Karnatak Law Society's

GOGTE INSTITUTE OF TECHNOLOGY

Udyambag, Belagavi- 590008

(AUTONOMOUS Institute)

[Affiliated to Visvesvaraya Technological University, Belagavi]

(Approved by AICTE, New Delhi)

(Accredited by NBA, New Delhi)

Department of Civil Engineering

LABORATORY MANUAL

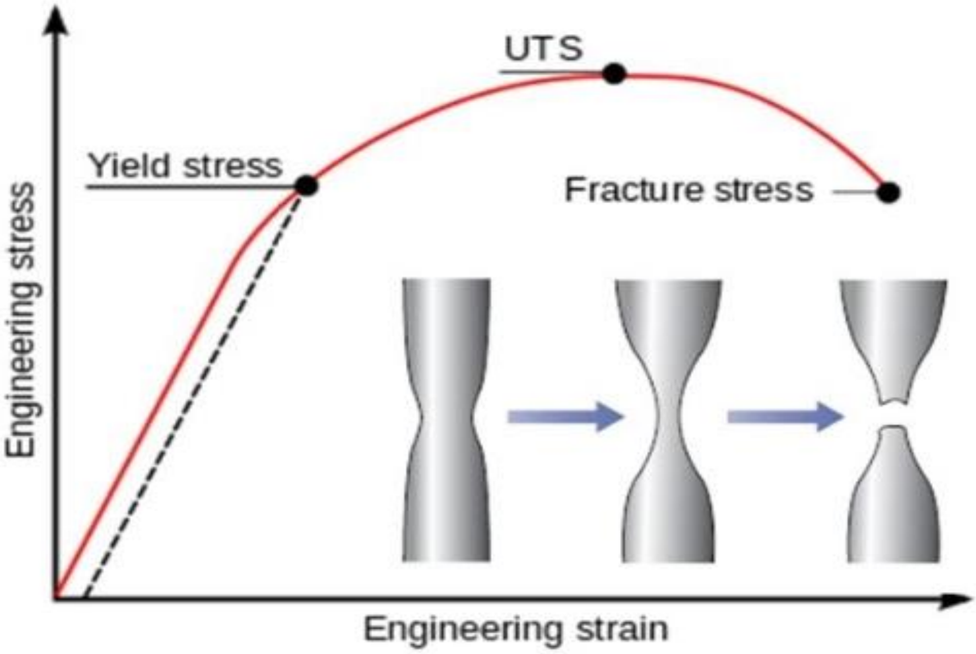
COURSE TITLE : STRENGTH OF MATERIALS LABORATORY

COURSE CODE : 18CVL37

PROGRAMME : B.E. [CIVIL ENGINEERING]

SEMESTER : III semester

PREPARED BY : Prof. SUJAY DESHPANDE



GENERAL INSTRUCTIONS TO STUDENTS

The following instructions should be strictly followed by the students in the Strength of Materials [Basic Material Testing] Laboratory-

1. All the students are expected to report to the lab in time.

2. For each lab session, the students are expected to come with a separate observations note-book, pen, pencil, eraser, sharpener, scale and graph sheets.

3. The students are expected to complete their laboratory work including calculations and get it corrected in the same laboratory session itself. Attendance will be given at the end of the lab session only to those students who get their record book signed by the staff in-charge.

4. While coming for any lab session, students are expected to submit the journal of experiments conducted in the previous lab session.

5. All the equipments, tools, accessories in the lab are expensive. Therefore, students are expected to handle the instruments with utmost care.

6. The tools and accessories required for conducting the experiments can be obtained from the staff and the same should be returned as soon as the experiment is over.

7. Breakage amount will be collected from the student(s) for causing any type of damage to the instruments/equipments either due to wrong operation or due to carelessness.

"If we all follow these guidelines, everyone will be happy and safe"

LIST OF EXPERIMENTS

Details of Equipments/ Instruments in the Lab

SI No.	Equipment/ Instrument Name	Make & Specifications
1	Universal Testing Machine (UTM) (Computerized)	Fine Spavy Associates & Engineers, Miraj Model No: FSA-TUE-C-1000/2006/20 Capacity= 1000kN Measuring range= 0 – 1000kN Least Count= 0.1kN Accuracy of the machine= +1% within 2% to 100% of the range Ram-Stroke= 250mm Power supply= 3-phase, 440V, 50 cycles, AC Machine dimensions= 250mm*800mm*2700mm Weight of the machine (Approx.)= 4200kg
2	Digital Hardness Testing Machines	1. Brinell Hardness Testing Machine Auto Instruments, Kolhapur Model No: AIE-RASNE-002 2. Rockwell Hardness Testing Machine Meta Test Instruments, Miraj Model No: MRB-250-089 Net weight= 65kg Max. test height= 220mm Depth of throat= 133mm Machine dimensions= 180mm*450mm*645mm 3. Vicker's Hardness Testing Machine Auto Instruments, Kolhapur Model No: AIE-VM-50-027 Max. test height= 230mm Depth of throat= 135mm

		Machine dimensions= 460mm*225mm*860mm Test load= 5, 10, 20, 30, 50 kg-f Scale Least Count= 0.001 Dwell Time= (0.30 $\pm$ 2 secs)
3	Digital Impact Testing Machine	Auto Instruments, Kolhapur Model No: AIE-IT-30E-038 Maximum impact energy of pendulum=300J Angle of drop of pendulum= 140^0 Effective weight of pendulum= 20.932kg Minimum value of scale graduation= 2 J Striking velocity of pendulum = 5.347m/sec Permissible frictional loss= 0.5%
4	Torsion Testing Machine	Auto Instruments, Kolhapur Capacity: 50KG-M Model No: AIE-MIT-200-021 Torque capacity (N-m)= 60, 100, 200, 500, 1000, 2000, 3000, 6000 Torsion speed (rpm)= 0.5, 1.5
5	Tile Abrasion Testing Machine	AIMIL Instruments Pvt. Ltd. Model No: AIM-462-85026
6	Tile Flexure Testing Machines	1. Roof Tile Flexural Testing Machine AIMIL Instruments Pvt. Ltd. Model No: AIM-460-84017 2. Floor Tile Flexural Testing Machine AIMIL Instruments Pvt. Ltd. Model No: AIM-461-84034
7	Strain Gauges/ Strain Indicators	A. K. Instruments, Bengaluru Model No: A-87/453

Laboratory Overview

Universal Testing Machine (UTM) (Computerized)

Compression Testing Machine (CTM)

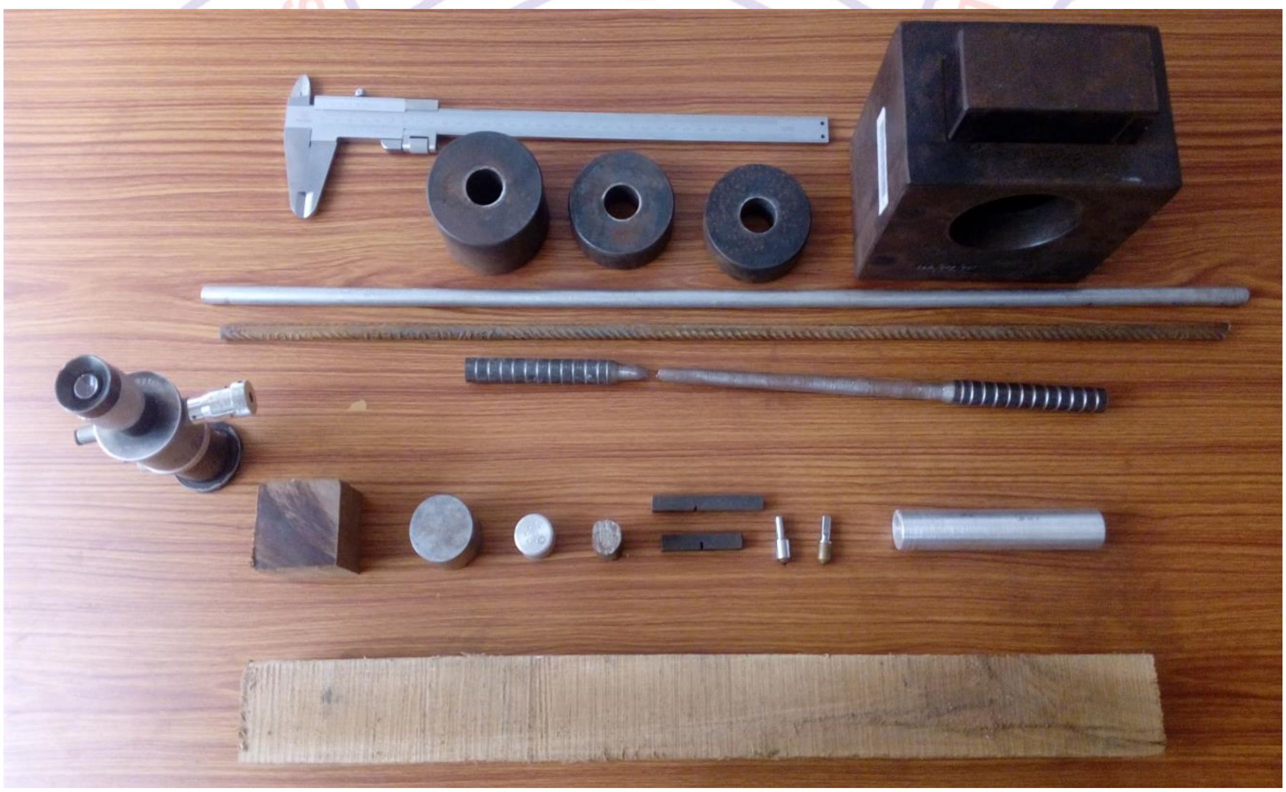
Hardness Testing Machine

Digital Impact Testing Machine

Tile Abrasion Testing Machine

Tile Flexure Testing Machine

Torsion Testing Machine



Some specimens and accessories used for the conduct of the Lab

EXPERIMENT NO. 01

Dimensionality test on Bricks

Aim: To carry out Dimensionality test on the given sample of bricks

Theory-

A brick is a basic building material used to build walls, pavements and other elements in masonry construction. Bricks can be joined together using mortar, adhesives or by interlocking them. Bricks are produced in numerous classes, types, materials and sizes which vary with region and time, and are produced in bulk quantities.

The bricks shall have smooth rectangular faces with sharp corners and shall be uniform in colour and emit a clear ringing sound when struck with fingers.

