**II Jai Sri Gurudev II**

# ADICHUNCHANAGIRI UNIVERSITY

**B G NAGARA - 571448**

# MATERIAL TESTING LABORATORY

## BGS INSTITUTE OF TECHNOLOGY

## DEPARTMENT OF CIVIL ENGINEERING

II Jai Sri Gurudev II

# BGS INSTITUTE OF TECHNOLOGY

**Department of Civil Engineering**

## VISION

- Producing technically competent and Environmental friendly Civil Engineering Professionals to cope with the societal challenges.

## MISSION

- Imparting quality education and professional ethics by proficient faculty.
- Providing infrastructure to meet the requirements of curriculum, research and consultancy.
- Motivating towards higher education and entrepreneurship.
- Promoting Interaction with design and construction industries.

## PROGRAM EDUCATION OBJECTIVES (PEOs)

**PEO 1:** Graduates will be pursuing successful career & higher education.

**PEO 2:** Graduates will be able to design safe, economical & sustainable civil engineering structures conforming to standards.

**PEO 3:** Graduates will display professional ethics to work in a team & lead the team by effectively communicating the ideas.

**PEO 4:** Graduates will practice lifelong learning.

## PROGRAM SPECIFIC OBJECTIVES (PSOs)

**PSO 1**: Graduates will be able to analyze, design and execute the civil engineering structures effectively for the sustainable development.

**PSO 2**: Graduates will acquire critical thinking abilities and technical skills for the usage of modern tools in development of civil engineering structures.

**PSO 3**: Graduates will be able to get opportunities for their professional growth, demonstrate communication and aptitude skills to face the challenges and needs of our society.

# CONTENTS

# 1. TENSION TEST ON MILD STEEL AND HYSD BARS

**Object:** To conduct tension test on the given mild steel rod for determining the yield stress, ultimate stress, breaking stress, percentage of reduction in area, percentage of elongation over a gauge length and young’s modulus.

**Apparatus:** Universal Testing Machine, Mild Steel Rod, Vernier caliper/Scale.

**Theory:** The tensile test is most applied one, of all mechanical tests. In this test ends of test piece and fixed into grips connected to a straining device and to a load measuring device. If the applied load is small enough, the deformation of any solid body is entirely elastic. An entirely deformed solid will return to its original form as soon as load is removed. However, if the load is too large, the material can be deformed permanently. The initial part of the tension curve, which is recoverable immediately after unloading ,is termed as elastic and the rest of the curve, which represents the manner in solid undergoes plastic deformation is termed as plastic. The stress below which the deformation is essentially entirely elastic is known as the yield strength of material. In some materials the onset of plastic deformation is denoted by a sudden drop in load indication both an upper and a lower yield point. However, some materials do not exhibit a sharp yield point. During plastic deformation, at larger extensions strain hardening cannot compensate for the decrease in section and thus the load passes through the maximum and then begins to decrease. At this stage the “ultimate strengths”, which is defined as the ratio of the load on the specimen to the original cross sectional are, reaches the maximum value. Further loading will eventually cause „nick“ formation and rupture.

Usually a tension testis conducted at room temperature and the tensile load is applied slowly. During this test either round of flat specimens may be used. The round specimens may have smooth, shouldered or threaded ends. The load on the specimen is applied mechanically or hydraulically depending on the type of testing machine.

**Procedure:**

1. Measure the diameter of the rod using Vernier caliper.
2. Measure the original length of the rod.
3. Select the proper jaw inserts and complete the upper and lower chuck assemblies.
4. Apply some graphite grease to the tapered surface of the grip surface forthe smooth motion.

5. Operate the upper cross head grip operation handle and grip fully the upper end of the test piece.
6. The left valve in UTM is kept in fully closed position and the right valve in normal open position.
7. Open the right valve and close it after the lower table is slightly lifted.
8. Adjust the load to zero by using large push button.
9. Operate the lower grip operation handle and lift the lower cross head up and grip fully the lower part of the specimen. Then lock the jaws in this position by operating the jaw locking handle.
10. Turn the right control valve slowly to open position (anticlockwise) untilwe get a desired loadings rate.
11. After that we will find that the specimen is under load and then unclamp the locking handle.
12. Now the jaws will not slide down due to their own weight. Then go on increasing the load.
13. At a particular stage there will be a pause in the increase of load. The load at this point is noted as yield point load.
14. Apply the load continuously, when the load reaches the maximum value. This is noted as ultimate load.
15. Note down the load when the test piece breaks, the load is said to be a breaking load.
16. When the test piece is broken close the right control valve, take out the brokenpieces of the test piece. Then taper the left control valve to take the piston down.

