sieve shaker, trays etc.

Procedure:

1. Take one kg of sand and break the clay lumps if any, in a clean dry ice plate.
2. Arrange the sieves in the order of Indian standard sieve numbers 4.75 mm, 2.36 mm, 1.18 mm, 600 µ, 300 µ,150 µ with 4.75 mm at the top and 150µ at the bottom, fix them in the sieve shaking machine with the pan at the bottom and cover at the top.
3. Keep the sand in the top sieve, carry out the sieving in the set of sieves for not less than ten minutes and find the mass retained in each sieve.

Observations & Calculations:

Weight of sand taken = ... g

Tabular Column

Sl.No	I.S Sieve size	Weight retained (g)	Percentage retained	Percentage passing	Cumulative percentage retained, F	Percentage Fines (100-F)

$\sum$ F=

Fineness Modulus= $\frac{\sum F}{100}$ =

Result: Fineness Modulus of the given fine aggregate =

(The range of fineness modulus for fine aggregate is between 2.0 to 3.5)

Experiment No. 2

Moisture Content of Fine Aggregates

Aim: To determine the moisture content in fine aggregates by drying method

Theory and scope : Water content 'w' of a fine aggregate is defined as the ratio of mass of water in the voids to mass of solids. The determination of moisture content of an aggregate is necessary in order to determine net water content ratio for a batch of concrete. High moisture content will increase effective water cement ratio to an appreciable extent and may even make the concrete weak unless a suitable allowance is made.

Apparatus: Balance (capacity 2kg or more and sensitive to 0.5 gm), Weight box, Metal tray (frying pan) and a source of heat..

Procedure:

1. Weigh approximately 1000gms of aggregates from the material to be tested by the method of quartering in a metal tray.
2. Heat the aggregates in the tray for about 20 min
3. Weight the tray with dry aggregate.
4. Take the aggregate out and clean the tray thoroughly and weigh it.
5. Express the loss in mass as a percentage of the dried sample to give the moisture content

Observations & Calculations:

Sl.No	Material	
1	Mass of tray and sample W_1 gm	
2	Mass of tray and dry sample W_2 gm	
3	Mass of empty tray W_3 gm	
4	Moisture (by difference) W_1-W_2 = W_m gm	
5	Mass of dry aggregate W_2-W_3 = W_d gm	
6	Moisture content %w = (W_m/W_d) *100	

Result:
Moisture content in the given fine aggregate = %

Experiment No. 3

Specific Gravity of Fine Aggregates

Aim: To determine the specific gravity of the given fine aggregates.

Theory: Specific gravity of an aggregate is defined as the ratio of the mass of the given volume of sample to the mass of an equal volume of water at the same temperature.

Apparatus: Balance, weight box, pycnometer, oven, metal tray etc.

Procedure:

1. Clean and dry the pycnometer and weigh it, M_1.
2. Select a mass of sand about 300 g and place the same in pycnometer and weigh it, M_2.
3. Fill the pycnometer with distilled water up to half its height and stir the mix with a glass rod and add more water till it reaches conical cap. Dry the pycnometer outside and find the mass M_3.
4. Remove the contents of a pycnometer and clean it. Fill the clean water up to the level of the hole in the cap. Weigh it, M_4.
5. Now use the following equation to determine specific gravity.

M_1 =................................ kg

M_2 =.................................kg

M_3 =................................ kg

M_4 =.................................kg

$$G = \frac{(M_2 - M_1)}{(M_2 - M_1)-(M_3-M_4)} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Result: Specific gravity of the given fine aggregates = …………………………….

Experiment No. 4

Bulk Density of Fine Aggregates

Aim: Determination of bulk density for fine aggregates.

Theory: Bulk density is the weight of material in a given volume. The higher the bulk density, the lower is the void content. The sample, which gives the minimum voids or the one, which gives the maximum bulk density, is taken as the right sample of aggregate for making economical mix.

Apparatus: Cylindrical mould of capacity 3 liter, tamping rod of 16 mm diameter, weighing balance accurate to 1 g and other accessories.

Procedure:

1. Take about 5 kg of fine aggregate (air dried) passing through 4.75 mm sieve size.
2. Measure the empty weight of cylindrical mould with base plate W_1.
3. Fill the sand in cylindrical mould about 1/3 the height each time and tamped with 25 strokes by a tamping rod.
4. The compaction must be uniform over the whole area, and a spatula scratching is done before adding another layer.
5. The filling must be such that the last layer projects in to the collar by about 5mm. After the completion of compaction remove the collar and remove the excess aggregate with the help of straight edge.
6. Find the mass of the mould with the base plate and the fine aggregate W_2.

Observations & Calculations:

Empty weight of cylindrical mould with base plate W_1 =.........................kg

Weight of the mould with the base plate and the fine aggregate W_2 =.................. kg

Height of the mould =......................... m

Diameter of the mould =..................... m

Volume of the cylindrical mould (V) = ...m^3

Bulk density = $\frac{W_1 - W_2}{V}$ = ... kg/m^3

Result: The bulk density of given fine aggregate = kg/m^3

Conclusion:

Experiment No. 5

Bulking of Fine Aggregates

Aim: To determine the necessary adjustment for the bulking of fine aggregate and to draw a curve between moisture content and bulking.

Equipment: Graduated cylinder, balance, beaker, metal tray, steel rule, and oven.

Procedure:

1. Weigh the empty graduated cylindrical glass jar.
2. Weigh sufficient quantity of oven dried sand loosely into the graduated cylinder. After filling, level the surface of sand in the cylinder.
3. Push a steel rule vertically down through the sand at the middle to bottom and measure the height of the sand; let it be ‘h’ mm.
4. Empty the sand into a clean metal tray without any loss.
5. Add 1 % of water by weight to mass of sand. Mix the sand and water thoroughly by hand. Put the wet sand loosely into the cylinder without tamping it.
6. Smooth and level the top surface of moist sand and measure its depth in the middle with the steel rule. Let it be ‘h^1’ mm.
7. Repeat the experiment steps up to step 6 of the above procedure with 2% of water by mass of sand. Go on increasing the percentage till bulking is maximum and yield starts falling down and ultimately bulking is zero.
8. Plot a curve between Water Content v/s Bulking Percentage.

It is seen that bulking increases with increase in moisture content up to a certain point where it is maximum and then it begins to decrease and ultimately bulking is zero, that is saturated sand occupies the same volume as the dry sand.

Observations:

Weight of empty graduated cylinder, W_1 =................................ g

Weight of cylinder + over dried fine aggregate, W_2 =................................ g

Weight of fine aggregate (W) = (W_2-W_1) =................................ g

Initial height of dry sand, h =............................ cm

Final height of wet sand, h_1 = ...cm

Tabular Column:

Weight of sand (g)	**% of water adding**	**Weight of water adding (g)**	**Height of sand (cm)**	**Bulking** $(h^1-h)/h$ x100

Result: Maximum Bulking =....................................%

Experiment No. 6

Sieve Analysis of Coarse Aggregates

Aim: To determine the fineness modulus and grain size distribution of the given coarse aggregate.

Apparatus: Indian standard plates of 80 mm, 20 mm, 10 mm, 4.75 mm, weighing balance, sieve shaker, trays, drying oven.