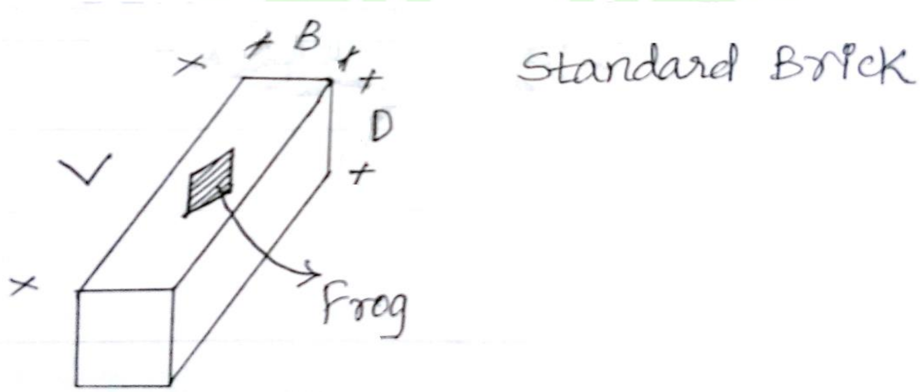
Bricks can be hand-moulded or machine-moulded and shall be prepared from suitable soils. They shall be free from cracks and flaws.

Bricks may be modular or non-modular. Sizes for both types of bricks shall be as per Table 1 below. While use of modular bricks is recommended, non-modular bricks can also be used where specified. Non-modular bricks of sizes other than the sizes mentioned in Table 1 may also be used where specified.

Table 1: Standard sizes of bricks

Type of Bricks/Tiles	Nominal Size mm	Actual Size mm
Modular bricks	200x100x100mm	190x90x90mm
Modular tile bricks	200x100x40mm	190x90x40mm
Non-modular tile bricks	229x114x44mm	225x111x44mm
Non-modular bricks	229x114x70mm	225x111x70mm

Diagram:



Dimensionality Test-

The Dimensionality test is carried out to access the size of the brick and carry out physical observations to check the given sample of bricks for any type of irregularities. The size of the brick is measured using a measuring scale.

Observations:

Brick No.	Size [Dimensions] of the brick	No. of Faces	Frog	Corners	Sound when struck with fingers	Remarks
1	L= ______mm B= ______mm D=______mm					
2	L= ______mm B= ______mm D=______mm					

Conclusions:

Based on the dimensionality test and the physical observations taken, the given sample of bricks can be ____________________________ as per Indian Standards.

EXPERIMENT NO. 02

Compression test on Bricks

Aim: To determine the Compressive strength of the given sample of bricks

Apparatus:

1) Compression Testing Machine [CTM]
2) Measuring scale, sand or mortar

Procedure (As per IS code)-

Pre-conditioning of the bricks-

1. Choose five bricks randomly from the given sample.
2. Remove unevenness observed in the bed faces to provide two smooth and parallel faces.
3. Immerse in water at room temperature for 24hours. Remove the specimen and drain out any surplus moisture at room temperature.
4. Fill the frog and all voids in the bed face flush with cement mortar (1 cement, clean coarser sand of 3mm and down size).
5. Store under the damp jute bags for 24hours followed by immersion in clean water for 3 days. Remove, and wipe out any traces of moisture.

Testing of the bricks-

1. Record the dimensions of the two sides of the bed faces.
2. Place the specimen with flat faces horizontal, and mortar filled face facing upwards between plates of the testing machine.
3. Apply the compressive load axially at a uniform rate till failure occurs and note down the load at failure.

Specifications/ Acceptance limits:

The test is conducted as per the provisions of-

“IS: 3495 (part 1)-1992 - Methods of tests of burnt clay building bricks”

“IS: 1077– 1992 – Common burnt clay building bricks specifications”

Based on the average compressive strength, burnt clay bricks are classified as follows-

Average Compressive Strength (N/mm^2)	Class of the Brick
10.00 & above	Class - I
3.50 to 10.00	Class - II
Less than 3.50	Not suitable for construction

Tabulation:

Brick No.	Dimensions of the brick	Failure load (N)	Area on which load is applied (mm^2)	Compressive strength (N/mm^2)	Average Compressive strength (N/mm^2)
1	L= ______mm B= ______mm D=______mm				
2	L= ______mm B= ______mm D=______mm				

Calculations:

Compressive strength = $\dfrac{\text{Failure Load}}{\text{Area on which load is applied}}$ = ____________ N/mm^2

Result:

Average Compressive strength of the given sample of bricks is ________ N/mm^2

EXPERIMENT No. 03

Water Absorption test on Bricks

Aim: To determine the % Water absorption of the given sample of bricks

Apparatus:

1. Weighing balance
2. Immersion tank
3. Measuring scale

Theory:

The percentage water absorption is expressed in terms of its dry weight when the brick is immersed in water for 24 hours. The water absorption of well-burnt class-I brick should not exceed 15% of its dry weight and that of class-II brick should not exceed 20% of its dry weight. A brick with higher water absorption when used in masonry work causes shrinkage of mortar and plaster, resulting in cracks.

Procedure: (As per IS code)

1. Five brick samples are selected randomly.
2. Dry the specimens in an oven at 105°C to 150°C till it attains a constant weight.
3. Cool the specimen to room temperature and obtain its wt. 'W_1'.
4. Immerse the specimen completely in water at room temperature for 24 hours.
5. Remove the specimen from water after 24 hours and wipe off its surface with a clean cloth and obtain its wet weight 'W_2'.
6. Calculate the % water absorption using the formulae.

Specifications/ Acceptance limits:

The test is conducted as per the provisions of:

"IS: 3495 (part 2)-1992- Determination of water absorption"

"IS: 1077 – 1992 – Common burnt clay building bricks specifications"

The % water absorption of a brick shall be as indicated below-

Class of the brick	Acceptable % Water absorption
Class – I	Less than 15%
Class – II	Less than 20%

Tabulation:

Brick No.	Dimensions of brick	Dry weight 'W_1' gms	Wet weight 'W_2' gms	% Water absorption	Average % Water absorption
1	L= ______mm B= ______mm D=______mm				
2	L= ______mm B= ______mm D=______mm				

Formulae:

% Water absorption = $\{(W_2 - W_1) / W_1\} * 100$

Results:

Average % Water absorption of the given sample of bricks is ________%

Conclusions:

Based on the average Compressive strength and the average % Water absorption, the given sample of bricks can be classified as ____________ according to Indian Standards.

EXPERIMENT No. 04

Compression test on Pavers

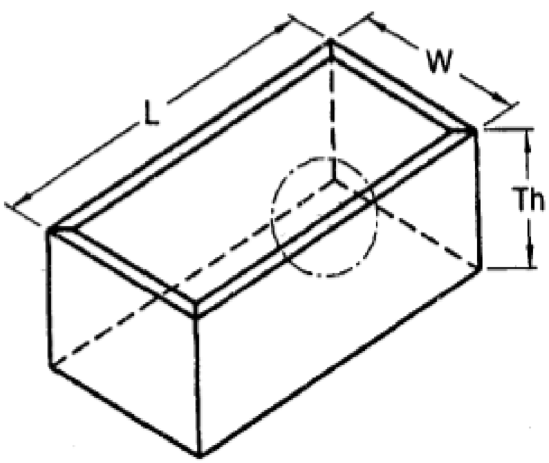
Aim: To determine the Compressive strength of the given sample of pavers.

Apparatus:

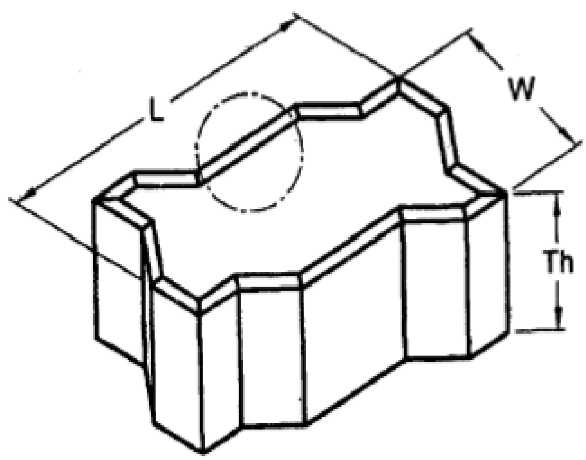
1. Compression Testing Machine [CTM]
2. Vernier Calipers/ Measuring scale

Theory: A paver is a stone, tile, brick or a brick-like piece of concrete commonly used for exterior flooring. This process is called block paving, which is a commonly used decorative method of creating a pavement. Pavers come in different styles, shapes and tones. They need to be inter-locked to get the finished paved surface.

Diagram:



Plain paver block



Arrised/ Chamfered paver block

Procedure:

1. Record the dimensions of the paver block.
2. Place the specimen with flat faces horizontal and between the upper and lower plates of the compression testing machine.
3. Apply the compressive load axially at a uniform rate till the failure occurs and note down the load at failure.
4. Determine the apparent compressive strength in N/mm^2 using the formulae and later apply the correction factors as given in Table, to obtain the actual compressive strength in N/mm^2.
5. Obtain the average compressive strength in N/mm^2.

Specifications/ Acceptance limits:

The test is conducted as per the provisions of-

"IS:15658-2006- Precast Concrete blocks for Paving - Specifications"

The apparent compressive strength of individual specimen shall be calculated by dividing the failure load (in N) by the plan area (in mm^2). The corrected compressive strength shall be calculated by multiplying the apparent compressive strength by the appropriate correction factor given in Table below.

Sl No.	Paver Block Thickness mm	Correction Factor for Plain Block	Correction Factor for Arrised/Chamfered Block
(1)	(2)	(3)	(4)
i)	50	0.96	1.03
ii)	60	1.00	1.06
iii)	80	1.12	1.18
iv)	100	1.18	1.24
v)	120	1.28	1.34

For any other thickness of the paver blocks, interpolation shall be done.

