SYLLABUS

BUILDING MATERIALS TESTING LABORATORY

Sub Code: 18CVL38 **CIE Marks: 40**
Hrs/ Week: 03 **Exam Hours: 03**
Total Hrs. 42 **SEE Marks: 60**

COURSE LEARNING OBJECTIVES:

The objective of this course is to make students to learn:

1. Ability to apply knowledge of mathematics and engineering in calculating the mechanical properties

of structural materials.

2. Ability to function on multi-disciplinary teams in the area of materials testing.

3. Ability to use the techniques, skills and modern engineering tools necessary for engineering.

4. Understanding of professional and ethical responsibility in the areas of material testing.

5. Ability to communicate effectively the mechanical properties of materials.

EXPERIMENTS

1. Tension test on Mild steel and HYSD bars.

2. Compression test of Mild Steel, Cast iron and Wood.

3. Torsion test on Mild Steel circular sections.

4. Bending Test on Wood Under two point loading.

5. Shear Test on Mild steel-Single and Double Shear.

6. Impact test on Mild Steel (Charpy & Izod).

7. Hardness tests on ferrous and non-ferrous metals – Brinell's, Rockwell and Vicker's.

8. Test on Bricks and Tiles.

9. Tests on Fine aggregates –Moisture Content, Sieve analysis, Specific gravity, Bulking, Bulk density.

10. Tests on Coarse aggregates –Moisture Content, Specific gravity, water absorption, Sieve analysis, Bulk Density.

11. Demonstration of Strain gauges and Strain Indicators.

COURSE OUTCOMES

After successful completion of the course, the students will be able to:

1. Reproduce the basic knowledge of mathematics and engineering in finding the strength in tension, compression, shear and torsion.
2. Identify, formulate and solve engineering problems of structural elements subjected to flexure.
3. Evaluate the impact of engineering solutions on the society and also will be aware of contemporary issues regarding failure of structures due to unsuitable materials.

QUESTION PAPER PATTERN

- Group experiments - Tension test, compression test, torsion test and bending test.
- Individual Experiments – Remaining tests.
- Two questions are to be set - One from group experiments and the other as individual experiment.
- Instructions as printed on the cover page of answer script for split up of marks to be strictly followed.
- All exercises are to be included for practical examination.

Experiment No. 1 **Date:**

TENSION TEST ON MILD STEEL

(IS 1608 – 2005 - METALLIC MATERIALS - TENSILE TESTING AT AMBIENT TEMPERATURE)

OBJECTIVES:

i) To study the behaviour of mild steel test specimen under the action of a gradually increasing load tested up to failure.

ii) To determine the Yield stress, Modulus of Elasticity, Percentage elongation, Percentage reduction in area, Ultimate stress and Breaking stress.

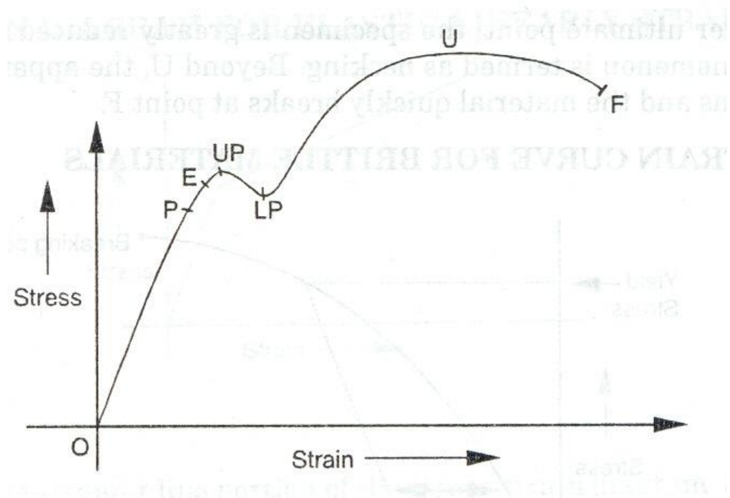
APPARATUS:

Universal testing machine, Dial Guage, Vernier Calipers, scale and Gripping devices.

THEORY:

Stress-strain diagrams: Common types of stress-strain relations for ductile materials like mild steel and HYSD bars are shown in Fig.1 and Fig.2. The figures shows that for initial stage of loading, the test point fall approximately on a straight line i.e., stress is proportional to the strain.

E is the constant of proportionality and is also called the Modulus of Elasticity in tension or Young's Modulus, and is an experimental constant that varies in magnitude depending upon the material. This simple relationship between the stress and strain was first reported by the English Scientist Sir Robert Hooke in 1678 and is known as Hooke's law. Point P in below figure is called the Proportionality limit and it is the stress value up to which the stress is proportional to strain. Beyond this point, the strain increases rapidly and for small increase in stress, there is large increase in deformation. For most structural and machine members, the design stresses are so selected that they are considerably less in value than the proportionality limit, thus ensuring small deformation and safety. The stress-strain diagrams for engineering materials such as concrete, cast iron and rubber are curved. However, for the relatively small stress values used in the design, the stress-strain relations may be assumed to be linear without serious error.



Cup and Cone Fracture for mild steel (ductile materials):

When a circular wire, rod or round tensile test specimen is stressed (in tension/pulling) beyond the yield point (or yield strength) the metal will become plastic and will "flow" at the weakest location. The circular cross section at this location will be diminished (necking). As the stressing/pulling continues, the metal will separate or fail at this location. The resultant fracture will have a characteristic appearance. One side of the fracture will appear to be a cup and the mating (pointed) fracture will appear to be a "cone". This type of tensile overload fracture is referred to as "cup and cone".

PROCEDURE:

1. Measure the diameter at three locations and take the average value. Similarly, note down the length of the specimen.
2. Fix the specimen in the jaws of the UTM.
3. Fix the extensometer on the specimen and note the gauge length of the extensometer.
4. Set the extensometer and side scale to read zero.
5. Apply the load gradually making observations at regular intervals of load, the corresponding reading on extensometer is noted.
6. Observe the yield point load indicating a slight kickback of the load pointer.
7. Remove the extensometer noting its reading at the yielding point.
8. Further load the specimen. Start measuring the change in length with the help of side scale reading on the UTM. Observe the maximum and breaking load.
9. Remove the broken specimen and measure its final length and diameter at the neck formation.

OBSERVATIONS:

1. Least count of the Callipers :
2. Least Count of Dial Gauge :
3. Initial Diameter of the specimen, d_1:
4. Final Diameter of the specimen, d_2 :
5. Initial Length of Specimen. L_1 :
6. Final Length of Specimen. L_2 :
7. Gauge Length :
8. Initial Area of Specimen, A_1 :

9. Final Area of Specimen, A_2 :

TABULAR COLUMN

Load		Dial Gauge Reading			Increase in length (δL) (mm) = Diff * LC	Stress = P / A_1 (N/mm^2)	Strain = ($\delta L / L_1$)
Kg	N	Initial Reading	Final Reading	Difference			

CALCULATION:

- Yield Stress = Yield load / Initial area

- Young's Modulus = Stress / Strain (From Graph)

- Ultimate Stress = Ultimate Load/ Initial Area

- Breaking Stress = Breaking Load/ Initial Area

- Proof Stress = 0.2 % of Strain (From Graph)
  = (0.2/100) * Gauge Length in mm
  =

- % Elongation $= \frac{(L_2 - L_1)}{L_1} \times 100$

- % reduction in Area $= \frac{(A_2 - A_1)}{A_1} \times 100$

CALCULATIONS:

RESULT:

- **Young's Modulus of specimen** =
- **Yield stress** =
- **Ultimate stress** =
- **Breaking stress** =
- **% Elongation** =
- **% Reduction in area** =

Experiment No. 2 **Date:**

COMPRESSION TEST ON MILD STEEL

OBJECTIVES:

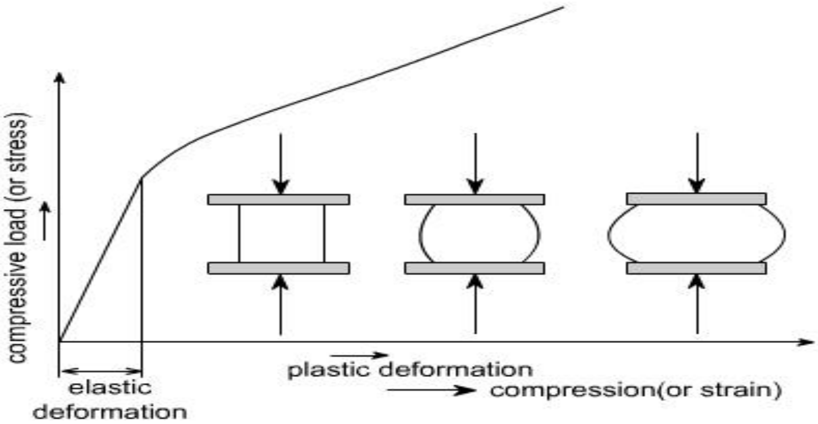
i) To study the behaviour of the material under a gradually increasing axial compressive load
ii) To determine the Young's Modulus and compressive strength

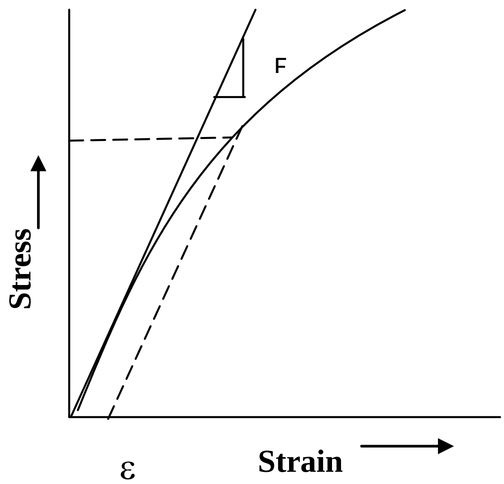
APPARATUS: Universal testing machine, Vernier calliper, Dial gauge and Scale.