Procedure:

1. Take 5kg of coarse aggregate of nominal size of 20mm.
2. Carry out sieving by hand, shake each size in the order 80 mm, 40 mm, 20 mm,10 mm,4.75 mm, over a clean dry tray for a period of not less than 2 minutes each. The shaking is done with a varied motion i.e.; back and forward, left and right, circular clock wise and anticlock wise.
3. Find the mass of aggregate retained on each sieve taken in the order.

Observations & Calculations:

Weight of coarse aggregate taken =.. g

Tabular Column

Sl.No	I.S Sieve size	Weight retained (g)	Percentage retained	Percentage passing	Cumulative percentage retained (F)	Percentage Fines (100-F)

$\sum F =$

Result:

Fineness Modulus of coarse aggregate $= \frac{(\sum F+500)}{100}$ = ………………………

Experiment No. 7

Moisture Content of Coarse Aggregates

Aim: Determination of water content of coarse aggregate by oven drying method.

Theory: Water content 'w' of a coarse aggregate is defined as the ratio of mass of water in the voids to mass of solids.

Apparatus: Non-corrodible airtight containers, weighing balance, thermostatically controlled oven to maintain temperature, other accessories.

Procedure:

1. Clean the container with the lid and find the mass M_1.
2. Select the required quantity of moist coarse aggregate, place it in the container, place the lid on it, and weigh it M_2.
3. Keep the container in the oven with lid removed and dry it for at least 24 hr at a temperature of 110^0C till the mass remains constant.
4. Remove the container from the oven, replace the lid, and cool it in the desiccators. Find the mass M_3.
5. Determine the water content 'w' by using the equation given below.

Observations & Calculations:

Sl.No	**Particulars**	**1**	**2**	**3**
1	Mass of empty container M_1 (g)			
2	Mass of container + wet coarse aggregate M_2 (g)			
3	Mass of container + dry coarse aggregate M_3 (g)			

Specimen Calculation : $$\mathbf{w\%} = \frac{(M_2-M_3)}{(M_3-M_1)} \times 100 = \text{……………………………………..}$$

Result: Average W% = ……………

Experiment No. 8

Specific Gravity and Water Absorption of Coarse Aggregates

Aim: To determine the specific gravity and water absorption of coarse aggregates.

Apparatus: Balance of capacity 5 kg or more, weight box, wire basket 200 mm in diameter and 200 mm height 4.75 mm Indian standard sieve, water tub for immersing the wire basket in water, absorbent cloth, suitable arrangement for suspending the wire basket from the center of scale pan of balance.

Procedure:

1. Take about 5 kg of aggregate by method of quartering rejecting all materials passing a 10 mm IS sieve.
2. Wash thoroughly to remove dust etc. dry to constant mass at a temperature of 105^0C in an oven.
3. Immerse the sample in water at 22 to 32^0 C for 30 minutes for lab practice.
4. Remove aggregates from water and roll the same in a large piece of absorbent cloth.
5. Weigh 3 kg of this sample in the surface dry condition and note its weight 'W_1' g.
6. Place the weighed aggregate immediately in wire basket and dip it in water.
7. Weigh this basket with aggregate while keeping it immersed in water with the balance. Note its weight 'W_3' g also note the weight of the empty basket, 'W_2' g.
8. Dry the sample to constant weight at 100^0C to 110 ^{0}C for 24 hrs cool at room temperature and weight 'W_4' g.

Observations & Calculations:

Weight of surface dry sample, W_1 =.. g

Weight of basket suspended in water, W_2 =.. g

Weight of material + basket suspended in water, W_3 = ... g

Weight of oven dried aggregate sample in air W_4 =..g

Bulk specific gravity = $\dfrac{W_1}{W_1-(W_3 - W_2)}$ =…………………………….

Apparent specific gravity = $\dfrac{W_4}{W_4-(W_3 - W_2)}$ =…………………………….

Percentage absorption = $\dfrac{(W_1 - W_4) \times 100}{W_4}$ =..%

Result:

Bulk specific gravity =……………………..

Apparent specific gravity =………………………

Percentage absorption =.................................%

Experiment No. 9

Bulk Density of Coarse Aggregates

Aim: Determination of bulk density for coarse aggregates.

Theory: Bulk density is the weight of material in a given volume. The higher the bulk density, the lower is the void content. The sample, which gives the minimum voids or the one, which gives the maximum bulk density, is taken as the right sample of aggregate for making economical mix.

Apparatus: Cylindrical mould of capacity 15 liter, tamping rod of 16 cm diameter and 60 cm height, weighing balance accurate to 1 g and other accessories.

Procedure:

1. Take about 15 kg of coarse aggregate (air dried) passing through 40 mm and retained on 4.75 mm sieve size.
2. Measure the empty weight of cylindrical mould with base plate W_1.
3. Fill the coarse aggregate in cylindrical mould about 1/3 the height each time and tamped with 25 strokes by a tamping rod.
4. The compaction must be uniform over the whole area.
5. After the completion of compaction remove the excess aggregate with the help of straight edge.
6. Find the mass of the mould with the base plate and the fine aggregate W_2.

Observations & Calculations:

Empty weight of cylindrical mould W_1 =..............................kg

Weight of the mould with coarse aggregate W_2 = ...kg

Height of the mould= .... m

Diameter of the mould= .... m

Volume of the cylindrical mould (V) = ...m^3

$$\text{Bulk density} = \frac{W_1 - W_2}{V} = \text{...} \text{kg/m}^3$$

Result: The bulk density of given coarse aggregate =................................kg/m^3

Conclusion:

Experiment No. 10

Compression Test

Aim: To study the behaviour of the given material under compression loading.

Apparatus: Universal Testing Machine (UTM), Slide calliper.

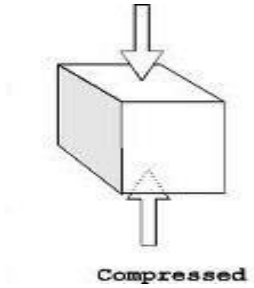
Theory: The compression test is exactly opposite to that of tension test with regard to direction of loading. However there are certain practical difficulties which may preclude error due to:

a) Difficulty in applying true axial load.
b) There is always a tendency of the specimen to buckle.

To avoid this, usually test is carried out on a short length cylindrical specimen whose length is not greater than twice the diameter. If the length to diameter ratio is greater, the specimen may be subjected to buckling.

In compression test, stress-strain curve up to the limit of proportionality, metals have approximately the same modulus of elasticity as in tension test. The curve will be continuous almost without limit as there is no fracture of the material due to its ductility and cross sectional area increases continuously with increase in load.

The specimen will shorten and bulge. Copper, brass and aluminum do not show any well-defined yield point. Compression test is mainly used for brittle material such as cast iron, concrete etc... Brittle materials usually fail along a diagonal plane due to shearing.



Procedure:-

1. Measure the dimensions of the given specimen.
2. Adjust the loading in the UTM to its maximum.
3. Place the specimen on the operating table and fix a dial gauge.
4. The load is applied gradually on the specimen.
5. For every increment, record the deformation reading.
6. The load at yield point is noted.
7. The specimen is continued to load till it fails.
8. Finally note down the final diameter and the length of the specimen. Calculate the stress strain for the data recorded and draw the graph of stress versus strain.