Tabulation:

Sl. No.	Dimensions of the Paver	Failure load (N)	Area on which load is applied (mm^2)	Apparent Compressive strength (N/mm^2)	Correction Factor	Actual Compressive strength (N/mm^2)	Average Compressive strength (N/mm^2)
1	L=______mm b=_____mm t=_____mm						
2	L=______mm b=_____mm t=_____mm						

Formulae:

$$\text{Compressive strength} = \frac{\text{Failure Load}}{\text{Area on which load is applied}}$$

Result:

Average Compressive strength of the given sample of pavers is ________ N/mm^2

EXPERIMENT No. 05

Specific Gravity test on Fine Aggregates

Aim: To determine the Specific Gravity of the given sample of Fine Aggregates

Apparatus:

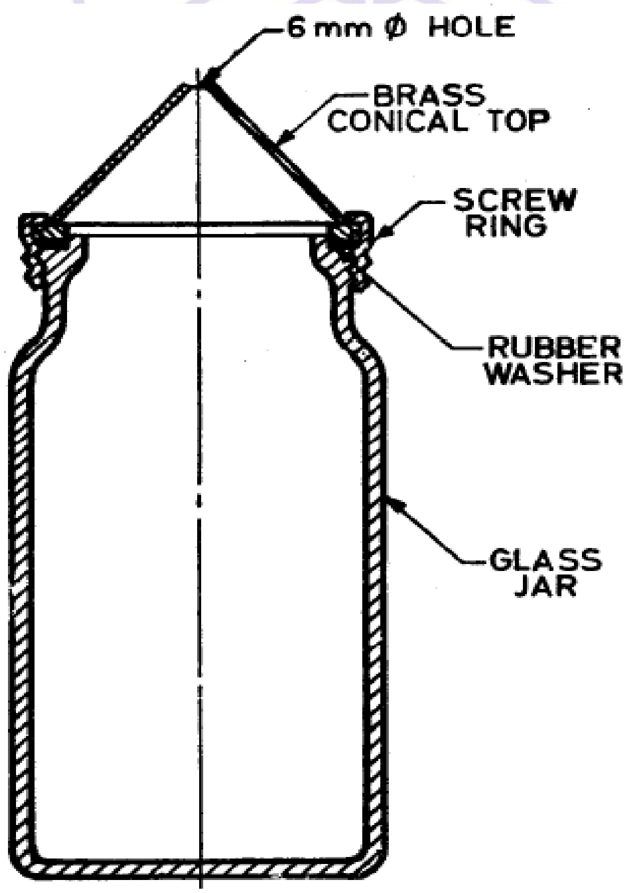
1. Weighing balance
2. Pycnometer bottle
3. Metal tray

Theory: As per IS:383-1970; aggregates shall consist of naturally occurring gravel and sand or their combination. *Aggregates most of which passes through the 4.75mm standard IS-sieve, is termed as Fine Aggregate.*

Specific Gravity of an aggregate is the measure of its strength or quality. Aggregates having lower specific gravity are generally considered weaker in strength.

Specific gravity is defined as the ratio of the weight of a given volume of aggregate sample to the weight of equal volume of water, taken at the same temperature.

Diagram:



Pycnometer bottle

Procedure:

1. Take a Pycnometer bottle and take its empty weight (W_1).
2. Take about 500gms of fine aggregate sample and pour it in the pycnometer and take its weight (W_2).
3. Pour distilled water into the pycnometer until it is full.
4. Eliminate the entrapped air by rotating the pycnometer on its side, the hole in the apex of the cone being covered with a finger.
5. Wipe out the outer surface of pycnometer and take its weight (W_3).
6. Transfer the contents of the pycnometer into a tray, care being taken to ensure that all the aggregate is transferred.
7. Refill the pycnometer with only water upto the same level. Find out its weight (W_4).
8. Calculate the Specific Gravity of the fine aggregate sample using the formulae.

Tabulation:

Sl. No.	Description	Value
1.	Empty weight of the pycnometer **'W_1'**	________ gms
2.	Weight of the pycnometer filled with Fine aggregates **'W_2'**	________ gms
3.	Weight of the pycnometer filled with Fine aggregates and Water **'W_3'**	________ gms
4.	Weight of the pycnometer filled with full of Water **'W_4'**	________ gms
5.	Specific Gravity of the Fine Aggregates sample	

Calculation:

$$\text{Specific Gravity of Fine Aggregates} = \frac{[W_2 - W_1]}{[(W_4 - W_1) - (W_3 - W_2)]}$$

Specifications/ Acceptance limits:

The Specific Gravity of Fine Aggregates ranges from 2.40 to 3.00.

Result/ Conclusion:

The Specific Gravity of the Fine aggregate sample is found to be _______ and it is __________________________ as per Indian Standards.

EXPERIMENT No. 06

Water Absorption test on Fine Aggregates

Aim: To determine the % Water Absorption of the given sample of Fine Aggregates

Apparatus:

1. Weighing balance
2. Vessel
3. Metal tray

Theory: Water absorption of an aggregate is a measure of its porosity. Water absorption is expressed as a percentage of the weight of the oven dried aggregate. Aggregates having greater water absorbing capacity will seriously affect the durability of the structure. Water absorption affects the bond between the aggregates and the cement paste and also the resistance of concrete to abrasion. Good aggregates should have lower % of water absorption.

The % of water absorption is calculated based on the increase in weight of the fine aggregates due to the presence of water in its pores, but not including the water adhering to the outside surface of the particles. This condition of the aggregates is called Saturated Surface Dry [SSD] condition.

Procedure:

1. Take about 1kg of oven-dried fine aggregate sample in a vessel.
2. Immerse the sample with vessel in clean water for 24 hours.
3. After 24 hours, take out the wet sample from water and freely spread it on a tray, uniformly, and wait until the outer surface of the aggregates is dry. [SSD condition]
4. Take the weight of the SSD fine aggregates sample.
5. Calculate the % of Water absorption using the formulae.

Tabulation:

Sl. No.	Description	Value
1	Empty weight of the vessel/ container **'W_1'**	__________ gms
2	Weight of oven-dried fine aggregates sample taken **'W_2'**	__________ gms
3	Weight of SSD fine aggregates sample + container **'W_3'**	__________ gms
4	Weight of SSD fine aggregates sample **'W_4' = $W_3 - W_1$**	__________ gms
5	Weight of the water absorbed = **$W_4 - W_2$**	__________ gms

Calculation:

% Water Absorption of Fine Aggregates = $\frac{[W_4 - W_2]}{[W_2]}$ = ________%

Specifications/ Acceptance limits:

The % Water Absorption of Fine Aggregates ranges from 0.10% to 2.00%

Result/ Conclusion:

The % Water Absorption of the Fine aggregate sample is found to be _______% and it is ____________________ as per Indian Standards.

EXPERIMENT No. 07

Bulk Density test on Fine Aggregates

Aim: To determine the Bulk Density of the given sample of Fine Aggregates

Apparatus:

1. Measuring cylinder of appropriate capacity
2. Weighing balance
3. Tamping rod

Theory: *Bulk Density is defined as the weight of the material in a given volume*. Bulk density of aggregates depends on the particle size distribution, shape of the aggregate particles and the manner in which the aggregates are filled in the measuring container.

The bulk density of fine aggregates is measured by filling a container of known volume in a standard manner and weighing it. Based on the manner in which the aggregates are filled in the measuring container, bulk density is determined for the following two conditions:

(i) Rodded or Compacted condition and (ii) Loose condition

Aggregates giving better bulk density will have minimum voids and shall result in an economical concrete mix. *The bulk density is expressed in kg/litre.*

Diagram:

Measuring Cylinder with Tamping rod

Procedure:

Bulk Density in Rodded or Compacted condition-

1. Fill the measuring cylinder with fine aggregate in 3 equal layers with each layer being tamped 25 times using the tamping rod.
2. Strike off the surplus aggregates on the surface using the tamping rod. Weigh the container with the compacted aggregates.
3. The bulk density in rodded or compacted condition of the aggregate is calculated using the formulae.

Bulk Density in Loose condition-

1. Fill the measuring cylinder with fine aggregate till it over-flows, by using a trowel or a scoop, the aggregate being discharged from a height not exceeding 50mm.
2. Strike off the surplus aggregates on the surface with a straight edge. Weigh the container with the aggregates.
3. The bulk density in loose condition of the aggregate is calculated using the formulae.

Observations:

1. Inner height of the measuring cylinder; h = _______mm = _______m
2. Inner diameter of the measuring cylinder; d = _______mm = _______m
3. Volume of the measuring cylinder; $\mathbf{V = [(\pi/4) * d^2 * h]*1000}$ = _______ litres

Tabulation:

<u>For Rodded or Compacted Condition</u>

Sl. No.	Description	Value
1	Empty weight of the measuring cylinder **'W_1'**	___________ kg
2	Weight of the measuring cylinder + fine aggregates in compacted condition **'W_2'**	___________ kg
3	Weight of the fine aggregates in compacted condition **'(W_2-W_1)'**	___________ kg
4	Bulk Density of the fine aggregates = $\mathbf{(W_2-W_1)/V}$	_________ kg/lit

For Loose Condition

Sl. No.	Description	Value
1	Empty weight of the measuring cylinder **'W_1'**	________ kg
2	Weight of the measuring cylinder + fine aggregates in loose condition **'W_2'**	________ kg
3	Weight of the fine aggregates in loose condition **'(W_2-W_1)'**	________ kg
4	Bulk Density of the fine aggregates = **(W_2-W_1)/V**	________ kg/lit

Calculations:

$$(\text{Bulk Density})_{\text{Compacted}} = \frac{\text{Weight of the aggregates in the compacted condition}}{\text{Volume of the measuring cylinder}}$$

= ____________kg/lit

$$(\text{Bulk Density})_{\text{Loose}} = \frac{\text{Weight of the aggregates in the loose condition}}{\text{Volume of the measuring cylinder}}$$

= ____________kg/lit

Specifications/ Acceptance limits:

The test is conducted as per the provisions of-

IS:2386 (part III)-1963; "Methods of test for aggregate for concrete"

IS:383–1970; "Specifications for coarse and fine aggregates from natural stones for concrete"

Since the bulk density of aggregates depends on the size and shape of the aggregate particles, there is no specified limit for it. The bulk density for fine aggregates derived from natural sources normally varies between 1.50kg/lit to 1.70kg/lit for rodded/compacted condition and between 1.40kg/lit to 1.60kg/lit for loose condition.

Results/Conclusion:

The Bulk Density of the fine aggregate sample in rodded/compacted condition is found to be ______ kg/lit and in loose condition is found to be ______ kg/lit and it is ____________________ as per Indian Standards.

EXPERIMENT No. 08

Specific Gravity test on Coarse Aggregates

Aim: To determine the Specific Gravity of the given sample of Coarse Aggregates

Apparatus:

1. Weighing balance
2. Wire basket and Tamping rod

Theory: As per IS:383-1970; aggregates shall consist of naturally occurring gravel and sand or their combination. *Aggregates most of which are retained on the 4.75mm standard IS-sieve are termed as Coarse Aggregates.*

Specific Gravity of an aggregate is the measure of its strength or quality. Aggregates having lower specific gravity are generally considered weaker in strength.

Specific gravity is defined as the ratio of the weight of a given volume of aggregate sample to the weight of equal volume of water, taken at the same temperature.