THEORY:

The compression test is commonly used for testing brittle material. The brittle materials are stone, concrete, cast iron etc., The results of compression tests are affected by the frictional forces occurring at the ends of the specimen. The influence of friction forces can be eliminated by lubricating the ends with paraffin wax or other suitable material. For ductile materials such as mild steel or copper, lateral distortion takes place. Due to the influence of friction at the load faces, the cross section becomes greatest at the centre of the test piece taking up a barrel shape. Failure finally occurs by cracks appearing on the surface and spreading inwards. Also, for mild steel, the behaviour is same as in tensile test up to elastic limit. The yield point is less pronounced than in the tension test.

For brittle materials such as cast iron and concrete the behaviour is quite different from that of ductile materials. There is no stage during which the material behaves as truly elastic. There is no yield point, and the plastic deformation is not prominent. But there is a definite load at which the specimen breaks. Brittle materials usually fail by shearing along planes inclined at 50° and 70° to the longitudinal axis. For brittle materials ultimate tensile strength is much lower than compressive strength. The strengths of concrete and cast iron in compression are greater than in tension and their main applications are in constructions or parts of constructions where stresses are compressive.





PROCEDURE:

1. Measure the diameter at three locations and take the average value using dial gauge, similarly note down the lengths of the specimen.
2. Fix the specimen in the jaws of UTM.
3. Adjust the dial gauge to zero reading.
4. Gradually apply the load and record the yield point and maximum load in the case of ductile materials or breaking load in the case of brittle material.
5. Remove the broken specimen (if it is brittle) from the machine. Observe the location and the character of the fracture and measure the final diameter and length.
6. Plot stress – strain diagram for the test and compute all properties.

OBSERVATIONS:

1. Least count of the Callipers :
2. Least Count of Dial Gauge :
3. Initial Diameter of the specimen, d_1:
4. Final Diameter of the specimen, d_2 :
5. Initial Length of Specimen. L_1 :
6. Final Length of Specimen. L_2 :
7. Gauge Length :
8. Initial Area of Specimen, A_1 :

9. Final Area of Specimen, A_2 :

TABULAR COLUMN:

Load		**Dial Gauge Reading**			**Increase in length (δL) (mm) = Diff * LC**	**Stress = P / A_1 (N/mm^2)**	**Strain = ($\delta L / L_1$)**
Kg	N	**Initial Reading**	**Final Reading**	**Difference**			

CALCULATION:

- Young's Modulus = Stress / Strain (From Graph)

- Compressive Stress = Ultimate Load/ Initial Area

- Proof Stress = 0.2 % of Strain (From Graph)
  = (0.2/100) * Gauge Length in mm

- % Reduction of Length $= \frac{(L_1 - L_2)}{L_1} \times 100$

- % Increase in Area $= \frac{(A_2 - A_1)}{A_1} \times 100$

CALCULATIONS:

RESULT:

- **Young's Modulus of specimen** =
- **Compressive Strength** =
- **% Reduction of Length** =
- **% Increase in Area** =

Experiment.No.3 **Date:**

TORSION TEST ON MILD STEEL CIRCULAR SECTIONS

IS 1717-2012 - METALLIC MATERIALS - TORSION TEST

OBJECTIVES:

To study the behaviour of mild steel when subjected to a gradually increasing torque and to determine:

i. Modulus of rigidity of the material
ii. Torsional Shear Strength

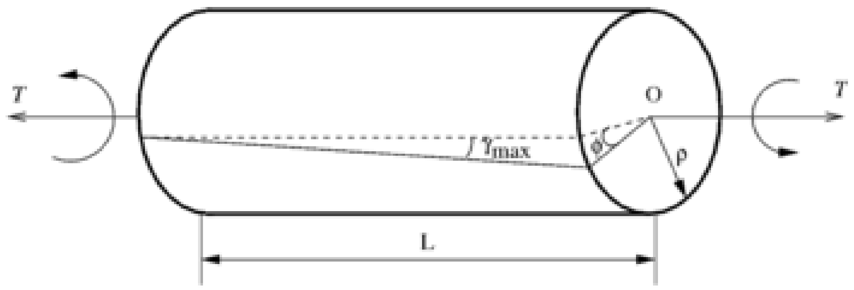
APPARATUS: Torsion testing machine, Vernier callipers.

THEORY:

A circular bar, when subjected to torque will be twisted; shearing stresses are developed in any cross-section of the bar whose value increases linearly from zero at the centre to a maximum at the outer periphery. The relation between the applied torque, the developed stress and the angular twist is given by the equation,

$$\frac{T}{J} = \frac{\tau}{r} = \frac{C\theta}{L}$$

where T is the applied torque, J is the Polar Moment of Inertia of the cross-section of the bar, τ is the magnitude of shear stress at radius r, C is the modulus of rigidity and θ is the angle of twist over a length L of the bar. Therefore the modulus of rigidity can be computed from the equation, C = (T/θ) x (L/J), where T/θ is the slope of the graph of the torque v/s twist. The yield point of shear stress is calculated from the equation f = (T/J) X R where T is the torque at the yield point and R is the outer radius. Modulus of rupture is the stress at failure and computed from the formula. $(\tau)_{failure} = (T_{failure} \times R) / J$



PROCEDURE:

1. Measure the diameter and length of the specimen accurately using Vernier Calipers.
2. Fix the specimen in the grips and clamps provided in the machine.
3. Operate the driving mechanism either by hand or motor to apply the torque.
4. Take the readings of torque at regular intervals of twist simultaneously until the specimen breaks.
5. Plot the graph of torque v/s angle of twist. Slope of the graph gives the torsional stiffness.
6. Calculate modulus of rigidity and torsional shear stress

OBSERVATIONS:

1. Least Count of Vernier Calipers =
2. Mean Length of the specimen (l) = ………………….. mm
3. Mean diameter of a specimen (D) = ……………mm

TABULAR COLUMN:

Torque Applied		Angle of twist	
Kg-cm	N-mm	Degrees	Radians

CALCULATION:

1. Polar Moment of Inertia =

2. Torsional Shear Strength =

3. Slope (From graph) =

4. modulus of rigidity (C) =

RESULT:

- **Modulus of rigidity of the given specimen = C =**
- **Maximum Torsional shear stress =**

Experiment No. 4 **Date:**

BENDING TEST ON WOOD UNDER TWO POINT LOADING

IS: 2380 (PART IV) - 1977 DETERMINATION OF STATIC BENDING STRENGTH

OBJECTIVES:

i. To study the behaviour of the wood specimen subjected to gradually increasing two point equal loads each at 1/3rd of the span from both end.
ii. To find the modulus of elasticity.
iii. To determine the modulus of rupture or flexure modulus.

APPARATUS:

Universal testing machine, dial gauge, Scale, Vernier calipers.

THEORY:

Whenever transverse loads or couples act on a member whose longitudinal dimensions are considerably large than its transverse dimensions, we say that the member is under bending. The stresses produced are bending stresses (flexural stresses) i.e. the force acting on the member induces compressive stresses on one part of the cross section and tensile stresses over the remaining part. There are very many members in engineering structures and machines in which most important criterion of performance is resistance to bending. Ex. Beams, shafts etc., The Fig.4 shows a beam subjected to transverse loading. The bending effect at any cross section is expressed as the bending moment M, which is a function of loading and span of the beam. The bending moment at any transverse cross section of the beam will cause normal stresses (bending stresses) across the cross section. The magnitude and sense of the normal stresses at any fibre is given by the flexure formula (Bernoulli's bending equation).

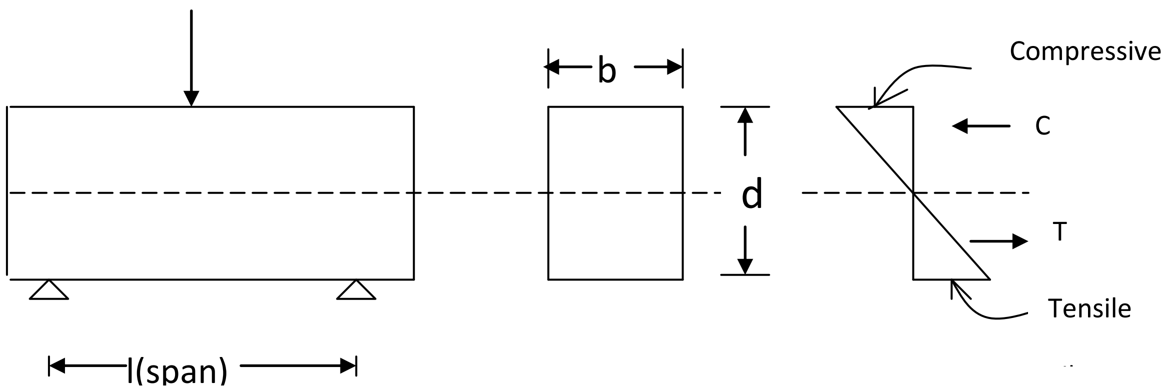
$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

Where, M = Moment of resistance = Bending moment.
I = Moment of inertia about the centroidal axis.
σ = Fibre stress.
y = Distance from neutral axis to any fibre.
E = Modulus of elasticity.
R = Radius of neutral fibre.