Observations:-

Initial gauge length of the specimen (L_o) =.........................mm

Initial gauge diameter of specimen (d) = ... mm

Original C/S area of specimen $A_o = \frac{\pi d^2}{4}$ = ... mm^2

Final gauge length of the specimen (L_f) = ... mm

Final gauge diameter of specimen (D) =..........................mm

Final C/S area of specimen $A_f = \frac{\pi D^2}{4}$ =..........................mm^2

Maximum load, P_{max} = ...kN

Percentage contraction in length at failure = $\frac{Lo - L_f}{L_o}$ x 100 =.................%

Percentage increase in area = $\frac{A_f - A_o}{A_o}$ x 100 =...................... %

Compression strength = $\frac{P_{max}}{A_o}$ = ... N/mm^2

Young's Modulus, E = $\frac{\sigma}{e}$ = ... N/mm^2

where, σ = stress within elastic point, N/mm^2
e = strain corresponding to σ

Material used	Load applied (kN)	Deformation (mm)	Stress, σ (N/mm^2)	Strain, e (δ_l / L_o)	Modulus of Elasticity (E) = (N/mm^2)

Result: - Young's Modulus of the specimen =................................(N/mm^2)

Experiment No. 11

Tension Test

Aim: To study the behavior of the given material under tensile loading.

Apparatus: Universal Testing Machine (UTM), Vernier caliper.

Theory: Ductile materials are characterized by their ability to yield at normal temperature. As the specimen is subjected to an increasing load, its length first increases linearly with the load and at a very slow rate. Hence the initial portion of the stress-strain diagram is a straight line with a steep slope. But after a critical value of the stress is reached, the specimen undergoes a large deformation with a relatively small increase in the applied load.

After certain maximum value of the load has been reached, the diameter of the specimen begins to decrease because of local instability. This phenomenon is known as necking. After this stage of necking, lower loads are sufficient to keep the specimen elongating further until it finally ruptures.

The stress at which yield is initiated is called yield strength of material. The stresses corresponding to maximum load applied to the specimen is known as ultimate strength and the stress corresponding to rupture is called breaking strength.

Procedure:-

1. The gauge length and diameter of the specimen are measured.
2. The specimen is fixed in between the middle and upward head jaws by operating the middle cross head.
3. The left and right operating valves are closed.
4. The deflection indicator is set to zero by pressing reset button.

5. The load indicator reading button is set to zero by pressing reset button.
6. The load is applied gradually on the specimen by operating the valves.
7. For every increment, record the deformation reading.
8. The load is continued to be applied on the specimen gradually till the specimen breaks and corresponding deflection readings are noted down by pressing the data button.

9. The required parameters are calculated and a graph of stress versus strain is plotted.

Observations

Initial gauge length of the specimen (L_i) = ... mm

Initial gauge diameter of specimen (d_i) =.............................. mm

Original C/S area of specimen A_o = $\frac{\pi d^2}{4}$ =.................. mm^2

Final gauge length of the specimen (L_f) = ... mm

Final gauge diameter of specimen (d_f) =.............................. mm

Final C/S area of specimen A_f = $\frac{\pi d^2}{4}$ =................... mm^2

Percentage elongation at failure = $\frac{L_f - L_i}{L_i}$ x 100 =.................%

Percentage reduction in area = $\frac{A_o - A_f}{A_o}$ x 100 = ... %

Ultimate load = ... kN

Breaking load =........................... kN

Ultimate stress = $\frac{\text{Ultimate load}}{\text{Original C/S area}}$ = ... N/mm^2

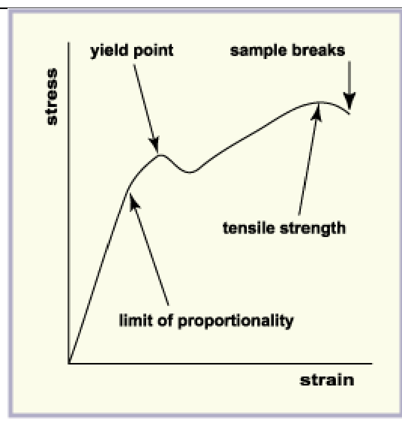
Breaking stress = $\frac{\text{Breaking load}}{\text{Original C/S area}}$ = ... N/mm^2

Young's Modulus, $E = \frac{\sigma}{e}$ = ... N/mm^2

Where, σ = stress within elastic point
e = strain corresponding to σ

Material used	**Load applied (kN)**	**Deformation (mm)**	**Stress, σ (N/mm^{2})**	**Strain, e (δ_l / L_i)**	**Modulus of Elasticity (E) = (N/mm^2)**

Result: - Young's Modulus of the specimen =............................N/mm^2.



Stress strain curve for mild steel	Mild steel specimen before and after tensile test

Relevant IS Codes:

IS: 1608 (1972), Method for tensile testing of steel products (First Revision), BIS, New Delhi.

IS: 1786 (2008), Specification for high strength deformed steel bars and wires for concrete reinforcement (Fourth Revision), BIS, New Delhi.

Experiment No. 12

Torsion Test

Aim: To conduct torsion test and to find out modulus of rigidity of the given specimen.

Apparatus: Torsion testing machine, Vernier caliper.

Theory: The torsion testing machine consists of a DC motor, a reduction gear box and a Troptometer to measure the angle of twist.

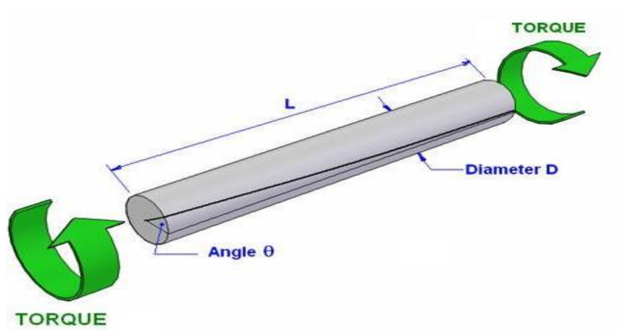
Torsion refers to the twisting of structural member when it is loaded by couples that produce rotation about its longitudinal axis.

The couples that produce twisting of a structural member are called torque, twisting couples or twisting moment.

Chucks are provided to hold the specimen. The distance between the two chucks can be adjusted to hold the specimen of different gauge length by rotating the wheel provided at the end.

Provision is also made to hold the specimen of different diameter. The Troptometer measures the angle of twist.

By noting down the torque and angle of twist in degrees and applying these values in the general torque equation, the modulus of rigidity of the given specimen is calculated.



Procedure:

1. The gauge length and diameter of the specimen are measured.
2. The specimen is fixed in between the jaws of the chuck.
3. The indicators of torque and angle of twist are set to zero.
4. The specimen is gradually loaded and the corresponding torque and angle of twist readings are noted down at regular intervals till the specimen fails.
5. A graph of torque versus angle of twist is drawn.

Observations:

Material used	**Torque (kgf-cm)**	**Angle of Twist (θ)**	
		In degrees	**In radians** (angle in radians = angle in degrees x π / 180)

Result: 1) Polar moment of inertia, $I_p = \frac{\pi d^4}{32}$ =......................... mm^4

2) Modulus of rigidity, $G = \frac{T \times L}{I_p \times \theta}$ =.......................... N/mm^2

Where T = Max torque in N-mm

L = Gauge length of the shaft in mm

Ip = Polar moment of Inertia in mm^4

θ = Angle of twist in radians

Experiment No. 13

Bending Test

Aim: To study the behavior of the given specimen under bending.