Diagram:

Wire basket

Tamping rod

Procedure:

1. Take the coarse aggregate sample and pour it inside the wire basket in three equal layers with each layer being tamped 25 times using the tamping rod.
2. The wire basket containing the compacted aggregates is then weighed while held suspended in clean water.
3. The aggregate sample is removed and then the weight of the empty wire basket while held suspended in water is taken.
4. The Specific Gravity of the coarse aggregate sample is calculated using the formulae.

Tabulation:

Sl. No.	Description	Value
1	Empty weight of the wire basket **'W_1'**	__________ kg
2	Weight of the wire basket + aggregates compacted in three layers **'W_2'**	__________ kg
3	Weight of the wire basket + compacted aggregates, fully immersed in water **'W_3'**	__________ kg
4	Weight of the empty wire basket fully immersed in water **'W_4'**	__________ kg
5	Specific Gravity of the Coarse aggregate sample	________

Calculation:

$$\text{Specific Gravity of Coarse Aggregates} = \frac{[W_2 - W_1]}{[(W_4-W_1) - (W_3-W_2)]} = \_\_\_\_\_\_\_\_$$

Specifications/ Acceptance limits:

The Specific Gravity of Coarse Aggregates ranges from 2.60 to 3.00.

Result/ Conclusion:

The Specific Gravity of the coarse aggregate sample is found to be _______ and it is __________________________ as per Indian Standards.

EXPERIMENT No. 09

Water Absorption test on Coarse Aggregates

Aim: To determine the % Water Absorption of the given sample of Coarse Aggregates

Apparatus:

1. Weighing balance
2. Vessel
3. Metal tray

Theory: Water absorption of an aggregate is a measure of its porosity. Water absorption is expressed as a percentage of the weight of the oven dried aggregate. Aggregates having greater water absorbing capacity will seriously affect the durability of the structure. Water absorption affects the bond between the aggregates and the cement paste and also the resistance of concrete to abrasion. Good aggregates should have lower % of water absorption.

The % of water absorption is calculated based on the increase in weight of the coarse aggregates due to the presence of water in its pores, but not including the water adhering to the outside surface of the particles. This condition of the aggregates is called Saturated Surface Dry [SSD] condition.

Procedure:

1. Take about 1kg of oven-dried coarse aggregate sample in a vessel.
2. Immerse the sample with vessel in clean water for 24 hours.
3. After 24 hours, take out the wet sample from water and freely spread it on a tray, uniformly, and wait until the outer surface of the aggregates is dry. [SSD condition]
4. Take the weight of the SSD coarse aggregates sample.
5. Calculate the % of Water absorption using the formulae.

Tabulation:

Sl. No.	Description	Value
1	Empty weight of the vessel/ container **'W_1'**	________ gms
2	Weight of oven-dried coarse aggregate sample taken **'W_2'**	________ gms
3	Weight of SSD coarse aggregate sample + container **'W_3'**	________ gms
4	Weight of SSD coarse aggregate sample **'W_4' = $W_3 - W_1$**	________ gms
5	Weight of the water absorbed = **$W_4 - W_2$**	________ gms

Calculation:

% Water Absorption of Coarse Aggregates = $\frac{[W_4 - W_2]}{[W_2]}$ = ________%

Specifications/ Acceptance limits:

The % Water Absorption of coarse aggregates ranges from 0.10% to 2.00%

Result/ Conclusion:

The % Water Absorption of the coarse aggregate sample is found to be _______% and it is ____________________ as per Indian Standards.

EXPERIMENT No. 10

Bulk Density test on Coarse Aggregates

Aim: To determine the Bulk Density of the given sample of Coarse Aggregates

Apparatus:

1. Measuring cylinder of appropriate capacity
2. Weighing balance
3. Tamping rod

Theory: *Bulk Density is defined as the weight of the material in a given volume*. Bulk density of aggregates depends on the particle size distribution, shape of the aggregate particles and the manner in which the aggregates are filled in the measuring container.

The bulk density of coarse aggregates is measured by filling a container of known volume in a standard manner and weighing it. Based on the manner in which the aggregates are filled in the measuring container, bulk density is determined for the following two conditions:

(i) Rodded or Compacted condition and (ii) Loose condition

Aggregates giving better bulk density will have minimum voids and shall result in an economical concrete mix. *The bulk density is expressed in kg/litre.*

Diagram:

Measuring Cylinder with Tamping rod

Procedure:

Bulk Density in Rodded or Compacted condition-

1. Fill the measuring cylinder with coarse aggregate in 3 equal layers with each layer being tamped 25 times using the tamping rod.
2. Strike off the surplus aggregates on the surface using the tamping rod. Weigh the container with the compacted aggregates.
3. The bulk density in rodded or compacted condition of the aggregate is calculated using the formulae.

Bulk Density in Loose condition-

1. Fill the measuring cylinder with coarse aggregate till it over-flows, by using a trowel or a scoop, the aggregate being discharged from a height not exceeding 50mm.
2. Strike off the surplus aggregates on the surface with a straight edge. Weigh the container with the aggregates.
3. The bulk density in loose condition of the aggregate is calculated using the formulae.

Observations:

1. Inner height of the measuring cylinder; h = _______mm = _______m
2. Inner diameter of the measuring cylinder; d = _______mm = _______m
3. Volume of the measuring cylinder; $V = [(\pi/4) * d^2 * h]*1000$ = _______ litres

Tabulation:

For Rodded or Compacted Condition

Sl. No.	Description	Value
1	Empty weight of the measuring cylinder **'W_1'**	___________ kg
2	Weight of the measuring cylinder + coarse aggregates in compacted condition **'W_2'**	___________ kg
3	Weight of the coarse aggregates in compacted condition **'(W_2-W_1)'**	___________ kg
4	Bulk Density of the coarse aggregates = **$(W_2-W_1)/V$**	_________ kg/lit

For Loose Condition

Sl. No.	Description	Value
1	Empty weight of the measuring cylinder **'W_1'**	___________ kg
2	Weight of the measuring cylinder + coarse aggregates in loose condition **'W_2'**	___________ kg
3	Weight of the coarse aggregates in loose condition **'(W_2-W_1)'**	___________ kg
4	Bulk Density of the coarse aggregates = **(W_2-W_1)/V**	_________ kg/lit

Calculations:

$$(\text{Bulk Density})_{\text{Compacted}} = \frac{\text{Weight of the aggregates in the compacted condition}}{\text{Volume of the measuring cylinder}}$$

= ______________kg/lit

$$(\text{Bulk Density})_{\text{Loose}} = \frac{\text{Weight of the aggregates in the loose condition}}{\text{Volume of the measuring cylinder}}$$

= ______________kg/lit

Specifications/ Acceptance limits:

The test is conducted as per the provisions of-

IS:2386 (part III)-1963; "Methods of test for aggregate for concrete"

IS:383–1970; "Specifications for coarse and fine aggregates from natural stones for concrete"

Since the bulk density of aggregates depends on the size and shape of the aggregate particles, there is no specified limit for it.

The bulk density for coarse aggregates derived from natural sources normally varies between 1.50kg/lit to 1.70kg/lit for rodded/compacted condition and between 1.40kg/lit to 1.60kg/lit for loose condition.

Results/ Conclusions:

The Bulk Density of the coarse aggregate sample in rodded/compacted condition is found to be _______ kg/lit and in loose condition is found to be _______ kg/lit and it is ______________________ as per Indian Standards.

EXPERIMENT No. 11

Charpy Impact test on Mild Steel

Aim: To observe the behavior of the given specimen under Charpy impact & to determine its Charpy Impact Strength

Apparatus:

1. Impact Testing Machine
2. Accessories for Charpy test

Theory:

To estimate the safe performance of a structure or a machine or their parts under dynamic loading, it is necessary to know the behavior & resistance of the component material to such loading. The impact test is a dynamic test in which a selected specimen usually with a notch or a groove is struck & broken by a single blow of a striker attached to a pendulum in a specially designed testing machine & the energy absorbed by the specimen before breaking is measured. If during the test, the specimen is not completely broken, then the impact value obtained is said to be indefinite.

Charpy test

In this test, a standard specimen with a U-notch of 2mm width and 5mm depth is simply supported over two end-supports & a sudden load is applied at its center. In this test, the angle of drop of the pendulum is 140^{o} & the corresponding energy imparted to the specimen is 300J.

Specifications for Charpy Test (As per IS-1499: 1977)

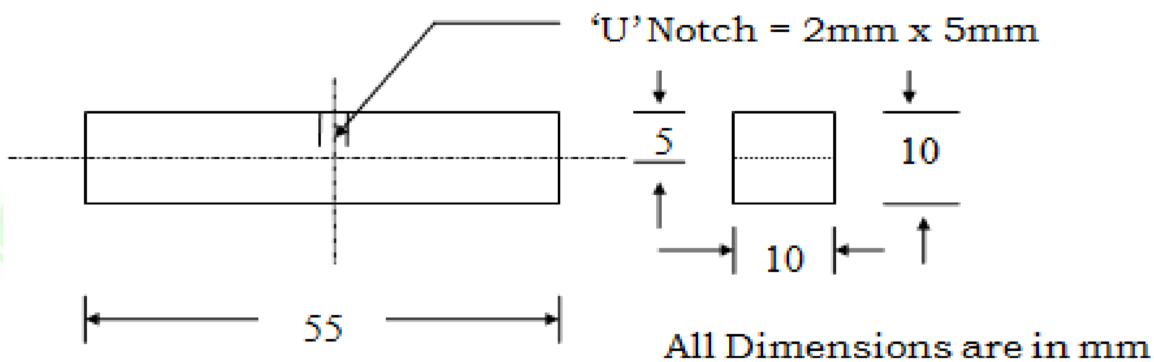
1. Maximum Impact energy of the pendulum = 300J
2. Angle of drop of the pendulum = 140^{0}
3. Effective weight of the pendulum = 20.9kg
4. Minimum value of scale graduation = 0.5J
5. Striking velocity of the pendulum = 5.35 m/sec
6. Permissible frictional loss = 0.5% of the impact energy imparted

Procedure:

1. A proper striker is firmly secured to the bottom of the pendulum & also the specimen mounting assembly is fixed at the base.