The variation of the normal stresses is as shown in the Fig. The maximum fibre stresses can be calculated by,

$$\sigma_{max} = \frac{M}{I} \times y_{max}$$

$$\sigma_{max} = \frac{M}{Z}, \text{ where } Z = \frac{I}{y_{max}} = \text{section modulus.}$$



PROCEDURE:-

1. The cross-sectional dimensions of the specimen are noted from which the moment of inertia about the neutral axis can be computed.
2. The specimen is placed on the roller supports which have been fixed on the lower Cross-head of the UTM and the span is noted.
3. Dial indicators are fixed to record the value of the deflections at the points of interest.
4. The load is gradually increased and the value of the central deflection is noted for regular load increments.
5. Plot the graph load v/s deflection.

OBSERVATIONS:

Least count of the Slide Calipers =

Depth of the specimen = d =

Width of the specimen = b =

Span of the specimen = l =

Moment of inertia, $I = \frac{bd^3}{12} =$

Section modulus, $Z = \frac{bd^2}{6} =$

TABULAR COLUMN:

Total load		**Dial Gauge reading**			**deflection (mm)**
Kg	**N**	**Initial Reading**	**Final Reading**	**Difference**	**= Diff*LC**

CALCULATIONS:

1. Max. bending moment, M = $\frac{Wl}{4}$ =

2. Moment of Inertia = I = $\frac{bd3}{12}$

3. Stiffness, k = $\frac{W}{\delta}$ (From Graph) =

4. Young's modulus, E = K * $\frac{l^3}{48EI}$ =

5. Modulus of rupture, $\sigma = \frac{3Wl}{2bd^2}$ =

CALCULATIONS:

RESULT:

- **Modulus of rupture or Bending Stress** =
- **Modulus of elasticity** =

Experiment No.5 **Date:**

SHEAR TEST ON MILD STEEL

IS 5242-1979 - METHOD OF TEST FOR DETERMINING SHEAR STRENGTH OF METALS

OBJECTIVES:

To determine the Ultimate Shear Strength of the given material in Single shear and Double shear.

APPARATUS:

Universal Testing Machine (UTM), Vernier Calipers, Shear attachments, Micrometer, Scale.

THEORY:

Shear stress is caused by forces which act parallel to an area of cross-sectional and tend to produce sliding of one portion over another.

If there is only one cross-section which resists the failure, the material is said to be in Single Shear and the average ultimate strength in Single Shear will be equal to the failure load divided by the area of cross-section. If two areas resist the failure, then the material is said to be in double Shear and the average ultimate strength in Double Shear will be equal to the failure load divided by twice the area of cross-section

Ultimate shear strength $\tau = F / A$ for single shear and

$$\tau = F / (2A) \text{ for double shear}$$

Where F is the fracture load and A is the cross sectional area.

PROCEDURE:-

1. The average diameter of the given specimen is measured.
2. For single shear test, fix the specimen and apply the load slowly at right angles to the axis of the piece through the central block. Note the fracture load.
3. Report the shape and texture of the fractured surface.
4. Repeat the above test by fixing the specimen for double shear.

OBSERVATIONS:

Original diameter of the specimen = d =

Cross sectional area of the specimen = A =

TABULAR COLUMN

Sl. No.	Type of Test	Mean diameter of the specimen (mm)	Cross-sectional area (mm^2)	Ultimate load (N)	Ultimate shear stress N / mm^2

CALCULATIONS:

Single Shear Stress = Load/Area

Double Shear Stress = Load/ 2*Area

RESULT:

- Ultimate shear strength (Single shear) =
- Ultimate shear strength (Double shear) =

Experiment No 6 (a) **Date:**

IMPACT TEST ON MILD STEEL

a) CHARPY IMPACT TEST

OBJECTIVES:

To determine the impact strength of given specimen.

APPARATUS:

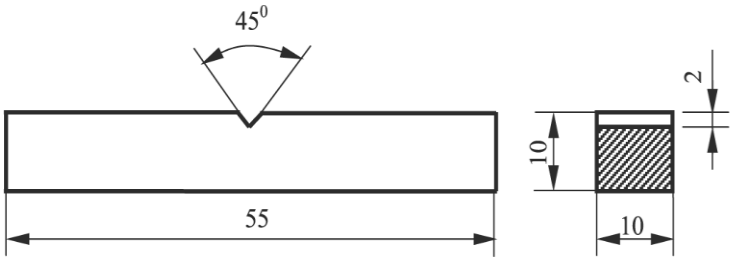
Pendulum type Impact Testing Machine, Vernier Calipers and scale.

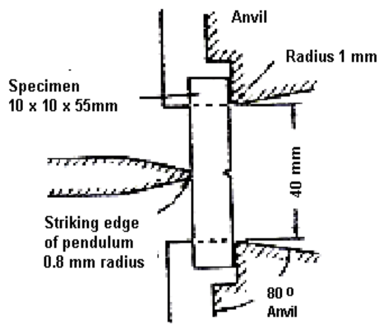
THEORY:

The Indian Standard method of Charpy test (U-notch) consists of breaking by one blow from a swinging hammer under prescribed conditions, a test piece U-notched in the middle and supported at each end. The energy absorbed for failure of the specimen is determined from which the impact value is obtained.

Impact strength with U-notch = KU = the energy absorbed in Joules for the failure of the specimen. The symbol KU signifies that the test was performed under standard test conditions, namely the strike energy of testing machine was 300 joules and a test piece having a 5mm deep U-notch was used. KU 100/3 indicates that the test was conducted with 100 joules, striking energy on a test piece with 3mm deep notch. If during the test, piece is not completely broken; the impact value obtained is indefinite.

A standard test piece of overall length of 55mm and a square cross-section of 10mm side with a central U-notch 5mm deep is employed to the test. It is placed in the Charpy impact testing machine as a simply supported beam with a span of 40mm. The notch is adjusted to be at the centre and such that it is on the tension side. The hammer is lifted to have an initial potential energy of 300 joules, it is released without any shock and is allowed to strike the specimen and swing to the other side. After it has reached the maximum height on the other side and is in the process of swinging back, it is brought to rest by the application of brakes or manually. The reading indicated by the pointer is recorded.





Charpy Top View

PROCEDURE:

1. Fix the charpy striker in its respective position, place the charpy test specimen on supports.
2. Align the centre at the specimen notch with respect to centre of support by means of setting guage.
3. Touch the striker to the test specimen and adjust the indicating pointer to 300J.
4. Lift the pendulum till it gets latched in its position at 140° from its vertical axis.
5. Allow the pendulum to swing freely and break the specimen.
6. After rupture apply the break to the pendulum slowly by operating break lever.
7. Note down the reading of absorbed energy directly on the dial as indicated by the indicating pointer.

8. Before proceeding for the next test, remove the broken piece of the tested specimen and bring indicating pointer, striker to its original position at 300J.

OBSERVATIONS:

Length of the specimen (L) =

Breadth of the Specimen (b) =

Depth of the Specimen below the notch (d) =

Area of the specimen below the notch, A = (b x d) =

TABULAR COLUMN

Sl .No	Area of Specimen, A (mm^2)	Initial Reading K_1 (J)	final Reading K_2 (J)	Charpy impact value $K = K_1 – K_2$ (J)	Charpy impact Strength $I = K / A$ (J / mm^2)

RESULT:

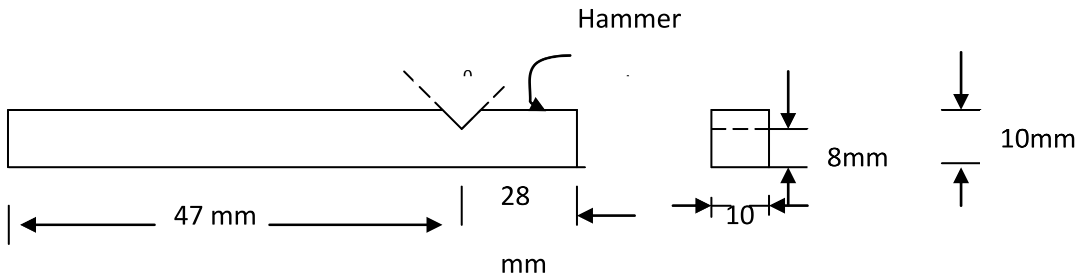
Average impact strength by Charpy Test =

Experiment No 6 (b) **Date:**

b) IZOD IMPACT TEST

THEORY:

The Indian standard method of Izod impact test consists of breaking by one blow from a swinging hammer, under specified conditions, a notched test-piece, gripped vertically with the bottom of the notch in the same plane as the upper faces of the grips. The blow is struck at a fixed position on the face having the notch. The energy absorbed is determined.



PROCEDURE:

1. Fix the Izod striker in its respective position, place the izod test specimen as a vertical cantilever.
2. Align the specimen notch by means of setting guage.
3. Touch the striker to the test specimen and adjust the indicating pointer to 170J.
4. Lift the pendulum till its gets latched in its position at 85^{o} from its vertical axis.
5. Allow the pendulum to swing freely and break the specimen.
6. After rupture apply the break to the pendulum slowly by operating break lever.
7. Note down the reading of absorbed energy directly on the dial as indicated by the indicating pointer.
8. Before proceeding for the next test, remove the broken piece of the tested specimen and bring indicating pointer, striker to its original position at 170J.