Apparatus: Universal Testing Machine (UTM), Shear attachment scale.

Theory: If forces act on a piece of material in such a way that they tend to include compressive stress over a part of the cross section of the specimen and tensile stress over the remaining part of the specimen then it is said to be in bending.

The line along which the bending stresses are zero is called a neutral axis. Pure bending of a specimen is in the form of a beam of either rectangular or circular section will occur when the material is subjected to loading perpendicular to the axis of the beam(i.e. from top or bottom) .

Procedure:

1. The cross sectional dimensions of the given specimen are measured and mid-point specimen along its length is marked.
2. The specimen is kept on two rollers supports and its span length is measured.
3. The load is applied gradually at the center of the specimen and corresponding readings of load & deflection are noted down simultaneously.
4. The load is increased gradually until the specimen begins to break. The load at which the specimen breaks is noted down as breaking load.
5. A graph of load versus deflection or stress versus strain is plotted.

Observations:

Width of the specimen (b) =....................................mm

Depth of specimen (d) =....................................mm

Span length of beam (L) = ...mm

C/S area of specimen (b x d) =...............................mm^2

Material used	Load applied (N)	Deflection (mm)	Stress (N/mm^2)	Strain, e ($\delta l / L$)	Modulus of Elasticity (N/mm^2)

Max bending moment = $\frac{P_E \times L}{4}$ =...................................kN-m

Moment of Inertia of specimen = I = $\frac{bd^3}{12}$ =............................. mm^4

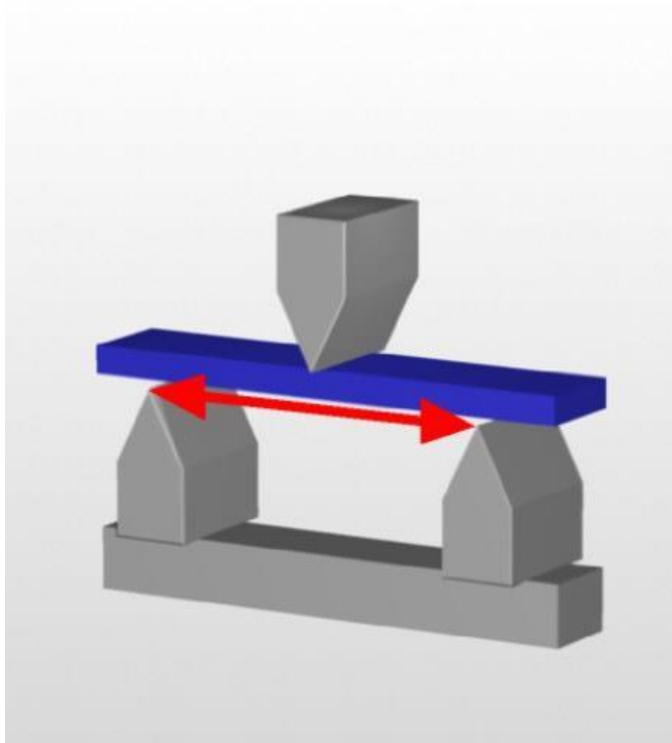
Section Modulus = Z = $\frac{I}{Y}$ =...................................... mm^3

Modulus of Elasticity = $\frac{P_E L^3}{48\,\delta_E I}$ =...N/mm^2

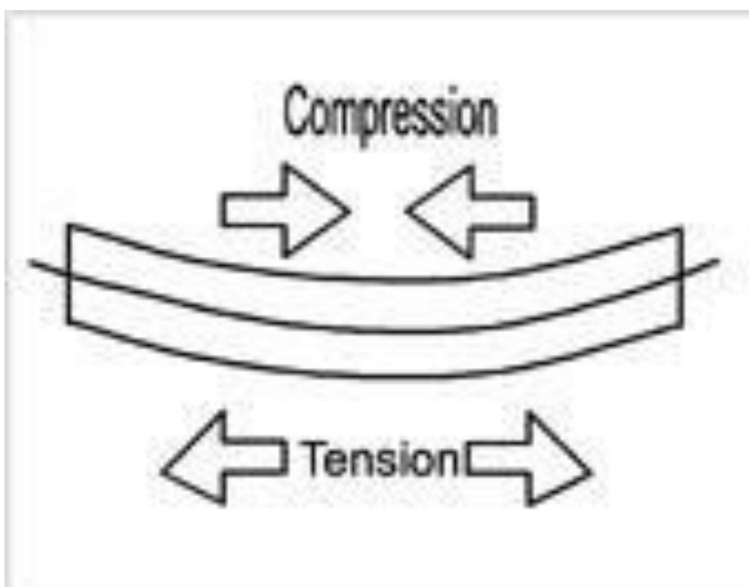
where, P_E = Load at proportional limit

δ_E = Deflection at proportional limit

Result: - Young's Modulus of the specimen =.....................................(N/mm^2)



Bending test set-up



Beam subject to bending

Experiment No. 14

Shear Test

Aim: To find the shear strength of material by single shear and double shear.

Apparatus: Universal Testing Machine (UTM), Shear test attachment, Vernier caliper.

Theory: A shearing stress acts parallel to a plane, whereas tensile and compressive stresses act normal to a plane. There are two types of shear stresses we encounter in laboratory. One is called direct or transverse shear stress and corresponds to the type of stress encountered in rivets, bolts and beams. The other type of shear stress is called pure or torsion shear encountered in a shaft subjected to pure torsion.

Direct shear test are usually employed to obtain a measure of shear strength and torsion test are usually employed to evaluate the basic shear properties of the material.

If single plane is involved then the condition is called single shear. If applied stresses acts simultaneously on two planes then the condition is called double shear.

In the test, the shackles should hold the specimen firmly and maintain good alignment. The load should be applied evenly at right angles to the axis of specimen.

Procedure:

1. The required accessories are fixed to UTM to perform the test.
2. Measure the dimensions of the given specimen.
3. The specimen is fixed in the shear attachment.
4. The left and right operating valves are closed.
5. The deflection indicator reading is set to zero.
6. The load is applied gradually by turning the valve until the specimen breaks.
7. The maximum load at which specimen fails is noted.

8. The experiment is repeated for double shear by fixing the specimen properly in shear attachment and corresponding readings are noted down.

Observations:

For single shear

Material of specimen = ……………………….

Length of the specimen = ...mm

Diameter of specimen = ...mm

Original C/S area of specimen (A) = $\frac{\pi d^2}{4}$ = ...mm^2

Max load (P) = ...N

For double shear

Material of specimen = ……………………...