**Formula used:**

Original area of the rod ($A_o$) = $\frac{\pi d_o^2}{4}$ in $mm^2$

Neck area of the rod ($A_n$) = $\frac{\pi d_n^2}{4}$ in $mm^2$

Where,

$d_o$ - Original diameter of the MS rod

$d_n$ - Neck diameter of the MS rod

**Observation:**

Yield load ($W_y$) =

Ultimate load ($W_u$) =

Breaking load ($W_b$) =

**Tabulation:**

| Specimen | Length (mm) | | Diameter (mm) | | Area (mm$^2$) | | Percentage ofElongation inlength (%) | Percentage ofReduction area (%) |
|---|---|---|---|---|---|---|---|---|
| | Initial | Final | Initial | Final | Initial | Final | | |
| MS rod | | | | | | | | |
| | | | | | | | | |

**Precautions:**

- The specimen should be prepared in proper dimensions.
- Take reading carefully.
- After breaking specimen stop to m/c.

**Result:**

1. Final length of the specimen = mm
2. Diameter of the Neck ($d_n$) = mm
3. Percentage of Reduction = %
4. Percentage of Elongation = %
5. Yield stress of MS bar = N/mm$^2$
6. Ultimate stress of MS bar = N/mm$^2$
7. Breaking stress of MS bar = N/mm$^2$
8. Young’s Modulus of MS bar = N/mm$^2$

**Graph:**

Draw a graph between stress and strain relationship.

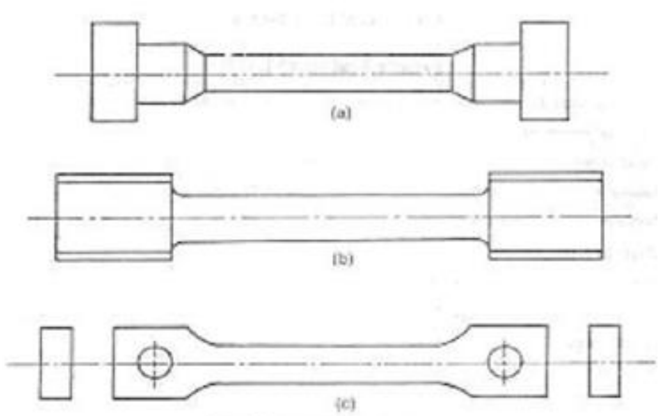
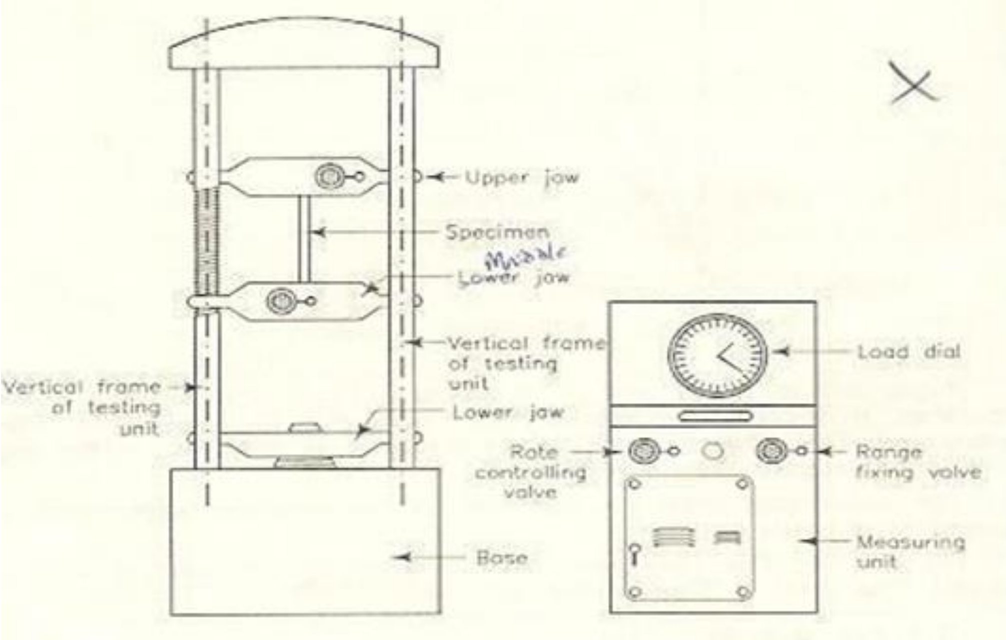
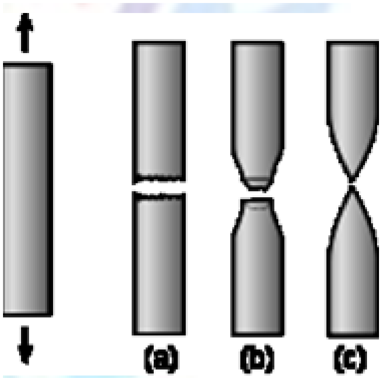
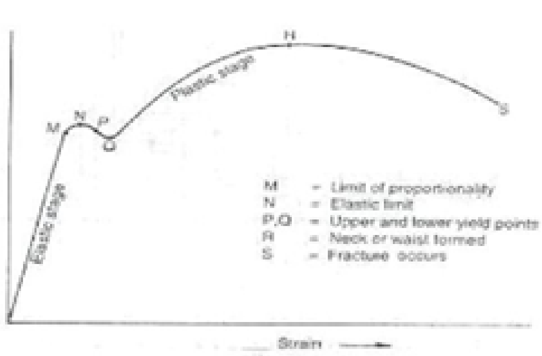