OBSERVATIONS:

Length of the specimen (L) =

Breadth of the Specimen (b) =

Depth of the Specimen below the notch (d) =

Area of the specimen below the notch, A = (b x d) =

TABULAR COLUMN

Sl .No	**Area of Specimen, A (mm^2)**	**Initial Reading K_1 (J)**	**final Reading K_2 (J)**	**Izod impact value $K = K_1 – K_2$ (J)**	**Izod impact Strength I = K / A (J / mm^2)**

RESULT:

Average impact strength by Izod Test =

Experiment No.7 (a) **Date:**

BRINELL HARDNESS TEST

IS 1500-2005-METHOD FOR BRINELL HARDNESS TEST FOR METALLIC MATERIALS

OBJECTIVES: To determine the Brinell's hardness number of ferrous and Non-ferrous metals.

APPARATUS: Brinell's hardness testing machine. Brinell's microscope and Stop watch.

THEORY:

The property of hardness of a metal is usually associated with its resistance to scratching, wear indentation or deformation. In the Brinell hardness test, which measures resistance to indentation, a ball having a diameter 'D' is pressed on the material to be tested under a load 'P'. The load is maintained for 10 to 15 seconds. The diameter'd' of the produced impression is measured.

The Brinell hardness number BHN is defined as the ratio of test load to the surface area of indentation.

Brinell hardness number,

$$BHN = \frac{2P}{\pi D\left[D - \sqrt{D^2 - d^2}\right]}$$

Where,

P = Applied load in Kg

D = Diameter of indentor in mm

d = Diameter of indentation in mm

Although the Brinell test is a simple one to make, several precautions are necessary in order to obtain good results. It is not adapted to testing extremely hard materials because the ball itself deforms too much, nor is it satisfactory for testing thin pieces such as raser blades, because the usual indentation may be greater than the thickness of the piece. It is not adopted to testing case hardened surfaces, because the depth of indentation may be greater than the thickness of the case and because the yielding of the soft core invalidates the results; also, for such surfaces the indentation is almost invariably surrounded by a crack that may cause fatigue failure if the part is used in service. Obviously the Brinell test should not be used for parts the marring of the surface of which impairs their value.

PROCEDURE:-

1. Place the specimen on the anvil so that its surface will be normal to the direction of the applied load.
2. With the hand wheel, raise the anvil until the specimen just makes contact with the ball.
3. Select the load, ball diameter and the time of application of the load according to the material to be tested as given the load test table.
4. Apply the load gradually and maintain it for the specified time.
5. Release the load and remove the specimen. Measure the diameter of the impression (indentation) left by the ball indenter by using Brinell's microscope.
6. Make three trials for each specimen for calculating the hardness number.

OBSERVATIONS:

Diameter of indenter = 5 mm.

TABULAR COLUMN

Type of material	Trial No	Force applied (P) Kg	Indentation diameter (d) in mm			Brinell Hardness Number	Average BHN Kg/mm^2
			d_x	d_y	d		
Mild steel							
Brass							
Copper							
Aluminium							

CALCULATIONS:

RESULT:

Brinell hardness number of the given specimens is

1. Mild steel =
2. Brass =
3. Copper =
4. Aluminium =

Experiment No. 7 (b) **Date:**

ROCKWELL HARDNESS TEST

IS 1586-2000-METHOD FOR ROCKWELL HARDNESS TEST FOR METALLIC MATERIALS

OBJECTIVES: To determine the Rockwell's hardness number of ferrous and non-ferrous metals.

APPARATUS:

1. Rockwell's hardness testing machine.
2. A ball indenter of 1.6 mm diameter.
3. A diamond cone with an apex angle of 120°.
4. Stop watch.

THEORY:

Two consecutive loads intend on the ball, a minor load of 10Kg which does not deform the metal and is used to seat the indenter, with the minor load still operating a major load is added which is 90kg, for the Rockwell B test and 140kg for Rockwell C test so that the total applied load will be 100kg and 150kg, for the 'B' and 'C' tests respectively. The depth of penetration effected by the additional load is the measure of the Rockwell hardness. The Rockwell hardness is read directly on the dial of the instrument that is graduated in the hardness units. The dial has two sets of figures, (i.e., B – 30 is at C – 0). It is made so, to avoid the negative hardness values on the B – scale, if used to test very soft materials. This also facilitates in establishing that the highest hardness that can be measured with a 1/16" diameter ball indenter is only B – 100 and for higher hardness the C –scale should be employed.

PROCEDURE:-

1. Select the indenter type, Scale and major load accordingly as given in the load test table.
2. Place the specimen on the anvil so that its surface will be normal to the direction of the applied load.
3. With the hand wheel, raise the anvil until the specimen just makes contact with the ball.
4. Select the load, ball diameter and the time of application of the load according to the material to be tested as given the load test table.
5. Apply the load gradually and maintain it for the specified time.
6. Release the load and remove the specimen. Measure the diameter of the impression (indentation) left by the ball indenter by using Brinell's microscope.
7. Make three trials for each specimen for calculating the hardness number.

OBSERVATIONS:

Minor load = kg

Type of material	Indenter	Scale	Total load (Kgf)
Hard metals	Diamond cone	C (Black graduations)	150
Soft metals	Ball of 1/16" in dia	B (Red graduations)	100

TABULAR COLUMN:

Sl. No	Type of material	Scale used	Total load (kg)	Rockwell Hardness Number			Average RHN
				1	2	3	
1	Mild steel						
2	Brass						
3	Copper						
4	Aluminium						
5	Hardened steel						

RESULT:

Rockwell hardness number of the given specimens is

1. Mild steel =
2. Brass =
3. Copper =
4. Aluminum =

Experiment No. 7(c) **Date:**

VICKERS HARDNESS TEST

IS 1501-2002 - METHOD FOR VICKERS HARDNESS TEST FOR METALLIC MATERIALS

OBJECTIVES:

To find the Vickers hardness number of the given specimen by using Vickers hardness tester.

APPARATUS: Vickers hardness testing machine

THEORY:

An indenter in the form of a right pyramid with a square base and an angle of 136° (α) between opposite faces, when forced into the meter under a load P applied for 10 to 15 seconds, causes an indentation which has a square base. If'd' is the diagonal of the indentation left on the surface of the test piece after the removal of the load, then the Vickers hardness VH is the quotient of the test load P(kg) and sloping area (sq mm) of indentation.

$$VH = \frac{Load}{Sloping\ area\ of\ indentation} = \frac{P}{\frac{d^2}{2} \sin 136^\circ / 2} = 1.854\, P / d^2$$

One of the advantages of the Vickers machine is in the measurement of indentation: a much more accurate reading can be made of the diagonal of the square than can be made of the diameter of a circle. Also, it is a fairly rapid method that can be used on metal as thin as 0.006 inch.

PROCEDURE:-

1. The specimen is cleaned from dirt, oil, scale etc and the test area is made even and polished.
2. Care is taken to see the thickness of the test piece is not less than 1.5times the diagonal of the indentation and that the distance from the centre of any indentation to the edges of the test piece or edges of any other indentation is not less than 2.5times the diagonal of the indentation.
3. Proper value of the load is selected which could vary from 1 to 120kg. Normally either 10kg or 30kg is selected.
4. The penetrate is inserted in the thrust piece of the machine and screwed.
5. The prepared specimen is placed on the supporting table and the hand wheel is turned on the right, until the surface of the specimen is sharply imaged on the screen. The clamping sleeve is turned to the left to clamp the specimen.
6. After ascertaining that there are enough gaps for the thrust piece to move in, the controlling current key is pushed in till the hand lever starts rising.
7. The full load will act on the specimen when the hand lever reaches its top position. The load is allowed to act for duration of 10 to 15 seconds after which the hand lever is pushed down to remove the load.
8. The image of the impression will now be clearly visible on the screen and the two diagonals are measured.

OBSERVATIONS:

Value of one division of the measuring scale

Main scale =

Vernier scale =

Micrometer =

TABULAR COLUMN

<table>
<tr><th rowspan="2">Sl.No</th><th rowspan="2">Material</th><th rowspan="2">Load (P)
kg</th><th colspan="3">Diagonal of indentation in mm</th><th rowspan="2">Vickers
Hardness
Number</th></tr>
<tr><th>d_1</th><th>d_2</th><th>Average d</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

CALCULATION:

Vickers Hardness Number VHN = 1.854 P/d^2 kg/ mm^2

RESULT:

Vickers hardness number of the given specimens is

Experiment No.8 (a) **Date:**

TEST ON BRICKS

IS 3495-1992 (PART I TO IV) - METHODS OF TESTS OF BURNT CLAY BUILDING BRICKS

a) WATER ABSORPTION OF BRICKS:

OBJECTIVES:

To determine the water absorption of bricks.

PROCEDURE:

1. Select five bricks at random out of the given sample.
2. Dry the bricks in a ventilated oven at a temperature of $105^o \pm 5^oC$ till these attain constant mass.
3. The weight of the brick is recorded after cooling them to room temperature.
4. The bricks are then immersed in water at a temperature of $27^o \pm 2^oC$ for 24 hours.
5. Remove the bricks from water and wipe off its surface with a damp cloth.
6. Weigh the brick within three minutes after its removal from water.
7. Determine the Water Absorption Capacity
8. Take the average value of the Water Absorption capacities of the five bricks.