2. Before proceeding to the actual test, the frictional loss in the machine is to be determined. For this, set the pointer reading to zero while the pendulum is hanging free vertically.
3. Now, raise the hammer by 140° and latch it safely. Then, release the hammer by operating the lever. The pointer will then indicate the energy loss due to friction. Confirm that the frictional loss is not exceeding 0.5% of the initial potential energy. If not, correction for frictional loss is to be applied in the form of a 'correction factor'.
4. Raise the hammer again by 140° & latch in safely.
5. Mount the specimen on the support with proper positioning of the notch using the centering gauge.
6. Release the pendulum by operating the levers and allow it to strike the specimen under impact. Bring the pendulum to a stand-still position by applying the brakes.
7. Read the position of the reading pointer against the scale and calculate the Charpy impact strength using the formulae.

Diagram:



Observations:

1. Total impact energy of the pendulum = _________J
2. Permissible frictional loss = 0.5% of total impact energy = ________J
3. Observed frictional loss = _______J [after free-swing]
4. Correction factor = Observed frictional loss - Permissible frictional loss = _________J
5. Energy absorbed by the specimen = __________J
6. Charpy impact strength of the specimen
   = (Energy absorbed by the specimen - Correction factor) = ___________J

Result:

Charpy Impact Strength of the given specimen is _________J

EXPERIMENT No. 12

Brinell's Hardness test on Mild Steel/ Aluminium

Aim: To determine the resistance to indentation offered by Mild steel/ Aluminium specimen and hence to determine its Brinell Hardness Value (BHV)

Apparatus:

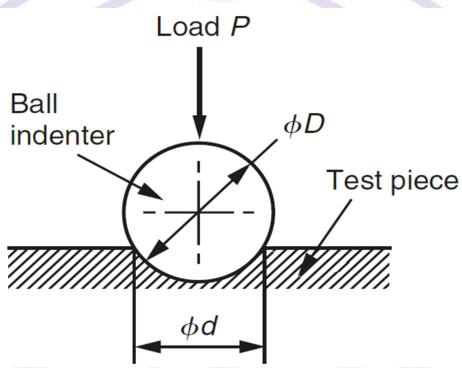
1. Brinell's hardness testing machine
2. Microscope

Theory:

The property of hardness of a metal is usually associated with its resistance to scratching, wear, indentation or deformation.

Brinell's Test

Brinell's hardness test measures the resistance to indentation. It measures the diameter of the indentation made by the indentor and not the depth. Brinell's test is ideal for castings and forgings that have rough surfaces or exhibit chemical variation. Because the indentor used is larger than in other test methods, hardness values derived from Brinell's test provide a more representative hardness of the specimen.



An indentor of diameter (D) is pressed on the material to be tested by applying a load (P). The load is maintained for about 10 to 15 seconds. The diameter of the indentation produced (d) is measured. The load to be applied depends on the type of the material under test and the diameter of the indentor to be used. ('P' is in kg and 'd' is in mm)

For hard materials like mild steel and cast iron; $P = 30d^2$

For medium hard materials like brass, copper, bronze and other alloys; $P = 10d^2$

For soft materials like aluminium, magnesium, zinc, cast brass; $P = 5d^2$

Procedure:

1. The surface of the specimen to be tested is first cleaned and is put on the supporting table and the hand wheel is turned in the clockwise direction till the

gap between the surface of the specimen and the clamping bush is only about 2mm to 5mm.
2. The hand wheel is brought into position which raises the supporting table till the specimen is clamped using the clamping bush.
3. A suitable indenter is identified and attached to the slot.
4. Then, the hand lever is operated to press the indenter onto the surface of the specimen. The load is allowed to act for a duration of about 10 to 15 seconds after which the hand lever is released.
5. The diameter of the indentation made is noted down using a microscope and the Brinell Hardness Value (BHV) is calculated.

Specifications/ Acceptance limits:

The test is conducted as per the provisions of-

"IS-1500:2005– Method of Brinell hardness test for metallic materials".

The Brinell Hardness Value obtained should comply with the values as mentioned in Table C.1 (Annexure 'C') of the above code.

Tabulation:

Material	Trial no.	Test Load 'P' (kg)	Scale used	Diameter of Indentor 'D' (mm)	Diameter of Indentation 'd' (mm)	BHV (kg/mm^2)
Mild Steel	1					
	2					
	3					
Aluminium	1					
	2					
	3					

Calculations:

$$BHV = \frac{\text{Test Load}}{\text{Surface Area of Indentation}}$$

$$= \frac{2P}{\Pi D [D - \sqrt{(D^2 - d^2)}]} \quad kg/mm^2$$

Results/ Conclusions:

Brinell Hardness Value for Mild Steel is _________ kg/mm^2 and for Aluminium is _________ kg/mm^2 and they are ___________________________ as per Indian Standards.

EXPERIMENT No. 13

Single and Double Shear test on Aluminium

Aim: To determine the shear strength of aluminium rod specimen in single shear and double shear.

Apparatus:

1. Shear test attachments
2. Vernier Calipers/ Measuring scale

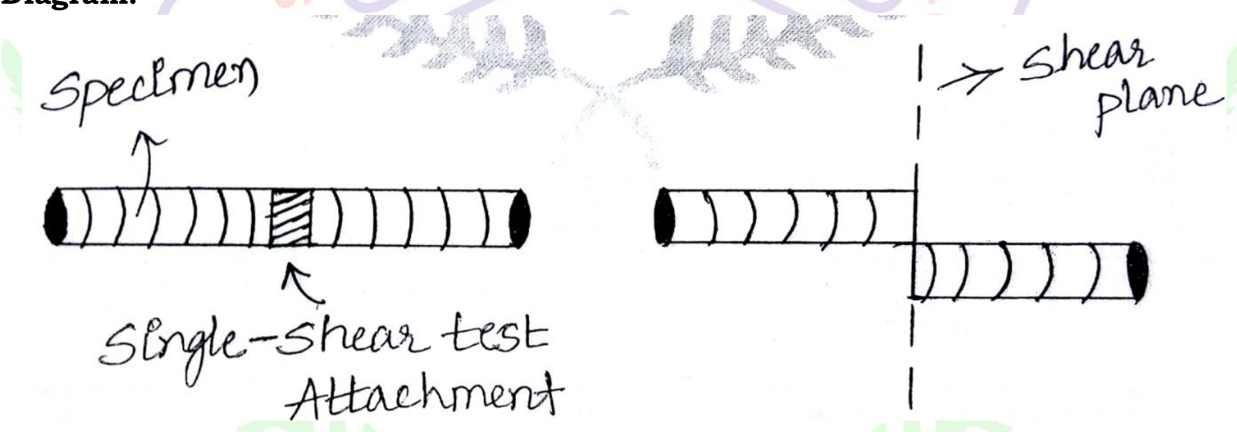
Theory:

Shear stress is caused by forces which act parallel to an area of cross-section and tend to produce sliding of one portion past the other.

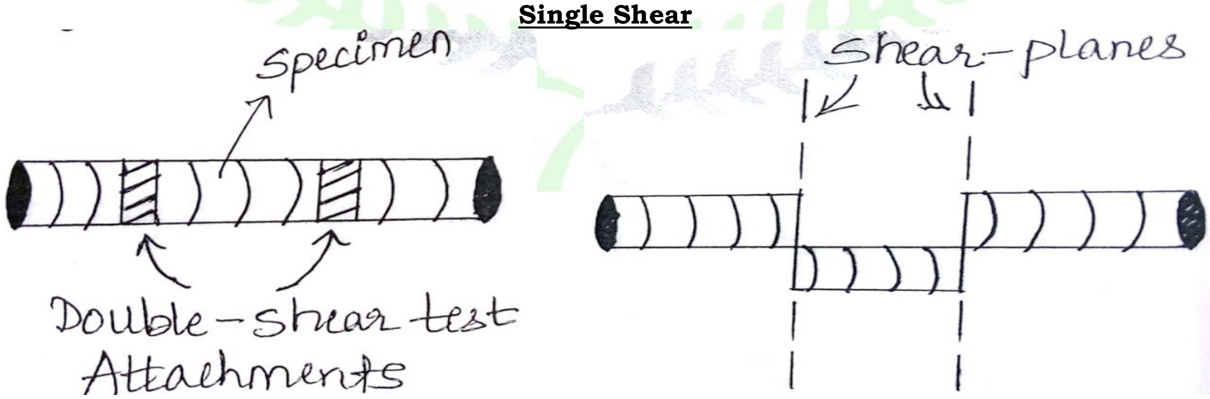
If only one cross-section resists the shear forces, then the material is said to be in a state of single shear and the average ultimate strength in single shear will be equal to the failure load divided by the area under single shear.

If two cross-sections resist the shear forces, then the material is said to be in a state of double shear and the average ultimate strength in double shear will be equal to the failure load divided by the area under double shear.

Diagram:



Single Shear



Double Shear

Procedure:

Single Shear Test

1. The mean diameter of the specimen is noted down.
2. The specimen is then placed in the shear attachment assembly with one number of bushing required for single shear.
3. The assembly is then placed in the universal testing machine.
4. The load is increased gradually and the ultimate load required to cause fracture is recorded.
5. The shear strength in single shear is calculated using the formulae.

Double Shear Test

1. The mean diameter of the specimen is noted down.
2. The specimen is then placed in the shear attachment assembly with two numbers of bushings required for double shear.
3. The assembly is then placed in the universal testing machine.
4. The load is increased gradually and the ultimate load required to cause fracture is recorded.
5. The shear strength in double shear is calculated using the formulae.

Specifications/ Acceptance limits:

The test is conducted as per the provisions of "IS-5242:1979- Methods of determining shear strength of materials".

Application of the test:

This test is useful to determine the ultimate shear strength of the specimen in single shear and double shear, and confirming its suitability for engineering applications.