Length of the specimen = ...mm

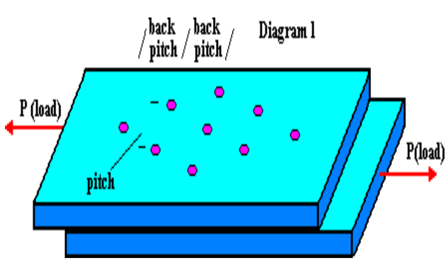
Diameter of specimen = ...mm

Original C/S area of specimen (A) = $\frac{\pi d^2}{4}$ = ...mm^2

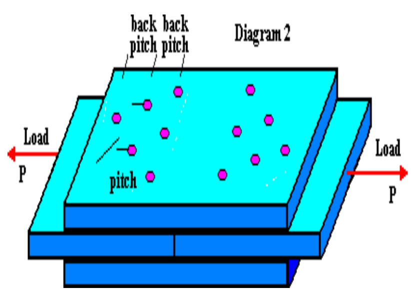
Max load (P) = ...N

Result: 1) Shear stress of given material for single shear = (P/A) =................ N/ mm^2

2) Shear stress of given material for double shear =(P/2A)=.................N/ mm^2



Lap joint welding- Single shear



Butt joint welding – Double shear

Experiment No. 15

Izod Impact Test

Aim: To determine the Impact strength of a given material (mild steel) by Izod method.

Apparatus: Impact testing machine, Test specimen with V-notch, Setting gauge, Vernier caliper, Allen key.

Theory: Many structural components are subjected to sudden load which acts for short duration. Such load is known as impact load. The structural components must be able to withstand these impact loads. The impact strength of materials can be defined as energy absorbed by material during its failure.

The Izod impact testing machine consists of pendulum which can be lifted to an angle of $90^{0.}$ By releasing the lever, the swinging pendulum will knock the specimen and breaks it.

Procedure:

1. The dimensions of the Izod specimen are measured using Vernier caliper.
2. The Izod striker is firmly secured to the bottom of the hammer with the help of clamping piece.
3. Pendulum is raised and fixed at 90^0.
4. Keep the reading pointer at appropriate outer scale (Maximum reading for Izod test).
5. The specimen is fixed in the specimen support with the help of clamping screw. The V-notch on the specimen should face the striking edge of the pendulum. The longer edge of V-notch should be inside the support in cantilever position.
6. The pendulum is released by operating the lever. The pendulum swings freely and the specimen will brake.
7. Stop the pendulum by applying brakes.
8. Note the reading on the dial corresponding to the pointer. This value gives the Izod impact strength

Observation:

Material	Breadth (mm)	Depth below v--notch (mm)	C/s area A= b X d (mm^2)	Raising angle of pendulum	Energy absorbed (Joules) (E_0)	Impact Strength $K= E_0/A$ (J/mm^2)
				90^0		
				90^0		
				90^0		

Result: - Impact strength =.................... J/mm^2.

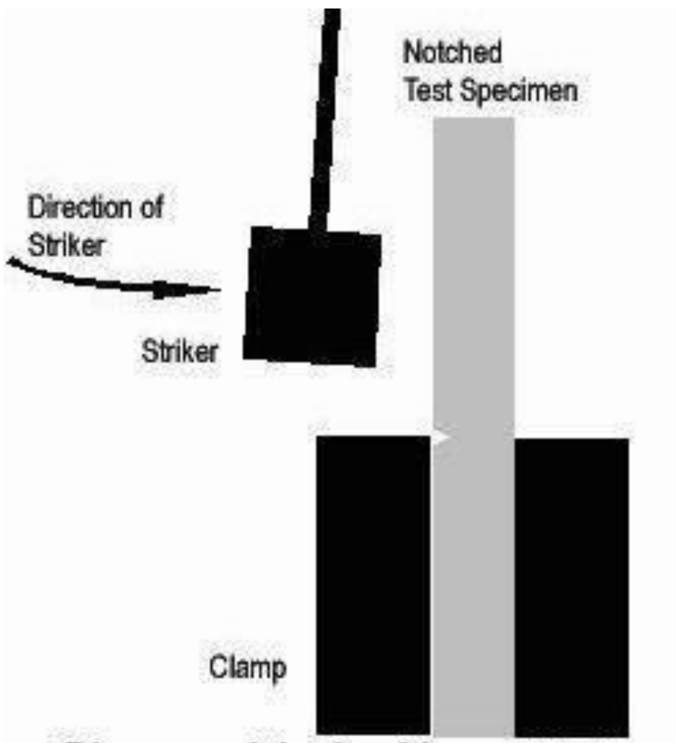


Diagram of the Izod impact test

Charpy Impact Test

Aim: To determine the Impact strength of a given material (mild steel) by Charpy method.

Apparatus: Impact testing machine, Test specimen with U-notch, Setting gauge, Vernier calipers, Allen key.

Theory: In Charpy test, the standard specimen is provided with a "U" shaped notch. The specimen is kept in the specimen holder as simply supported. The impact load is applied at the center. The specimen is kept such that the notch is opposite to the striking end of the hammer. The energy used by the specimen is confirmed as the measure of the impact value.

Procedure:

1. Raise the Charpy pendulum and fix it to the latch of Charpy pendulum holder. Place a thick wooden plank on the stand.
2. Keep the reading pointer at appropriate outer scale (Maximum reading for Charpy test). Release the Charpy lever and allow the pendulum to swing freely. Arrest the movement of pendulum. See the indicator reading so that it will be Zero.
3. Raise the pendulum and fix it to the notch.
4. Place the specimen on the support as a simply supported beam such that the projection of the setting gauge fit exactly inside the U- groove of the charpy specimen. This is required for correctly centering the specimen on the supporting block. The specimen is placed such that U-notch is opposite to the direction of knife-edge striker. Angle of fall of the pendulum is 135^0.
5. Release the pendulum by operating the Charpy lever. The pendulum swings freely and the specimen will break.
6. Stop the pendulum.

7. Note the reading on the dial corresponding to the pointer. This value gives the Charpy impact energy.

Observation:

Material	Breadth (mm)	Depth below U-notch (mm)	C/s area A= b x d (mm^2)	Raising angle of pendulum	Energy absorbed (Joules) (E_0)	Impact Strength K= E_0/A (J/mm^2)
				135^0		
				135^0		
				135^0		

Result: - Impact strength =......................... J/mm^2.

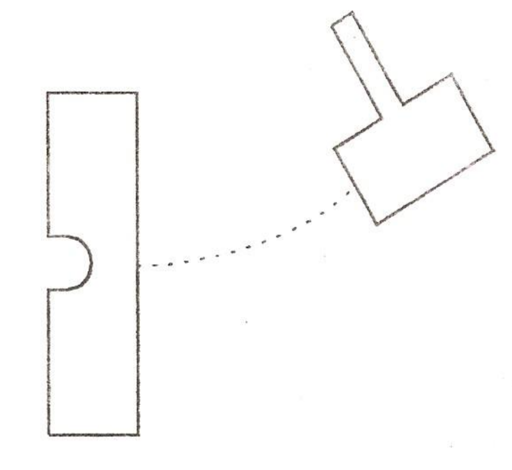


Fig: Diagram of Charpy test set up

Relevant IS Codes:

IS: 1499 (1977), Method for Chaprty impact test (U-notch) for metals [1st Revision, with amendment No. 1 (reaffirmed 1987)], BIS, New Delhi.
IS: 1598 (1977), Method for Izod impact test of metals [1st Revision, reaffirmed 1987] , BIS, New Delhi.

Experiment No. 16

Rockwell's Hardness Test

Aim: To determine the Rockwell's hardness number of a given specimen.

Apparatus: Rockwell's hardness testing machine, Diamond indenter, Steel ball indenter.