TABULAR COLUMN:

Specimen No	Initial Weight (W_1) in g	Weight of Specimen after 24 hours immersion (W_2) in g	Water absorption in % = $(W_2 - W_1)/W_1$ *100

CALCULATIONS:

RESULT:

Average water absorption of bricks =

Experiment No.8 (b) **Date:**

b) COMPRESSION STRENGTH TEST ON BRICKS ;

OBJECTIVES: To determine the compressive strength of bricks.

APPARATUS:

1. Compression testing machine ,
2. Balance of capacity.
3. Electric Oven

PROCEDURE:

1. Take five bricks out of the sample at random.
2. The bricks are immersed in water at room temperature for 24 hours.
3. These are then taken out of water and surplus water on the surfaces is wiped off with cotton or a moist cloth.
4. The frog of the brick is flushed level with cement mortar 1:1 & 1:3 and the brick is stored under damp jute bags for 24hrs followed by its immersion in water at room temperature for three days.
5. The specimen is placed in the compression testing machine with flat faces horizontal and mortar filled face being upwards.
6. Load is applied at a uniform rate of 14 N/mm^2 per minute till failure.
7. Take the average value of the compressive strengths of the five bricks.
8. The maximum load at failure divided by the average area of bed gives the compressive strength.

TABULAR COLUMN:

Brick No.	Dimensions of brick (mm)			c /s Area of brick (l *b) (mm^2)	Compressive load (N)	Compressive strength (N/mm^2)
	Length(l)	Width(b)	Height			
1						
2						

Result:

The average compressive strength of bricks is

TEST ON CONCRETE BLOCKS

IS 2185-2005 (PART I) - CONCRETE MASONRY UNITS — SPECIFICATION

Hollow (Open or Closed Cavity) Block

A block having one or more large holes or cavities which - either pass through the block (open cavity) or do not effectively pass through the block (closed cavity) and having the solid material between 50 and 75 percent of the total volume of the block calculated from the overall dimensions.

Solid Block

A block which has solid material not less than 75 percent of the total volume of-the block calculated from the overall dimensions.

Experiment No.8 (c)

WATER ABSORPTION OF CONCRETE BLOCKS

OBJECTIVES:

To determine the water absorption of Concrete Blocks.

PROCEDURE:

1. Select three blocks at random out of the given sample.
2. Dry the blocks in a ventilated oven at a temperature of $105^o \pm 5^oC$ till these attain constant mass.
3. The weight of the block is recorded after cooling them to room temperature.
4. The block are then immersed in water at a temperature of $27^o \pm 2^oC$ for 24 hours.
5. Remove the block from water and wipe off its surface with a damp cloth.
6. Weigh the block within three minutes after its removal from water.
7. Determine the Water Absorption Capacity
8. Take the average value of the Water Absorption capacities of the three block.

TABULAR COLUMN:

Specimen No	Initial Weight (W_1) in g	Weight of Specimen after 24 hours immersion (W_2) in g	Water absorption in % = $(W_2 - W_1)/W_1$ *100

CALCULATIONS:

RESULT:

Average water absorption of Concrete blocks =

Experiment No.8 (d) **Date:**

COMPRESSION STRENGTH TEST ON CONCRETE BLOCKS

OBJECTIVES: To determine the compressive strength of blocks.

APPARATUS:

1. Compression testing machine ,
2. Balance of capacity.
3. Electric Oven

PROCEDURE:

1. Take three blocks out of the sample at random.
2. Take the dimensions of the specimen.
3. The specimen is placed in the compression testing machine. Load is applied at a uniform rate till failure.
4. Take the average value of the compressive strengths of the five bricks.
5. The maximum load at failure divided by the average cross sectional area of block gives the compressive strength.

TABULAR COLUMN:

Sample No.	Dimensions of block (mm)			c /s Area of block (l *b) (mm^2)	Maximum load (N)	Compressive strength (N/mm^2)
	Length(l)	Width(b)	Height			
1						
2						

Result:

The average compressive strength of concrete block is

Experiment No.9 (a) **Date:**

TEST ON FINE AGGREGATE

IS 2386-1963 (PART I) METHODS OF TEST FOR AGGREGATES FOR CONCRETE

a. SIEVE ANALYSIS :

OBJECTIVE:

To determine the Particle size distribution and fineness modulus of the given sample of fine aggregate by sieve analysis.

APPARATUS:

IS test sieves of 4.75mm, 2.36mm, 1.18mm, 600μ, 300μ, 150μ and 75μ. Weighting balance, sieve shaker, trays, drying oven

THEORY:

Fine aggregates as the aggregate most of which will pass 4.75mm IS sieve. The fine aggregate is often termed as a sand size aggregate. The sand is generally considered to have a lower size limit of 0.07mm. The material between 0.06mm and 0.002 mm is classified as silt and still smaller particles are termed as clay. The **Coarse aggregate** is defined as an aggregate most of which is retained on 4.75mm IS sieve.

The fineness modulus is a numerical index of fineness, giving some idea of the mean size of the particles present in the entire body of the aggregate.

PROCEDURE:

1. Take 1Kg of sand from a laboratory sample of 10 Kg by quartering and break clay lumps, if any.
2. Arrange the sieves in order of IS sieve no: 4.75mm, 2.36mm, 1.18mm, 600μm, 300μm and 150μm keeping sieve nos. 4.75mm at the top and 150μm 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 sieving in the set of sieves as arranged before for not less than 10minutes.
4. Find the mass retained on each sieve.
5. Fineness modulus is an empirical factor which is obtained by dividing the cumulative sum of the percentage of aggregate retained on each IS sieves taken in order by 100.

TABULAR COLUMN:

Weight of sand taken, W = 1000g

Sieve No.	Weight of sand retained W_1 (g)	Percentage of sand retained in sieve = $(W_1/1000)*100$	Cumulative percentage retained (F)	Percentage finer X= (100- F)
4.75 mm				
2.36 mm				
1.18 mm				
600 µm				
300 µm				
150 µm				
Pan				

ΣF =

CALCULATION:

Fineness modulus of Fine aggregate = $\frac{\Sigma F}{100}$

Result:

Fineness modulus of the given fine aggregate is

Experiment No.9 (b) **Date:**

b) SPECIFIC GRAVITY OF FINE AGGREGATE

IS 2386-1963 (PART III) METHODS OF TEST FOR AGGREGATES FOR CONCRETE

OBJECTIVE:

To determine the Specific gravity of Fine aggregate.

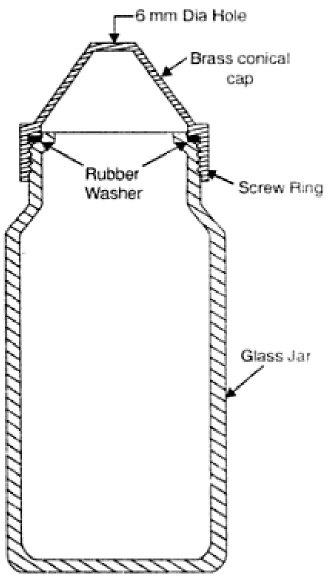
APPARATUS:

1. Balance of capacity.
2. Pycnometer (64mm diameter at top, 90mm diameter at bottom and 73mm in height)

THEORY:

The Specific gravity of an aggregate is defined as the ratio specific weight of a given sample to the specific weight of water at the same temperature.

The Specific gravity of the fine aggregate is generally required for calculations in connection with concrete mix design for determination of moisture content and for the calculation of volume yield of concrete. The Specific gravity also gives information on the quality and properties of aggregate.



PROCEDURE:

1. Dry the Pycnometer and weigh it with its cap. (W_1)
2. Take about 200gm of fine aggregate in to Pycnometer and weigh again (W_2).
3. Add sufficient de-aired water to cover the soil and screw on the cap.
4. Shake the Pycnometer well and remove entrapped air if any.
5. After the air has been removed, fill the Pycnometer with water completely.
6. Thoroughly dry the Pycnometer from outside and weigh it (W_3).
7. Clean the Pycnometer by washing thoroughly.
8. Fill the cleaned Pycnometer completely with water up to its top with cap screw on.
9. Weigh the Pycnometer after drying it on the outside thoroughly (W_4).
10. Repeat the procedure for three samples and obtain the average value of specific gravity.

OBSERVATIONS AND CALCULATIONS:

Determine the specific gravity of soil grains (G) using the following equation

$$G = \frac{(W_2 - W_1)}{\{(W2 - W_1) - (W_3 - W_4)\}}$$

Where

W_1 = Empty weight of pycnometer.

W_2 = Weight of pycnometer + Fine aggregate

W_3 = Weight of pycnometer + Fine aggregate + water

W_4 = Weight of pycnometer + water

Sample Number	W_1 in gms	W_2 in gms	W_3 in gms	W_4 in gms	Specific Gravity G
1					
2					
3					

Calculations

Result:

Average specific gravity of soil solids G =

Experiment No.9 (c) **Date:**

c) MOISTURE CONTENT OF FINE AGGREGATE

OBJECTIVE:

To determine the moisture content of fine aggregate.

APPARATUS: Balance of capacity 3kg, Electric Oven, Tray.