Observations:

Single Shear Test

1. Mean diameter of the specimen; $d = (d_1 + d_2 + d_3)/3$ = ______ mm
2. Cross-sectional area of the specimen in single shear; $A_s = \{(\pi/4)*d^2\}$ = ______mm^2
3. Load at failure; P = ________ kN = ________ N

Double Shear Test

1. Mean diameter of the specimen; $d = (d_1 + d_2 + d_3)/3$ = ______ mm
2. Cross-sectional area of the specimen in double shear; $A_d = \{(\pi/4)*d^2\} *2$ = ______mm^2
3. Load at failure; P = ________ kN = ________ N

Result:

1) Ultimate shear strength of the given specimen in single shear is _________ N/mm^2

2) Ultimate shear strength of the given specimen in double shear is _________ N/mm^2

EXPERIMENT No. 14

Flexure test on Tiles

Aim: To observe the behavior of the given tile specimen under flexure upto failure & to determine the flexural stress at failure (Modulus of Rupture)

Apparatus:

1. Flexure test assembly
2. Vernier Calipers/ Measuring scale

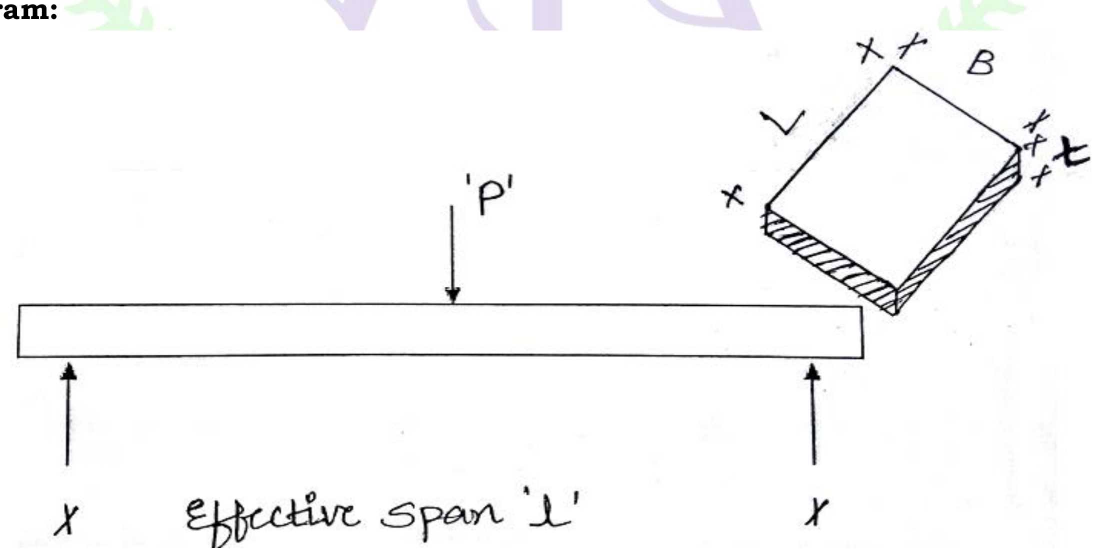
Theory:

The flexural strength of tiles is of prime importance since they are subjected to transverse loads during their use. The test is conducted in a wet state wherein the tile sample to be tested is soaked in water for 24hrs before testing. The test consists of subjecting a tile specimen to flexure (bending with shear) due to a point load applied at the center. The load is distributed over the entire width of the tile. The specimen is tested up to failure. The bending stresses at any load can be calculated using the bending equation. Modulus of Rupture is the value of the maximum bending stress corresponding to the bending moment which causes fracture of the specimen.

The effective span between the supports shall be taken as follows-

Size of Tile	Effective Span to be taken
200mm x 200mm	150mm
250mm x 250mm	200mm
300mm x 300mm	250mm

Diagram:



Formulae:

From the bending equation;

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

where;

M= Maximum bending moment = (P*l)/4

I = Moment of Inertia = $(b*t^3)/12$

σ= Flexural stress

y= Distance of neutral axis from extreme fiber = (t/2)

E= Young's modulus

R= Radius of curvature due to bending

Now, from the bending equation; we get-

$$\sigma = \frac{M}{I} * y$$

$$= \frac{(P*l)/4}{(b*t^3)/12} * (t/2)$$

$$= \frac{3*P*l}{2*b*t^2}$$

where;

P= Failure load

l= effective span

t= thickness of the tile

b= breadth of the tile

Procedure:

1. Note down the length, breadth and thickness of the tile specimen.
2. Mark the effective span and the load position.
3. Place the specimen in the machine over the supports and place the loading point on the marked position. Apply the load gradually using the lead shots.
4. Stop the application of the load after the specimen has failed and determine the failure load.

Specifications/ Acceptance limits:

The test is conducted as per the provisions of

"IS: 13630 (part 6) – 2006- Ceramic tiles- Methods of test, sampling and basis for acceptance".

The wet transverse flexural strength of the tile shall not be less than 3N/mm^2

Observations:

1. Type of the tile = ___________________________
2. Length of the tile; L = ________ mm
3. Breadth of the tile; b = ________ mm
4. Thickness of the tile; t = ________ mm
5. Effective span; l = _____________ mm
6. Weight of [empty pan] = W_1 = _______ kg
7. Weight of [pan + lead shots] = W_2 = _______ kg
8. Weight of lead shots = W = ($W_2 - W_1$) = ________ kg

Calculations:

Failure Load = (Weight of lead shots) x 9.81 x (Multiplying factor for test assembly)

P = W x 9.81 x 12 = __________ N

$$\sigma = \frac{3*P*l}{2*b*t^2} = \_\_\_\_\_\_\_\_\_ \ N/mm^2$$

Result:

Flexural stress at failure (Modulus of Rupture) for the given tile specimen is observed to be ________ N/mm^2 and it is ______________________ as per Indian standards.

EXPERIMENT No. 15

Bending test on Timber under Two-point loading

Aim: To observe the behavior of the given timber beam specimen subjected to two-point loading upto failure & to determine-

a. Extreme fiber stress at proportionality limit

b. Extreme fiber stress at failure (Modulus of Rupture)

c. Young's modulus (Modulus of Elasticity)

Apparatus:

1. Universal Testing Machine (UTM) with digital display system
2. Bending test assembly
3. Vernier Calipers/ Measuring scale

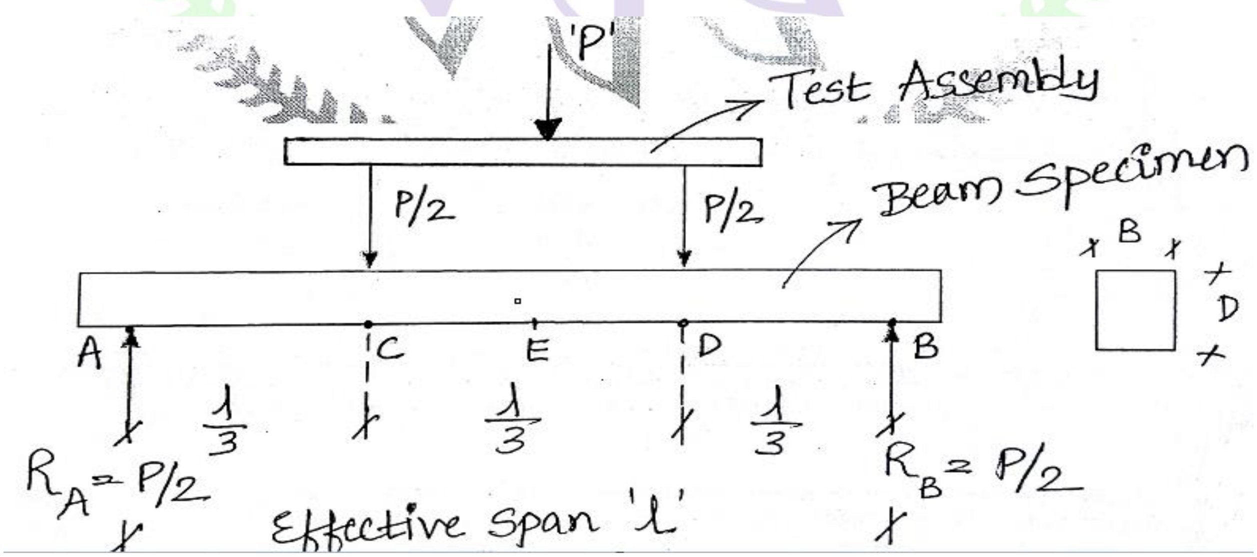
Theory:

A member subjected to bending results in bending stresses and it also undergoes deflection. Bending test consists of subjecting a beam specimen of standard size to two-point loading. The central portion of the beam will be under a state of *pure bending (i.e. Constant Bending Moment and Zero Shear Force)*. The specimen is tested upto failure and deflection under the load is recorded at frequent intervals.

The bending stresses can be calculated using the bending equation. Modulus of Rupture is determined as the value of the bending stress corresponding to the bending moment which causes failure of the specimen.

A graph of Load vs. Deflection is plotted which is used to determine the value of Young's Modulus.

Diagram:



Formulae:

From the bending equation;

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

where;

M= Maximum bending moment

I= Moment of inertia

σ= Bending stress

y= Distance of neutral axis from extreme fiber

E= Young's Modulus

R= Radius of curvature due to bending

(P/2)= Two-point loads on the beam (where 'P' is the total load applied by the UTM)

l= Effective span

a= Offset of the two point loads from each support = (l/3)

From the bending equation;

$$\sigma = \frac{M * y}{I}$$

$$= \frac{(P*l)/6}{(b*d^3/12)} * (d/2)$$

$$= \frac{P*l}{bd^2}$$

The maximum deflection under the loads is given by-

$$\delta = \frac{5Wl^3}{162EI}$$

Young's modulus; $E = \frac{a*(3l^2 - 4a^2)}{24*I} * (P/\delta)$

where; (P/δ) is the slope obtained from the graph.

Procedure:

1. Note down the length, width and depth of the beam specimen.
2. Mark the effective span and the load position.
3. Place the specimen in the machine over the supports and place the loading points on the marked position.
4. Place a dial gauge on the lower block of the machine so as to read the deflection under the load points.
5. Apply the load gradually at a rate such that the deflection is 1.5mm per minute.
6. At equal intervals of loads, note down the deflection under the load.

7. Stop the load application after the specimen has failed and note down the failure load.
8. Remove the specimen from the machine and study the failure pattern.

Specifications/ Acceptance limits:

The test is conducted as per the provisions of "IS: 1708 - (part 6) 1986- Determination of static bending strength under two-point loading".