Theory: Hardness is defined as the resistance of a material against permanent indentation, scratching, abrasion, cutting and drilling.

Hardness test consists of measuring the resistance to plastic deformation of metal near the surface of the specimen. In this test, an indentor of standard shape and size is pressed into the material to be tested under a given load. The hardness is measured as function of indentation produced by a given load. The significance of conducting hardness test on any material lies in grading the material for a particular service. It is also possible to establish relation between hardness number and other properties of metals like tensile strength.

Working Principle: Rockwell's hardness testing machine consists of an anvil which can be moved up and down by turning the hand wheel provided at the bottom of spindle. The loading can be applied by operating a lever. Two type of indentation are used in this tester:

a) Conical shaped diamond indentor having 120^0 apex angle for testing material with a higher hardness value.
b) Steel ball indentor of 1/16 in. diameter for testing the softer materials.

The load is applied in two stages namely, a seating load of 10 kg and an additional load of 90-140 kg. The seating load does not deform the metal and it is used to make a seat for the indentor whereas the additional load makes the indentation which is the measure of Rockwell's hardness number.

Procedure:

1. Select the Rockwell's scale and the corresponding load based on the material to be tested.
2. Keep the lever at position "A".
3. The specimen is placed on the testing table and hand wheel is rotated clockwise so that the specimen will push the indentor. This makes the small pointer in the dial to move. Continue to raise the specimen slowly till the small pointer in the dial reaches red dot on the scale.
4. Set the longer pointer on the scale to zero on black scale or 30 on the red scale.
5. Shift the position of the lever from A to B slowly so that the major load is applied on the specimen.
6. The longer pointer of the dial gauge starts moving. Wait until the pointer reaches steady position and then reverse the lever to position A.
7. Note down the reading shown by the long pointer which will be the direct reading of the hardness of the specimen.
8. Hand wheel is turned back to remove the specimen.

Observation:

Material used	Major load (Kg)	Indentor used	Rockwell's Hardness Number

Result: - The Rockwell's hardness number of a given specimen = …………………

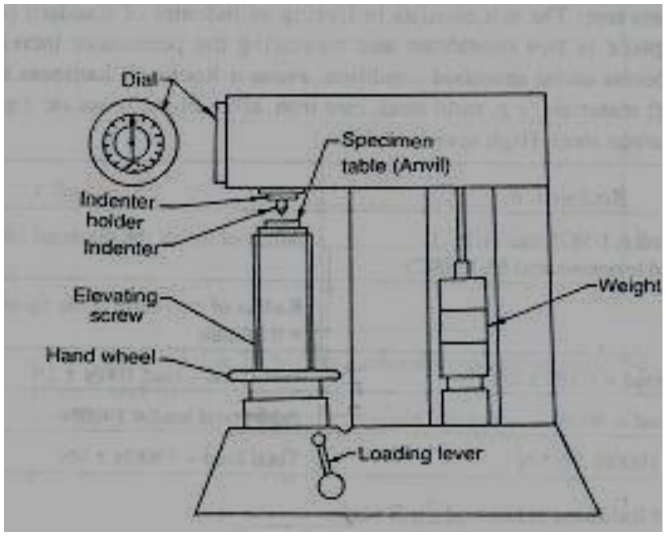
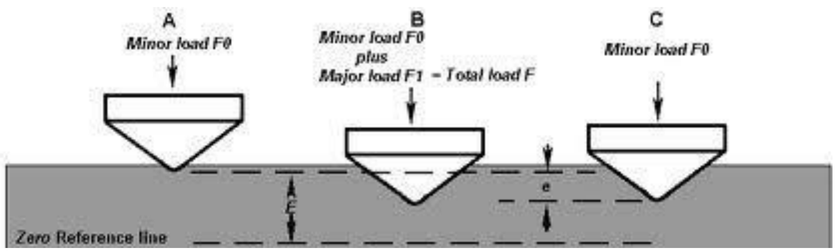


Fig: Rockwell's Hardness Tester



Relevant IS Codes:

IS: 1586 (2000), Method for Rockwell Hardness Test for Metallic Material (Scales A-B-C-DE-F-G-H-K 15N, 30N, 45N, 15T, 30T and 45T) (Third Revision), BIS, New Delhi

Brinell’s Hardness Test

Aim: To study the Brinell’s hardness test and to determine the hardness number of the given specimens.

Equipment: Brinell’s hardness tester, micrometer microscope, specimens and indentor.

Theory & Principle: Hardness is the resistance of metal to deformation. It is the property of the material by which it offers resistance to scratching Indentation. Sometimes hardness is defined as 'resistance to penetration, abrasion and cutting. '

The Brinell hardness is one of the oldest and most used types. Brinell test are static indentation tests using relatively large indentors (2.5mm to 10mm). The Brinell Hardness Number (BHN) is defined as the ratio of the load to the surface area of the indentation

$$\text{BHN}(\text{Kg/mm}^2) = \frac{2P}{\Pi D[D - \sqrt{D^2 - d^2}} = \frac{P}{\Pi D}$$

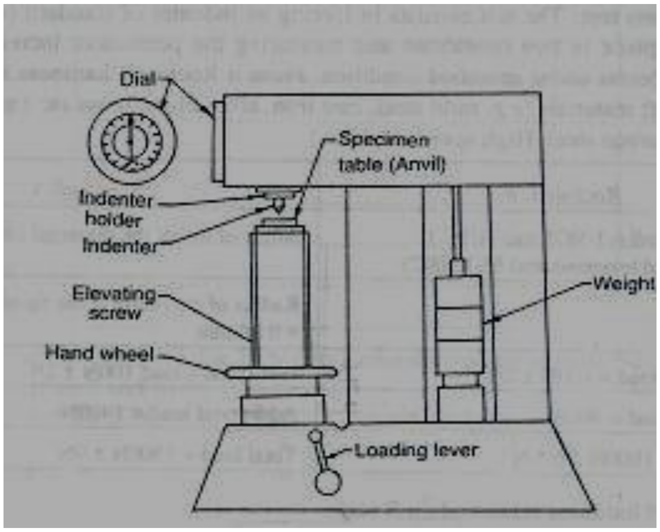
Where P is the Load in Kg or N, D is the diameter of the ball in mm, d is the diameter of impression in mm and t is the depth of indentation in mm as shown in fig 1 & 2. BHN is expressed in Kg/mm^2 or N/mm^2 or N/m^2.

The steel ball diameter and applied load are constant and are selected from the Table 1, to suit, the composition of the metal, and its hardness. The Brinell’s hardness number varies with the diameter of the ball and the load employed. For strictly comparable results faced values must be used for D & P as shown in the Table 1.

The Brinell test is not suitable for extremely hard materials, because the ball itself would deform under the load. It is not adopted for use with case hardened surfaces, because the depth of indentation may be greater than the thickness of the case and the soft case below will start yielding. The specimen surface must be flat & reasonably well polished.