THEORY:

Since aggregates are porous (to some extent) they can absorb moisture. This is a concern for Cement Concrete because aggregate is generally not dried and therefore the aggregate moisture content will affect the water content (and thus the water-cement ratio also) of the produced Concrete and the water content also affects aggregate proportioning (because it contributes to aggregate weight).

PROCEDURE:

1. Take a sample of the fine aggregate and weigh it.
2. Keep the sample in an oven at 100 - 110°C for 24 hours.
3. After 24 hours weigh the dry fine aggregate with tray.
4. Calculate moisture content as the percentage of oven dry mass.

OBSERVATIONS AND CALCULATION:

Mass of empty tray, W_e =

Mass of tray + Fine aggregate sample, W_s =

Mass of Fine aggregate sample, $W_1 = (W_s - W_e)$ =

Mass of tray + oven dry sample, W_o =

Mass of oven dry sample, $W_2 = (W_o - W_e)$ =

$$\text{Moisture Content} = \frac{(W_1 - W_2)}{W_1} \times 100$$

RESULT:

Moisture Content of the given fine aggregate sample is

Experiment No.9 (d) **Date:**

d) BULKING OF FINE AGGREGATE

OBJECTIVE:

To determine the bulking of fine aggregate and to draw curve between water content and bulking.

APPARATUS:

Balance, Cylindrical container, graduated cylinder, tray.

THEORY:

In concrete mix design, the quantity of fine aggregate used in each batch should be related to the known volume of cement. The difficulty with measurement of fine aggregate by volume is the tendency of sand to vary in bulk according to moisture contents. The extent of this variation is given by this test. Thus, Bulking of sand indicates an apparent increase in volume of sand due to formation of thin layers of water around sand particles.

If sand is measured by volume and no allowance is made for bulking, because for given mass, moist sand occupies a considerably larger volume than the same mass of dry sand, as the particles are less closely packed when the sand is moist. Usually the sand is measured by loose volume, it is necessary in such case to increase the measured volume of the sand, in order that the amount of sand put into concrete may be the amount intended for the nominal mix used (based on the dry sand). It will be necessary to increase the volume of sand by the 'percentage bulking'.

PROCEDURE:

1. Take about 500cc of dry sand in measuring jar.
2. Weigh the 500 cc of dry sand.
3. Add about 1% of water by weight to the sand and mix it thoroughly.
4. Note the volume of the sand in the measuring jar.
5. Add 2% of water, mix it thoroughly and note down the volume.
6. Repeat the procedure until the volume of sand is decreased.
7. Plot the graph of water content vs. percentage increase in volume.

OBSERVATION:

1. Volume of dry sand taken= V1=500cc
2. Weight of dry sand corresponding to 500cc= w=
3. Weight of water added i.e. 15 by weight = (1/100)* w

TUBULAR COLUMN:

% of water added	Water added by weight	Final Volume of Sand (V_2)	Increase in Volume (V_2-V_1)	% Increase in volume (V_2-V_1/V_1) * 100

RESULT:

The maximum bulking of sand is

Experiment No.9 (e) **Date:**

e) BULK DENSITY OF FINE AGGREGATE

OBJECTIVE:

To find the bulk density of fine aggregates.

APPARATUS:

Weighing balance, cylindrical container, and Vibrating machine.

THEORY:

Bulk density is the total mass M per unit of its total volume.

$$\rho = M / V$$

It is expressed in terms of g / cm^3, Kg / m^3, KN / m^3.

The bulk density or unit weight of aggregate gives information regarding specific gravity and grading of the aggregate. The bulk density of aggregate is measured by filling a container by known volume in standard manner and weighing it. Bulk density of aggregate is of interest when we deal with light weight aggregate and heavy weight aggregate.

PROCEDURE:

1. The diameter and height of the container is measured to calculate the volume.
2. The container is weighed and its weight is noted.
3. The container is filled with the given sample of fine aggregate and its weight is noted.
4. The container is filled with aggregate in loose state. The weight of the container with aggregate loosest state is noted.
5. The container is placed on the vibrating machine. Start the vibrating machine and go on adding fine aggregates till the container is filled with aggregates upto the brim. Note down the weight of the container with aggregate in densest state is noted
6. Bulk density and percentage voids are calculated in both loose and compacted state.

OBSERVATIONS AND TABULAR COLUMN:

Diameter of the container, D =

Height of the container, H =

Volume of container, V =

TABULAR COLUMN:

Sl. No	Description	Trial 1	Trial 2	Average
1	Empty weight of container, W_1 (Kg)			
2	Weight of container + fine aggregate in loose state, W_2 (Kg)			
3	Weight of fine aggregate in loose state $(W_2 - W_1)$ (Kg)			
4	Bulk density, $\rho_{loose} = (W_2 - W_1) / V$ Kg/ m^3			
5	Weight of container + fine aggregate in compacted state, W_3 (Kg)			
6	Weight of fine aggregate in compacted state $(W_3 - W_1)$ (Kg)			
7	Bulk density, $\rho_{compact} = (W_3 - W_1) / V$ (Kg/ m^3)			

CALCULATIONS:

RESULT:

Bulk density of fine aggregate in loose state, ρ_{loose} =

Bulk density of fine aggregate in loose state, $\rho_{compact}$ =

Experiment No.10 (a) **Date:**

TEST ON COARSE AGGREGATE

a. SIEVE ANALYSIS :

OBJECTIVE:

To determine the Particle size distribution and fineness modulus of the given sample of coarse aggregate by sieve analysis.

APPARATUS:

IS test sieves of 80mm, 63mm, 50mm,40mm,31.5mm,25mm,20mm,16.5mm,10mm,6.3mm,4.75mm. Weighing balance, sieve shaker, trays, drying oven

THEORY:

Coarse aggregate is defined as an aggregate most of which is retained on 4.75mm IS sieve. The fineness modulus is a numerical index of fineness, giving some idea of the mean size of the particles present in the entire body of the aggregate.

PROCEDURE:

1. Take 5Kg of coarse aggregate from a laboratory sample.
2. Arrange the sieves in order of IS sieve no: 80mm, 63mm, 50mm,40mm,31.5mm,25mm,20mm,16.5mm,10mm,6.3mm,4.75mm. Fix them in the sieve shaking machine with the pan at the bottom and cover at the top.
3. Keep the coarse aggregate in the top sieve; carry out sieving in the set of sieves as arranged before for not less than 10minutes.
4. Find the mass retained on each sieve.
5. Fineness modulus is an empirical factor which is obtained by dividing the cumulative sum of the percentage of aggregate retained on each IS sieves taken in order by 100.

TABULAR COLUMN:

Weight of sand taken, W = 1000g

Sieve Size (mm)	Weight of coarse aggregate retained W_1 (g)	Percentage of coarse aggregate retained in sieve = $(W_1/1000)*100$	Cumulative Percentage Retained (F)	Percentage finer X= (100- F)
80				
63				
50				
40				
31.5				
25				
20				
16.5				
10				
6.3				
4.75				
pan				
			ΣF =	

CALCULATION:

Fineness modulus of Fine aggregate = $\frac{\Sigma F}{100}$

RESULT:

Fineness modulus of the given fine aggregate is

Experiment No.10 (b) **Date:**

b) SPECIFIC GRAVITY OF COARSE AGGREGATE

OBJECTIVE:

To determine the Specific gravity of coarse aggregate.

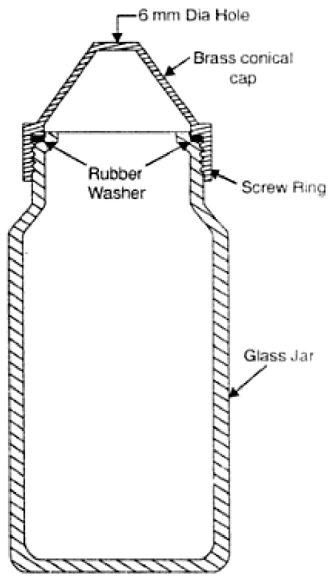
APPARATUS:

3. Balance of capacity.
4. Pycnometer (64mm diameter at top, 90mm diameter at bottom and 73mm in height)

THEORY:

The Specific gravity of an aggregate is defined as the ratio specific weight of a given sample to the specific weight of water at the same temperature.

The Specific gravity of the fine aggregate is generally required for calculations in connection with concrete mix design for determination of moisture content and for the calculation of volume yield of concrete. The Specific gravity also gives information on the quality and properties of aggregate.



PROCEDURE:

1. Dry the Pycnometer and weigh it with its cap. (W_1)
2. Take about 200gm of coarse aggregate in to Pycnometer and weigh again (W_2).
3. Add sufficient de-aired water to cover the aggregate and screw on the cap.
4. Shake the Pycnometer well and remove entrapped air if any.
5. After the air has been removed, fill the Pycnometer with water completely.
6. Thoroughly dry the Pycnometer from outside and weigh it (W_3).
7. Clean the Pycnometer by washing thoroughly.
8. Fill the cleaned Pycnometer completely with water up to its top with cap screw on.
9. Weigh the Pycnometer after drying it on the outside thoroughly (W_4).
10. Repeat the procedure for three samples and obtain the average value of specific gravity.

OBSERVATIONS AND CALCULATIONS:

Determine the specific gravity (G) using the following equation

$$G = \frac{(W_2 - W_1)}{\{(W2 - W_{1)} - (W_3 - W_4)\}}$$

Where

W_1 = Empty weight of Pycnometer.