Observations:

1. Type of timber = ____________________________
2. Length of the specimen; L = ________ mm
3. Breadth of the specimen; b = ________ mm
4. Depth of the specimen; d = ________ mm
5. Effective span; l = ________ mm
6. Offset of the load from the support; a = l/3 = ______mm
7. Distance of neutral axis from extreme fiber; y = d/2 = _______mm

Tabulation:

Sl. No.	Load applied 'P' (in kN)	Load 'P' (in N)	Deflection under the load 'δ' (in mm)
1			
2			
.....			
Upto Failure			

Calculations:

1. Extreme fiber stress at proportionality limit;

   $\sigma' = (P' * l)/ (bd^2)$ = ______ N/mm^2

2. Extreme fiber stress at failure (Modulus of rupture);

   $\sigma'' = (P'' * l)/ (bd^2)$ = _______ N/mm^2

3. Young's Modulus;

$$E = \frac{a*(3l^2 - 4a^2)}{24*I} * (P/\delta)$$

where; P' - load at proportionality limit as obtained from the graph

P" - load at failure

(P/δ) is the slope obtained from the graph

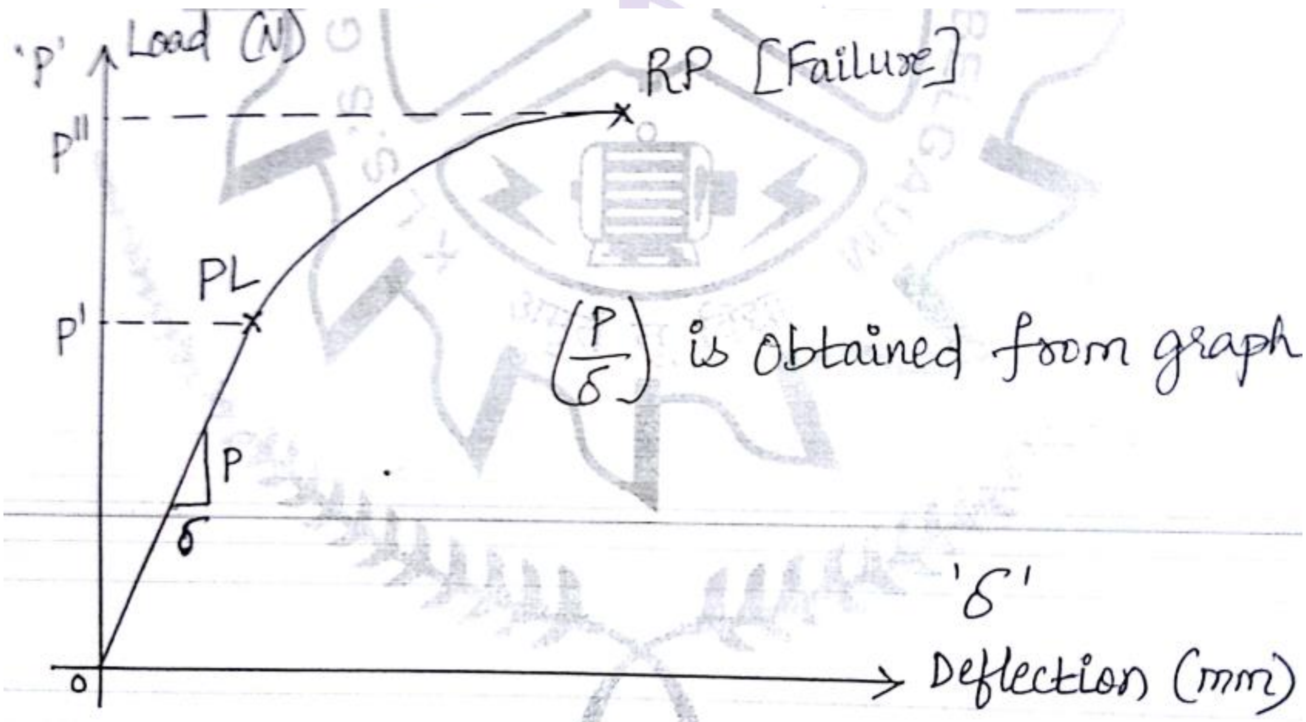
Results:

a. Extreme fiber stress at proportionality limit; σ' = __________ N/mm^2

b. Extreme fiber stress at failure (Modulus of Rupture); σ" = __________ N/mm^2

c. Young's Modulus (Modulus of Elasticity); E = __________ N/mm^2

Nature of the Graph:



PL = Proportionality Limit

RP = Rupture Point

EXPERIMENT No. 16

Tension test on Mild Steel

Aim: To observe the behavior of the given Mild Steel specimen under static tension upto failure & to determine-

1. Young's modulus
2. Yield stress
3. Ultimate stress
4. Breaking stress
5. Percentage elongation in length
6. Percentage reduction in c/s area

Apparatus:

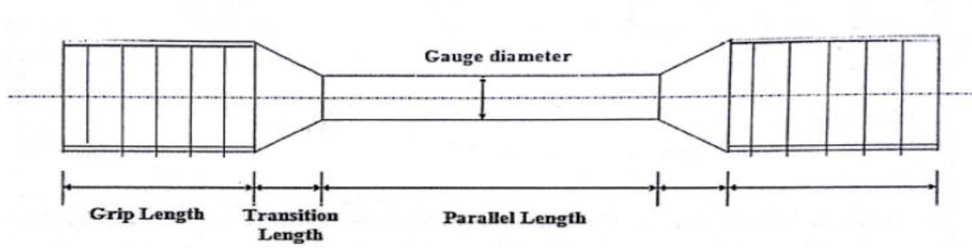
1. Universal Testing Machine (UTM) with digital display system
2. Vernier Calipers
3. Scale & Punch

Theory:

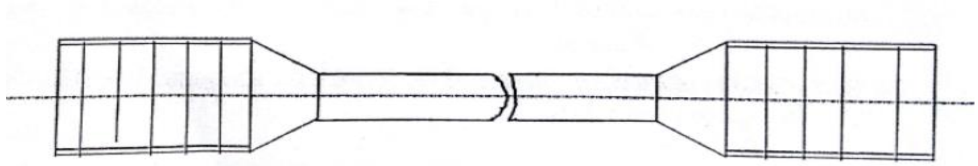
Based on the carbon content, steel is classified into mild steel, medium carbon steel and high carbon steel. The respective carbon content % varies as 0.10 for mild steel, 0.25 to 0.60 in medium carbon steel and 0.60 to 1.10 in high carbon steel. Mild Steel is suitable for all constructional purposes in general. Mild steel is malleable and ductile. It can be welded but rusts rapidly. Mild steel is used for as reinforcing rods in reinforced concrete in construction sector, motor-body building works etc. Mild steel is available in grade "Fe-250" where '250' indicates the yield strength of steel in N/mm^2.

Diagram:

1) ORIGINAL SPECIMEN



2) FAILURE PATTERN SHOWING CUP & CONE FORMATION



Procedure:

1. Measure the diameter of the specimen at several sections and obtain the mean initial diameter.
2. Make punch marks at a distance of 'five times the nominal diameter' along the length of the specimen & mark the gauge length.
3. Mount the specimen in the machine & apply the tensile load gradually at the rate of 0.5 $kg/cm^2/sec$.
4. At equal increments of the load, note down the load and corresponding elongation on the digital display system.
5. When the load reaches the ultimate load, note down the elongation and continue to load the specimen upto its failure.
6. Remove the broken specimen from the machine and measure the final diameter of the neck. Place the two parts together and measure the final length over the original gauge length marks.

Specifications/ Acceptance limits:

"I.S: 432 (part I & II)-1982; Specification for Mild Steel and Medium Tensile Steel rods and Hard Drawn Steel wire for concrete reinforcement"

Application of the Test:

This test is useful to determine the physical properties of the given mild steel specimen and confirming its suitability for use as reinforcement in concrete.

Observations:

Specimen before testing

1. Original diameter of the specimen; $d_o = (d_1 + d_2 + d_3)/3$ = ______ mm
2. Nominal diameter of the specimen; d_n = _____ mm
3. Original cross-sectional area of the specimen; $A_o = [\pi * d_o^2]/4$ = ______ mm^2
4. Original gauge length; $l_o = 5*d_n$ = _____ mm
5. Original parallel length; L = _______ mm

Specimen after testing

1. Final diameter of the specimen; d_f = ________ mm
2. Final cross-sectional area of the specimen; A_f = ________ mm^2
3. Final gauge length; l_f = ______ mm
4. Ultimate Load = ______ kN
5. Breaking load = ________ kN

Tabulation:

Sl. No.	Load 'P' (in kN)	Load 'P' (in N)	Elongation 'δL' (in mm)	Stress; ($\sigma = P/A_0$) (in N/mm^2)	Strain; ($\varepsilon = \delta L/L$)
1					
2					
…..					
Upto Failure					

Specimen Calculations:

1. Young's Modulus [to be determined from the graph]; E = __________ N/mm^2
2. Yield stress [to be determined from the graph]; f_y = __________ N/mm^2
3. Ultimate stress; $f_u = \frac{\text{Ultimate load}}{\text{Original c/s area}}$ = __________ N/mm^2
4. Breaking stress; $f_b = \frac{\text{Breaking load}}{\text{Original c/s area}}$ = __________ N/mm^2
5. Percentage elongation in length = $\frac{\text{Final gauge length} - \text{Initial gauge length}}{\text{Initial gauge length}} * 100$

   = ________ %
6. Percentage reduction in c/s area = $\frac{\text{Initial area} - \text{Final area}}{\text{Initial area}} * 100$

   = ________ %

Results: The given mild steel specimen is tested under static tension upto failure & the mechanical properties are-

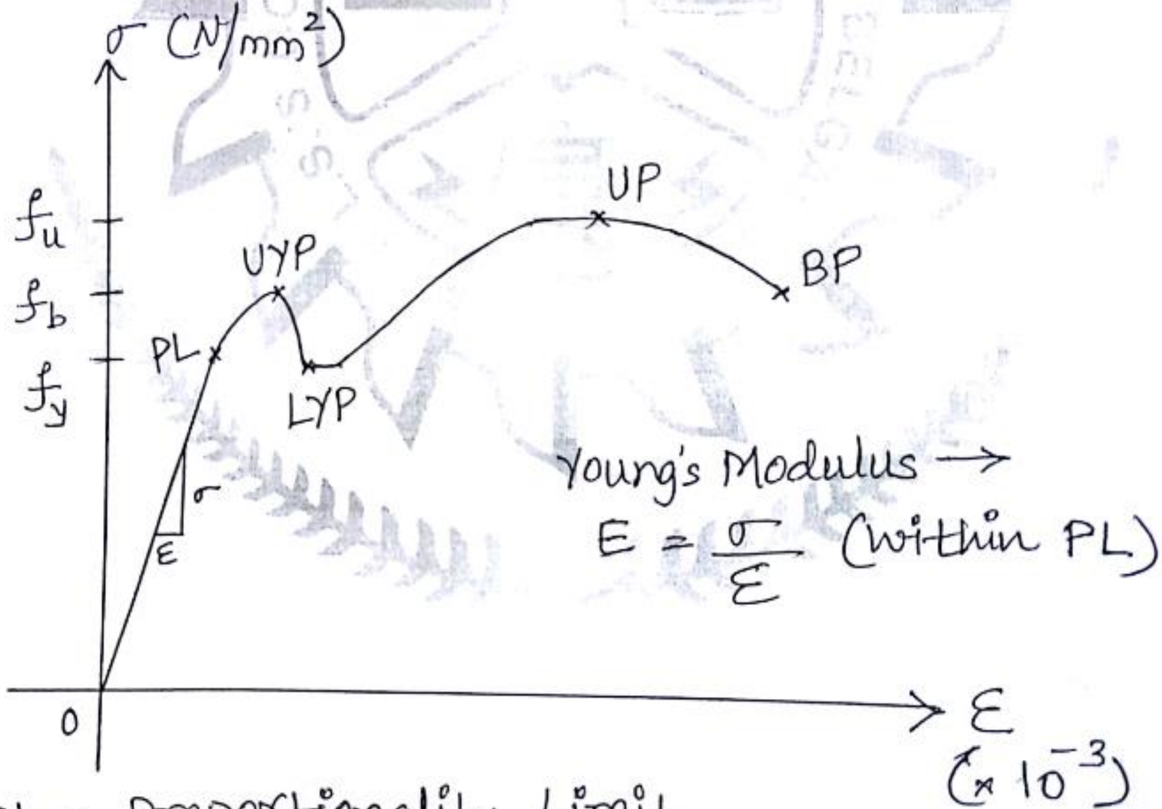
1. Young's modulus; E = _________ N/mm^2
2. Yield stress; f_y = _________ N/mm^2
3. Ultimate stress; f_u = _________ N/mm^2
4. Breaking stress; f_b = _________ N/mm^2
5. Percentage elongation in length = ________%
6. Percentage reduction in c/s area = ________%

Conclusions:

The specimen exhibited the phenomenon of yielding and the failure shows a cup and cone type of fracture.