Procedure:

1. Keep the hand lever (23) at position ‘B’.
2. Start the motor & then take handle lever from position ‘B’ to position ‘A’ and Wait until the Weight hanger reaches at its position.
3. Place the specimens securely on testing table.
4. Turn the hand-wheel (1) close wise direction so that specimen will push the indicator and will show a reading on dial gauge (15) The movement is continued until the long pointer will stop at ‘O’ and small pointer at red dot, when the initial load of 250 kg is applied. If little error exists the same can be adjusted by rotating the outer ring of dial gauge (15).
5. Turn the hand lever (23) from position ‘A’ to ‘B’ so that the total load is brought into action.
6. When the long pointer of dial reaches a steady position the load may be released for normal production testing or may be maintained for up to 15 seconds for accurate work. For releasing load take back the lever (23) to ‘A’ position. The weights are lifted off and the indicator will come to rest at the required depth reading. Thus only the initial load is a remaining active.
7. Turn back the hand wheel (1) and remove the specimen, carry the same procedure for further specimens.
8. For accurate tests measure the diameter of impression by Brinelle Microscope and find out the Brinell’s Hardness number referring to the chart.



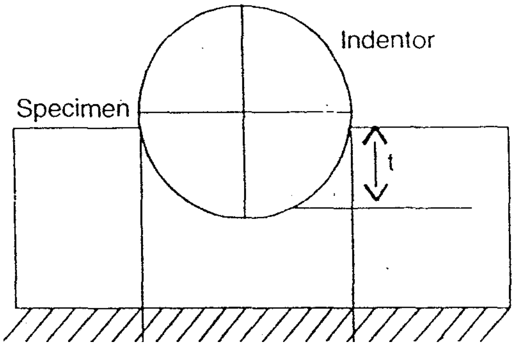


Fig : Brinell’s Hardness Testing Machine

Table 1

Sl no	Material	Diameter of the Ball Indentor	Load Applied P (kg)	Time for Load applied (S)	Diameter of indentation 'd' in mm	BHN $= \frac{2P}{\prod D\left[D - \sqrt{D^2 - d^2}\right]}$ kg/mm²		

Table 2

Material	Ball Diameter mm	$\frac{P}{D^2}$	Applied Load (Kg)	Time of Load applied (Seconds)	BHN (kg/mm²)
Ferrous Metals Steel & Cast Fe	10	30 5	3000 30	10 750	up to 450
Non Ferrous Metal Cu & its alloys Brass	10 5	10	1000 250	30	32 to 130
AI & its alloys	10	5	500	30	8 to 35

Result: The Brinell's hardness number of a given specimen = ………………………….

Relevant IS Codes:

IS: 1500 (1983), Method of Brinell hardness test for metallic materials (2nd Revision), BIS, New Delhi.

Experiment No. 17

Testing of Burnt Clay Building Bricks

Aim: To study the dimensional characteristics, to determine the water absorption and to determine the compressive strength of burnt clay building bricks.

General Quality of Bricks:

Bricks shall be hand moulded or machine moulded and shall be made from suitable soils. They shall be free from cracks, flaws and nodules of free line. Hand moulded bricks of 90 mm or 70 mm height shall be moulded with a frog 10 to 20 mm deep on one of its flat sides. The bricks shall have smooth rectangular faces with sharp corners and shall be uniform in colour.

The standard size of common building bricks:

Type of bricks	Length (L) mm	Width (W) mm	Height (H) mm
Modular bricks	190	90	90
	190	90	40
Non-modular bricks	230	110	70
	230	110	30

A) To study the dimensional characteristics of burnt clay building bricks:

Procedure:

Twenty bricks shall be selected at random from the sample. All blisters, loose particles of clay and small projections shall be removed. They shall then be arranged upon a level surface one by the side of other length wise, width wise and height wise. The overall length, overall width and overall height of the assembled bricks shall be measured with a steel tape to the nearest mm. The tolerances for the dimensions of bricks when measured as indicated above shall be within the following limits.

Type of bricks	Length (L) mm	Width (W) mm	Height (H) mm
Modular bricks	3800 $\pm$ 80	1800 $\pm$ 40	1800 $\pm$ 40
	3800 $\pm$ 80	1800 $\pm$ 40	800 $\pm$ 40
Non-modular bricks	4600 $\pm$ 80	2200 $\pm$ 40	1400 $\pm$ 40
	4600 $\pm$ 80	2200 $\pm$ 40	600 $\pm$ 40

Observation:

• Type of bricks:

• Identification mark on the bricks:

Sl No of bricks	Length (L) mm	Width (W) mm	Height (H) mm
1			
2			
3			
4			
5			

Conclusion:

B) To determine the water absorption of burnt clay building bricks.

Apparatus:

• A sensitive balance capable of weighing within 0.1% of the mass of the specimen.

• A ventilated, temperature controlled oven.

Procedure:

• Measure the dimensions of the bricks to the nearest 1 mm.

• Dry the specimen in a ventilated oven at a temperature of 105 to 115^{o}C till it attains substantially constant mass.

• Cool the specimen to the room temperature and note down its mass (M_1).

• Completely immerse the dried specimen in clean water at a temperature of 27 ± 2^{o}C for 24 hours.

• Take the specimen out of water and wipe out any traces of water with a damp cloth.

• Note down the mass of the specimen (M_2), taking care to see that the process of measuring the mass takes not more than 3 minutes after the specimen is removed from water.

• Calculate the water absorption, percent by mass, after 24 hours of immersion in cold water using the formula.

Water absorption = $[(M_2 – M_1) / M_1] \times 100$

• The water absorption for burnt clay building bricks when tested after immersion in cold water for 24 hours shall not be more than 20% by mass upto class 12.5 and 15% by mass for higher classes (refer above Table).

Observation:

- Type of bricks:
- Identification mark on the bricks:

Sl No	**Dimensions (mm) (L x W x H)**	**Mass of Bricks, g**		**Water absorption, %**
		Oven dried mass, (M_1)	**Mass after 24 hours immersion in cold water, (M_2)**	
1				
2				
3				
4				
5				

Average water absorption =

Conclusion:

C) To determine the compressive strength of burnt clay building bricks.

Apparatus:

- A compressive testing machine.

Procedure:

- Remove the unevenness observed on the bed faces of the specimen to provide too smooth & parallel faces by grinding and measure the dimensions of the specimen.
- Immerse the specimen in water at room temperature for 24 hours.
- Take the specimen out of water and drain out any surplus moisture at room temperature.
- Fill the frog (where provided) and all voids in the bed faces flush with cement mortar (one cement: 1 clean coarse of sand of grade 3 mm and down.
- Store the specimen under the damp jute bags for 24 hours followed by immersion in clean water for 3 days.
- Take the specimen out of water and wipe out any traces of moisture.
- Place the specimen with flat faces horizontal, and mortar filled face facing upwards

between two 3 – ply plywood sheets each of 3 mm thickness and carefully center the specimen between the plates of the testing machine.

- Apply the load axially at an uniform rate of 14 N/mm^2 per minute till the failure occurs and note down the maximum load at failure.
- Calculate the compressive strength in N/mm^2 using the formula.

Compressive strength = (Maximum load at failure) / Average area of the bed faces.