W_2 = Weight of Pycnometer + coarse aggregate

W_3 = Weight of Pycnometer + coarse aggregate + water

W_4 = Weight of Pycnometer + water

Sample Number	**W_1 in gms**	**W_2 in gms**	**W_3 in gms**	**W_4 in gms**	**Specific Gravity G**
1					
2					
3					

<u>CALCULATIONS:</u>

<u>RESULT:</u>

Average specific gravity of coarse aggregate G =

Experiment No.10 (c) **Date:**

c) WATER ABSORPTION OF COARSE AGGREGATE

OBJECTIVE:

To determine the water absorption of coarse aggregate.

APPARATUS: Weighing Balance, Electric Oven, Tray.

THEORY:

It influences the behaviour of aggregate in concrete in several important aspects. A highly absorptive aggregate, if used in dry condition, will reduce effective water-cement ratio to an appreciable extent and may even make the concrete unworkable unless a suitable allowance is made. Hence determination of absorption of aggregate is necessary to determine net water-cement ratio.

PROCEDURE:

1. Take a sample of the coarse aggregate and soak it in water and keep it for 24± 1/2 hours. The temperature should be 27± 5°C
2. Take out and spread the sample (approximately 1 kg) on a clean flat surface, exposed to gently moving current of warm air until the material just reaches free running condition (flowing freely).
3. Weigh the 1 Kg of saturated surface dry sand in the tray of known weight.
4. Dry the sample in an oven at 100 - 110°C for 24 hours.
5. Weigh the dry sand with tray.
6. Calculate absorption capacity as the percentage of oven dry mass.

OBSERVATIONS AND CALCULATION:

Mass of empty tray, W_e =

Mass of tray + saturated surface dry sample , W_s =

Mass of saturated surface dry sample, $W_1 = (W_s - W_e)$ =

Mass of tray + oven dry sample, W_o =

Mass of oven dry sample, $W_2 = (W_o - W_e)$ =

Absorption percentage = $\frac{(W_1 - W_2)}{W_1} \times 100$

RESULT:

Water absorption of the given fine aggregate sample is

Experiment No.10 (d) **Date:**

d) BULK DENSITY OF COARSE AGGREGATE

OBJECTIVE:

To find the bulk density of coarse aggregates.

APPARATUS:

Weighing balance, cylindrical container, and Vibrating machine.

THEORY:

Bulk density is the total mass M per unit of its total volume.

$$\rho = M / V$$

It is expressed in terms of g / cm^3, Kg / m^3, KN / m^3.

The bulk density or unit weight of aggregate gives information regarding specific gravity and grading of the aggregate. The bulk density of aggregate is measured by filling a container by known volume in standard manner and weighing it. Bulk density of aggregate is of interest when we deal with light weight aggregate and heavy weight aggregate.

PROCEDURE:

1. The diameter and height of the container is measured to calculate the volume.
2. The container is weighed and its weight is noted.
3. The container is filled with the given sample of fine aggregate and its weight is noted.
4. The container is filled with aggregate in loose state. The weight of the container with aggregate loosest state is noted.
5. The container is placed on the vibrating machine. Start the vibrating machine and go on adding fine aggregates till the container is filled with aggregates upto the brim. Note down the weight of the container with aggregate in densest state is noted
6. Bulk density and percentage voids are calculated in both loose and compacted state.

OBSERVATIONS AND TABULAR COLUMN:

Diameter of the container, D =

Height of the container, H =

Volume of container, V =

TABULAR COLUMN:

Sl. No	Description	Trial 1	Trial 2	Average
1	Empty weight of container, W_1 (Kg)			
2	Weight of container + coarse aggregate in loose state, W_2 (Kg)			
3	Weight of coarse aggregate in loose state (W_2 - W_1) (Kg)			
4	Bulk density, $\rho_{loose} = (W_2 - W_1) / V$ Kg/ m^3			
5	Weight of container + coarse aggregate in compacted state, W_3 (Kg)			
6	Weight of coarse aggregate in compacted state (W_3 - W_1) (Kg)			
7	Bulk density, $\rho_{compact} = (W_3 - W_1) / V$ (Kg/ m^3)			

CALCULATIONS:

RESULT:

Bulk density of coarse aggregate in loose state, ρ_{loose} =

Bulk density of coarse aggregate in loose state, $\rho_{compact}$ =

Experiment No.10 (e) **Date:**

e) MOISTURE CONTENT OF COARSE AGGREGATE

OBJECTIVE:

To determine the moisture content of Coarse aggregate.

APPARATUS: Balance of capacity 3kg, Electric Oven, Tray.

PROCEDURE:

1. Take a sample of the Coarse aggregate and weigh it.
2. Keep the sample in an oven at 100 - 110°C for 24 hours.
3. After 24 hours weigh the dry Coarse aggregate with tray.
4. Calculate moisture content as the percentage of oven dry mass.

OBSERVATIONS AND CALCULATION:

Mass of empty tray, W_e =

Mass of tray + coarse aggregate sample, W_s =

Mass of Coarse aggregate sample, $W_1 = (W_s - W_e)$ =

Mass of tray + oven dry sample, W_o =

Mass of oven dry sample, $W_2 = (W_o - W_e)$ =

$$\text{Moisture Content} = \frac{(W_1 - W_2)}{W_1} \times 100$$

RESULT:

Moisture Content of the given coarse aggregate sample is

STRAIN GAUGES

Strain gauges are mostly used to measure strains on the free surface of a body. Strain gauges of all types are essentially devices that sense the change in length, magnify it and indicate it in some form. They can be classified broadly into five groups on the basis of the physical principle employed for the magnification of change in length:

1. Mechanical 2. Optical 3. Electrical
4. Pneumatic 5. Acoustical

Further each strain gauge is sub divided into two types:

1. Bonded strain gauge 2. Unbonded strain gauge

In bonded strain gauge a grill of fine wire is cemented to a thin paper sheet. In unbonded strain gauge a resistance wire is wound around the structure under study.

Properties of good strain gauge:

1. The gauge factor should be high to get more resolution.
2. The wires used in the strain gauge should have high resistance.
3. The wires have low temperature co-efficient of resistance.
4. The wires should not have any hysterisis in its response.
5. The wires should have a linear relationship between strain and resistance.

Mechanical strain gauge:

These mechanical devices are generally known as extensometers and are to measure strain under static or gradually varying loading conditions. An extensometer is usually provided with two knife edges which are clamped firmly in contact with the test component at a specific distance or gauge length apart. When the test component is strained, the two knife edges undergo a small relative displacement. This is amplified through a mechanical linkage and the magnified displacement or strain is displayed on a calibrated scale.

Optical Gauges:

Mechanical Optical gauges**:**

In mechanical-optical gauges a combination of mechanical & optical levers are used to amplify the relative displacement between the knife edges. The moving knife is pivoted so that it rotates while undergoing displacement.

Electrical Gauges:

In an electrical strain gauge a change in length or strain produces a change in some electrical property. The greatest advantage common to all electrical gauges is the ease with which the electrical signal can be displayed, recorded or conditioned as required. Three types of electrical gauges are in use: (i) Inductance gauges, (ii) Capacitance gauges & (iii) Electrical resistance gauges. Well over 90 percent of the strain gauges used in practice are of the electrical-resistance type and a large proportion of these are foil gauges.

THEORY

ENGINEERING MATERIALS:

A material is that out of which anything is done. It is the stuff of which something is made. It comprises a wide range of metals and non-metals, which must be operated up on to form the finished product.

PROPERTIES OF MATERIALS:

The term property indicates that defines a specific characteristic of a material. It provides a basis for predicting its behavior under various conditions like forces, temperatures, pressures, etc.

1. Physical Properties: Shape, size, finish, colour, specific gravity, density, porosity, structure, etc

2. Mechanical Properties: Strength, stiffness, elasticity, plasticity, ductility, creep, brittleness, hardness, toughness, resilience, impact, fatigue, bending, malleability.

3. Thermal Properties: Specific heat, heat of transformation, thermal expansion, thermal conductivity, thermal stresses, thermal fatigue, thermal shock, latent heat of fusion, melting point etc.

4. Chemical Properties: Corrosion resistance, atomic weight, equivalent weight, valence, molecular weight, acidity, alkalinity, atomic number, chemical composition.

5. Optical Properties: Colour, diffraction, fluorescence, reflectivity, hysterisis, luminescence, refractive index, etc.

TESTS ON MATERIALS:

1. Destructive tests: After being destructively tested, the component or specimen either breaks or remains no longer useful for further use.
   Ex: Tensile test, Compression test, Torsion test, Shear test, fatigue test.

2. Non- Destructive tests: A component does not break and even after being tested so, it can be used for the purpose for which it was made.
   Ex: Radiography test, ultrasonic inspection, dye-penetrant test, magnetic particle test, etc.

DEFINITIONS:

1. **Stress**:
   The force per unit area of resistance offered by a body against deformation is called the stress.

2. **Tensile Stress**:
   Stress induced in the uniform cross sectional area 'A' subjected to equal and opposite collinear forces 'P' resulting in the elongation of the member.

3. **Compressive Stress**:
   When two equal and opposite collinear are applied to a member resulting in the reduction in the length of the member, then the stress induced is called compressive stress.

4. **Strain**:

It is defined as change in length per unit length, also termed as linear strain.

Strain = (elongation / original length of specimen)

5. **Yield Stress**:

Stress at which considerable elongation first occurs in the test piece without **i**ncrease in the load.

6. **Direct Stress**:

The resistance developed in a material due to the action of direct load or axial load passing through the centroidal axis of the section is termed as direct stress.