Nature of the Graph:

Nature of the Graph [Theorotical] :-



PL = Proportionality Limit

UYP = Upper Yield Point ; UP = Ultimate Point

LYP = Lower " " ; BP = Breaking "

EXPERIMENT No. 17

Torsion test on Mild Steel/ HYSD rod

Aim: To observe the behavior of the given Mild steel/ HYSD rod specimen under applied Torsion and to determine the value of Modulus of Rigidity and Torsional shear stress developed in it.

Apparatus:

1. Torsion testing machine
2. Vernier calipers

Theory:

From the general equation of torsion for a circular specimen-

$$\frac{T}{J} = \frac{G \times \theta}{l} = \frac{\tau}{r}$$

where,

T = Applied Torque [N-mm]

J = Polar Moment of Inertia [mm^4]

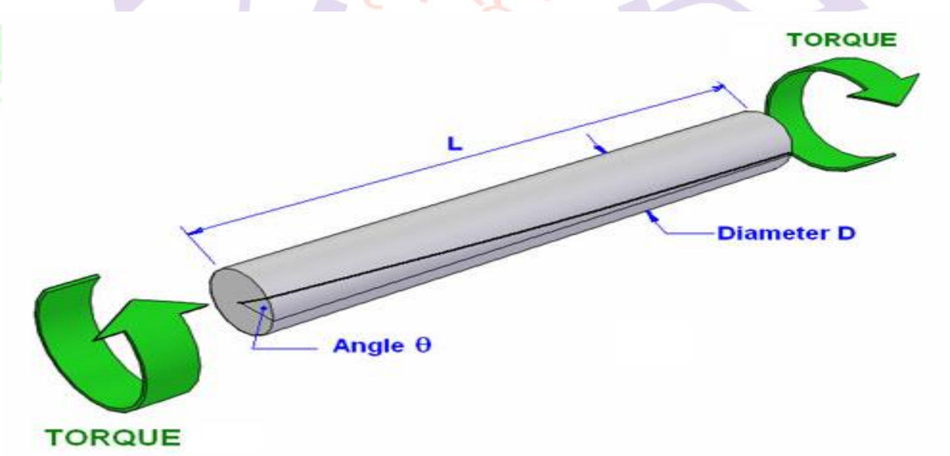
G = Modulus of Rigidity [N/mm^2]

θ = Angle of twist over length 'l' [radians]

τ = Torsional shear stress at radius 'r' [N/mm^2]

r = Radius [mm]

Diagram:



Procedure:

1. Measure the diameter of the specimen at three different positions and note down the mean diameter. Obtain the Polar Moment of Inertia and the Gauge length.

2. Adjust the measuring range according to the capacity of the test piece and hold the specimen in driving chuck with the help of handles.
3. Adjust the angle measuring dial at zero position with black pointer at the starting position. Bring the red dummy pointer in line with the black pointer.
4. Start the machine and now the specimen will be subjected to torsion.
5. Note down the maximum value of torque (from the indicating dial) and the corresponding angle of twist at the instant when the specimen breaks into two pieces.
6. Determine the value of modulus of rigidity and torsional shear stress.

Observations:

1. Mean diameter of the specimen; $d = (d_1 + d_2 + d_3)/3$ = ______ mm
2. Polar Moment of Inertia = $J = I_{XX} + I_{YY}$
   $= [\pi * d^4/64] + [\pi * d^4/64]$
   $= [\pi * d^4/32]$ = ______________ mm^4
3. Gauge length; $l = 5*d$ = _______ mm
4. Torque at failure; T = _________ N-mm
5. Angle of twist at failure; θ = _________ degrees = _________ radians

Calculations:

1. Modulus of Rigidity = $G = (T*l)/(J*\theta)$ = _______ N/ mm^2
2. Torsional Shear stress = $\tau = (16*T)/(\pi*d^3)$ = _______ N/ mm^2

Results:

1. Modulus of Rigidity = _______ N/ mm^2
2. Torsional Shear Stress = _______ N/ mm^2

EXPERIMENT NO. 18

Bend-Rebend test on Mild Steel or HYSD rod

Aim: To conduct the bend-rebend test on Mild Steel or HYSD rod specimen and to observe the pattern of cracking/rupture.

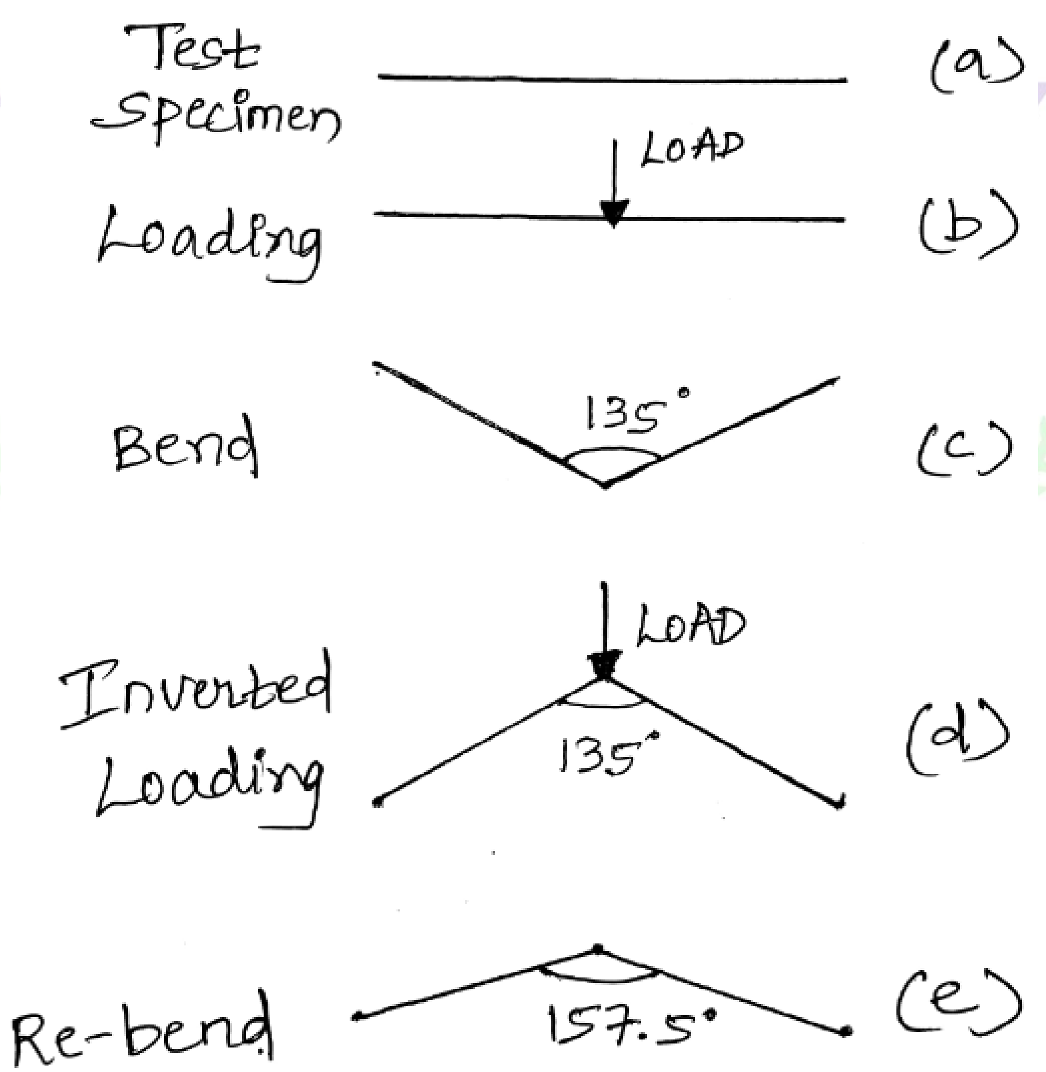
Apparatus:

1. Universal Testing Machine (UTM) with digital display system
2. Test assembly

Theory:

This test is useful to determine the ductility of the given specimen and hence its suitability for use as reinforcement in concrete.

Diagram:



Procedure:

1. The test piece shall be doubled over the mandrel/support by continuous pressure until the sides are parallel.
2. The test piece shall then be bent by loading it at the center, till it subtends an included angle of 135° as shown in the diagram.
3. Then, the test piece shall be bent backwards by keeping it in inverted position and loading it till it subtends an included angle of 157.5°.
4. The specimen shall be considered to have passed the test if there is no rupture or cracks visible in the region of bend/rebend to a person of normal or corrected vision and the same shall be considered as acceptable.

Specifications/ Acceptance limits:

The bend-rebend test shall be performed in accordance with the requirements of- "IS-1786:2008 - High Strength Deformed Steel Bars and Wires for Concrete Reinforcement – Specifications (Fourth Revision)"

If Cracks are Observed- UNACCEPTABLE
If Cracks are Not Observed- ACCEPTABLE

Conclusion:

Bend-Rebend test was conducted on the given Mild steel/ HYSD rod specimen and it is ________________________ as per Indian standards, since cracking or rupture in the specimen was ________________________