- Report the average of results and classify the sample of bricks tested (use above Table as reference)

Table 1: Classes of Common Burnt Clay Bricks

Class Designation	35	30	25	20	17.5	15	12.5	10	7.5	5	3.5
Average compressive strength (not less than), N/mm^2	35	30	25	20	17.5	15	12.5	10	7.5	5	3.5

Observation:

- Type of bricks:
- Identification mark on the bricks

Sl No	**Dimensions of the brick, mm**		**Average cross sectional area, mm^2**	**Maximum load at failure, N**	**Compressive strength, N/mm^2**	**Remarks**
	L	**W**				
1						
2						
3						
4						
5						

- Average compressive strength = ______________________________N/mm^2
- 80% of the minimum average compressive strength specified for the class of brick = ______________________________N/mm^2

Conclusions:

Relevant IS Codes:

IS: 1077 (1992), Indian Standard Common Burnt Clay Building Bricks - Specification, BIS, New Delhi
IS: 3495-Part 1 (1992), Indian Standard Methods of Tests of Burnt Clay Building Bricks: Determination of Compressive Strength, BIS, New Delhi
IS: 3495-Part 2 (1992), Indian Standard Methods of Tests of Burnt Clay Building Bricks: Determination of Water Absorption, BIS, New Delhi
IS: 5454 (1978-Reaffirmed 1995), Indian Standard Methods for Sampling of Clay Building Bricks, BIS, New Delhi

Testing of Clay Roofing Tiles – Mangalore Pattern

Aim: To determine the water absorption and braking load for machine – pressed, clay interlocking roofing tiles of the 'Mangalore Pattern' and to classify the tiles.

General Quality of Tiles:

- The roofing tiles shall be made of suitable clay of even texture and shall be well burnt. They shall be free from irregularities such as twists, bends, cracks and laminations.
- The roofing tile shall be free from impurities like particles of stone, lime or other foreign
materials visible to the naked eye either on the surface or on the fractured face of the tile obtained by breaking the tile. However, occasional particles up to 2 mm in size may be permissible. When struck, the tile shall give a characteristic ringing sound and when broken, the fracture shall be clean and sharp at the edges. The Class AA tile shall be of uniform colour.
- When the roofing tile is placed on either face on a plane surface, the gap at the corners shall be not more than 6 mm.

The dimensions of the tiles:

Sl No	Overall Length (L), mm	Overall Width (W), mm
1	410	235
2	420	250
3	425	260

- The average weight of 6 tiles, when dried at 105 to 110$_o$ C to constant weight and weighed, shall be not less than 2 kg and not more than 3 kg. The weight of the tile shall be noted correct to the nearest 0.01 kg.

A) To determine the water absorption of tiles:

Procedure:

- Six tiles shall be used for this test.
- Dry the six tiles selected in an oven at a temperature of 105 to 110$_o$C till they attain

constant mass. Cool them and record their masses (A).

• Immerse the dry specimens completely in clean water at 24 to 30$_o$C for 24 hours.

• Remove the tiles, wipe of the surface water carefully with a damp cloth and record their masses nearest to a gram (B) within 3 minutes after removing them from the tank.

• Calculate the percentage water absorption using the formula

Percentage absorption = [(B-A) / A] x 100

• Report the average percentage average water absorption of the six tiles.

Observation:

• Identification mark on the tiles:

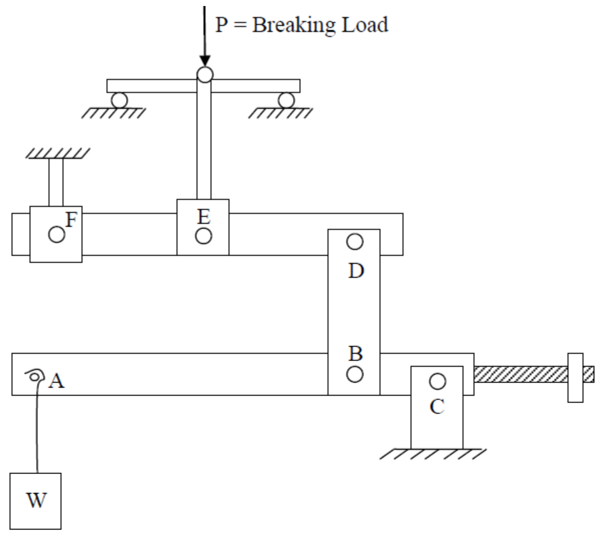
Sl No	**Mass of the Tiles, g**		**Water absorption, %**
	Oven dried mass, (A)	**Mass after 24 hours immersion In clean water, (B)**	
1			
2			
3			
4			
5			
6			

Average water absorption =

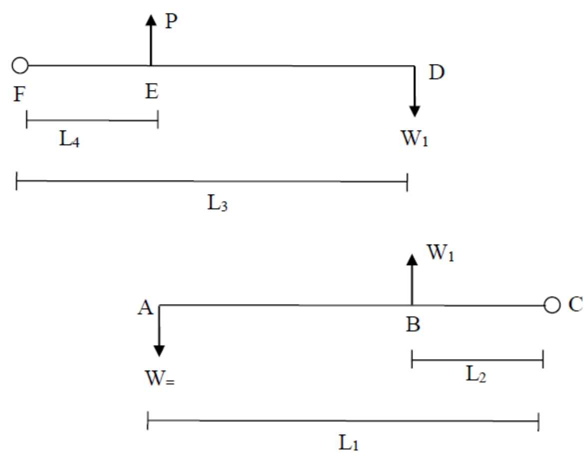
B) To determine the breaking load of tiles:

Apparatus:

• Tile testing machine.



Determination of LAC



$$LAC = (L_1 / L_2) \times (L_3 / L_4) = (300 / 75) \times (225 / 75) = 12$$

Procedure:

- Six tiles shall be used for this test.
- Six tiles shall be soaked in water at $27 \pm 2^{o}C$ for 24 hours.
- Take the tiles out of water and test them in the wet condition only.
- Support the tiles evenly flat wise on the bearers set with a span of 25 cm and resting on the bottom surface.
- Apply the load with the direction of the load perpendicular to the span, at a uniform rate of 450 to 550 N/minute.

- Note down the load at failure for each of the six tiles separately.
- Report the average value calculated.

Observation:

- Identification mark on the tiles:
- Lever Arm Constant (LAC): 12

Sl No	Mass of the led shots in pan (M), kg	Breaking load (P), N	Average value of the breaking load, N
1			
2			
3			
4			
5			
6			

Breaking Load = P = M x LAC x 9.81 = ____________________N

Results and Conclusions:

C) To classify the clay roofing tile, 'Mangalore Pattern':

Procedure:

- Classify the given Mangalore pattern clay roofing tile according to the specifications given in Table 1.

Sl. No.	Characteristic	Requirement	
		Class AA	Class A
1	Water absorption, % (Max)	18	20
2	Breaking load, kN (Min) a) Average	1.0 (for 410 x 235 mm) 1.1 (for 420 x 250 mm) and (425 x 260 mm)	0.8 (for 410 x 235 mm) 0.9 (for 420 x 250 mm) and (425 x 260 mm)
	b) Individual	0.9 (for 410 x 235 mm) 1.0 (for 420 x 250 mm) and (425 x 260 mm)	0.68 (for 410 x 235 mm) 0.78 (for 420 x 250 mm) and (425 x 260 mm)

Results:

Relevant IS Codes:
IS: 654 (1992), Indian standard clay roofing tiles, Mangalore pattern – specification, BIS, New Delhi
IS: 2248 (1991), Glossary of terms relating to structural clay products, BIS, New Delhi