7. **Shear Stress**:

The stress caused by forces which are parallel to an area of cross section and tend to produce sliding of one position over another is termed as shear stress.

8. **Young's Modulus**:

It is defined as ratio of linear stress to the linear strain **or** the ratio of normal stress to the axial strain within elastic limit.

9. **Bulk Modulus**:

When a body is subjected to three mutually perpendicular direct stress of equal intensity, the ratio of direct stress to the corresponding volumetric strain is known as Bulk modulus.

10. **Lateral Strain**:

It is the ratio of change in lateral dimension to original is called lateral strain.

11. Volumetric Strain:

It is the ratio of change in volume to original volume is called volumetric strain.

12. **Elasticity constants**:

They are the properties of materials such as young's modulus, rigidity modulus, Bulk modulus and Poisson's ratio.

Young's Modulus = Linear Stress / Linear Strain

Bulk Modulus = K = (Volumetric stress / Volumetric strain)

Poisson's ratio = (Lateral stress / Longitudinal strain)

Rigidity Modulus: (Shearing stress / Shearing strain)

13. **Elastic Length**:

It is the maximum load attained within the elastic limit divided by the cross sectional area of the specimen.

14. **Deflection**:

A beam when loaded gets deflected. The axis of the loaded beam bends in a curve known as the elastic curve. The deflection at any point on the axis of the beam is the vertical distance between its position before the load and after loading.

15. **Ultimate stress**:

The maximum load to which a bar is subjected to in a test divided by its original cross-sectional area gives a nominal stress which is known as ultimate stress.

16. **Breaking Stress**:
    The stress corresponding to fracture load is called breaking stress.

17. **Factor of Safety**:
    The ratio of ultimate strength to allowable stress is called factor of safety.

18. **Ductile material**:
    It is an important property of the material that enables it to be drawn into a wire.

19. **Brittle material**:
    A material is said to be brittle if it undergoes only small permanent deformation prior to fracture.

20. **Malleability**:
    It is the property of the material that enables it to get rolled into structural shapes and sheets.

21. **Shearing Force**:
    The algebraic sum of all the vertical force to one side of the section in a beam is called its shearing force.

22. **Tangential Stress**:
    Tensile stress induced in the wall along the circumference of the cylinder is known as tangential stress.

23. **Longitudinal Stress**:
    If the ends of the cylinder are closed, then the pressure at the ends will lead to stress in the walls in the direction parallel to longitudinal axis of the cylinder and this stress is termed as longitudinal stress.

24. **Resultant Stress**:
    The resultant of normal and tangential stress acting on any plane is called resultant stress.

25. **Complementary Stress**:
    The stress which acts right angles to the original active stress is called complementary stress.

26. **Hooke's Law**:
    Within the elastic limit, stress is proportional to strain.

27. **Elastic Limit**:
    It is the limit of stress up to which the material will behave elastically (and regains its original shape on removal of load).

28. **Proportional Limit**:
    It is the limit of stress up to which the stress of the material is proportional to strain.

29. **Yield Point**:
    It is the strain at which the elastic nature is completely lost and the materials develops permanent deformation.

30. **Yield Limit**: It is the limit of stress at which considerable elongation first occurs in the test piece without increase in the load.
31. **Ductility**:
    It is indicated by the amount of deformation that is possible until fracture.

32. **Toughness**:
    It is its ability to absorb energy in the plastic range.

33. **Elasticity**:
    It is the property by which a body returns to its original shape after the removal of external load.

34. **Gauge length**:
    It is the failure length of the parallel portion of the specimen over which extensions are measured.

35. **Resilience**:
    The strain energy stored in a body due to external loading within the elastic limit is known as resilience and the maximum energy which can be stored in a body upto the elastic limit is called as proof resilience.

36. **Plasticity**:
    It is the property of material by which no strain disappears when it is relieved from the stress.

37. **Proof stress**:
    It is the stress at which the stress-strain diagram departs by a specified percentage of gauge length from the produced straight line of proportionality (0.2%).

38. **Brittleness**:
    A material is said to be brittle when it cannot be drawn out by tension to smaller section. Here, failure takes place with small deformation.

TENSILE TEST:

In this, the operation is accomplished by gripping opposite ends of the specimen and pulling it apart. Here, the specimen elongates in a direction parallel to the applied load. It is most commonly made and one of the simplest test among the mechanical tests.

The versatility of the test lies in the fact that it permits both strength and ductile properties to be measured. In conducting the test, a specimen of the steel is subjected to an increasing tensile pull until it fractures.

COMPRESSION TEST:

It is similar to tension test, expect that the loading is in opposite direction, i.e., compressive load which produce crushing action. It is used for testing brittle materials such as stone, concrete, cast iron, glass etc. The result of this is so affected by the frictional force occurring at the ends of the specimen.

For ductile material such as mild steel or copper, lateral distortion takes place due to the influence of the friction at the load faces; the cross-section becomes greatest at the center, the specimen taking up a barrel shape. Failure finally occurs by cracks appearing on the surface and spreading inwards.

For brittle material the behavior is quite different from that of ductile material. But there is definite load at which specimen breaks. Materials fails by shearing along thee plane inclined at 50^o deg and to the longitudinal axis.

HARDNESS TEST:

Hardness is the resistance of the metal to the penetration of another harder body which does not receive a permanent set. It is the ability of a material to resist scratching, abrasion cutting or penetration.

It consists of measuring the resistance to plastic deformation of layers of metal near the surface of the specimen. In the process of the hardness determination, when the metal is intended by a special tip (ball indentor), the tip first overcomes the resistance of the metal to elastic deformation and then a small amount of plastic deformation.

SCOPE:

Hardness number cannot be utilized directly in design or analysis but it is used to grade the available materials, according to hardness and indicate utility for certain use.

USES:

1. Similar materials may be graded according to hardness.
2. Quality of the material or products may be checked or controlled.
3. By establishing a co-relation between hardness and some other desired property like tensile strength, etc.
4. Used to test the result of heat treatment like case hardening etc.

TYPES OF HARDNESS MEASUREMENTS:

1. Scratch hardness
2. Indentation hardness
3. Rebound or Dynamic hardness

- Scratch hardness is of primary interest to mineralogists. With this measure of hardness various materials and other are rated on their ability to scratch one another. It is measured according to the Mohr's scale.
- Indentation hardness test is performed by impressing into the specimen, which is resting on a rigid platform, an indentor of fixed and known geometry, under a known static load applied by means of lever system. Depending upon the test, the hardness is expressed by a number that is either inversely proportional to the depth of indentation for a specified load and indentor or proportional to a mean load over the area of indentation.
- In rebound hardness measurements, the indentor is usually dropped onto the metal surface, and the hardness is expressed as the energy of impact. The shore Scleroscope measures the hardness in terms of the height of the rebound of the indentor.

Rockwell Hardness Test:

In this the hardness of a material is determined by the depth of indentation of a diamond cone or small steel ball. This is conducted in a specially designed machine that applies load through a system of weights and levers. This test utilizes the depth on indentation under constant load as a measure of hardness. Minor load minimizes the amount of surface penetration needed and reduces the tendency for sinking in by the indentor. The dial is reversed so that a high hardness, which corresponds to a small penetration, results in high hardness number.

Brinell hardness Test:

It is oldest and most used type. This is static test using relatively large indentors.

Advantages of Rockwell Hardness Test over Brinell hardness Test:

1. Due to the application of minor load to the penetrator, any effects due to surface imperfections are eliminated.
2. Unskilled labour can operate.
3. The dial indicator eliminates the necessity for a microscope for measuring the indentation and so that the test can be done quickly and more accurately.

4. On account of small impression made, the test is suitable for the majority of finished components.

Note: 75HB 10/500/30 indicates a Brinell hardness of 75 measured with a ball of 10mm diameter and

load of 500kg applied for 30seconds.

IMPACT TEST:

The principal measurement is the energy absorbed in fracturing the specimen. After breaking the test bar, the pendulum rebounds to a height which decreases as the energy absorbed in fracture increases. The energy absorbed in fracture, usually expressed in joules, is read directly from calibrated graduated scale on the machine.

SCOPE:

1. Useful in designing those components of machine which are subjected to a sudden applied loads.
2. It gives necessary energy required to rupture the specimen.
3. For evaluating the uniformity of properties in similarly heat treated steels.
4. Gives guidance to the sensitivity of the material to notch propagation, or the resistance of the material to the propagation of the crack, once it is formed.

SHEAR TEST:

A type of forces which tends or causes two continuous parts of the body to slide relative to each other in a direction parallel to their plane of contact is called shear force.

The stress required to produce fracture in the plane of cross-section acted on by the shear force is called shear strength.

A shearing force acts parallel to a plane whereas the tensile and compressive forces act normal to a plane. There are two main types of shear stresses used in the laboratory.

1. Direct or transverse stress- stress encountered in rivets, bolts and beams.
2. Pure or torsional stress- stress encountered in a shaft subjected to pure torsion.

- Direct shear tests are conducted to obtain a measure of shear strength and pure shear tests are employed to evaluate the basic shear properties of a material.
- For direct shear stress of metal, a bar is usually sheared in some device that clamps a portion of the specimen while the remaining portion is subjected to a load by means of suitable dies. If the force is resisted by failure through one plane and single area, then the material is said to be **single shear**. If two areas resist the fracture, then the material is said to be in **double shear**.