Fig. 2. Mild steel specimens.




**VIVA QUEST1I.ONS:**

1. What is uniformly distributed load?
2. Define: Shear force.
3. Define: Bending Moment at a section.
4. What is meant by positive or sagging BM?
5. What is meant by negative or hogging BM?

# 2. COMPRESSION TEST ON MILD STEEL, CAST IRON AND WOOD

**Object:** To determine the compressive strength of mild steel, cast iron and wood in given sample material.

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**Apparatus:** Compressometer (or) Compression Testing Machine, Mild Steel, Cast Iron and Wooden specimen.

**Procedure:**

1. Calculate the material required for preparing the wood of given specification.
2. Immediately after being made, they should be covered with wet mats.
3. Compression tests of wood specimens are made as soon as practicable after removal from making factory. Test-specimen during the period of their removal from the making factory and till testing, are kept moist by a wet blanket covering and tested in a moist condition.
4. Place the specimen centrally on the location marks of the compression testing machine and load is applied continuously, uniformly and without shock.
5. Also note the type of failure and appearance cracks.

**Formula:**

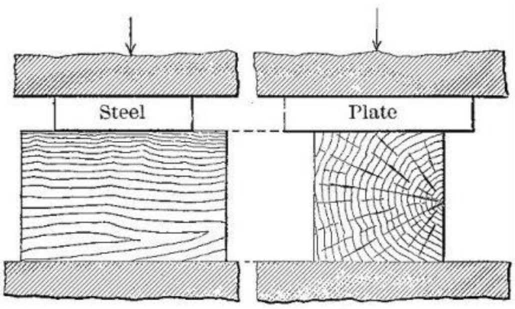
The compressive strength of wooden specimen = $\frac{\text{Taking compressive load}}{\text{Cross sectional area}}$

**Observation and Tabulation:**

| Specimen | Trial | | Mean value N/mm$^2$ |
|---|---|---|---|
| | 1 | 2 | |
| Load on wood.KN | | | |

**Result:**

The compressive stress of the wooden specimen = ---------------N/mm$^2$




# 3. TORSION TEST ON MILD STEEL CIRCULAR SECTIONS

**Object:** To conduct the torsion test on the given specimen for the following.

1. Modulus of Rigidity.
2. Shear stress.

**Apparatus:** Torsion test apparatus, Vernier caliper/Scale, Specimen.

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**Theory:** A torsion test is quite intruded in determining the values of modulus of rigidity of metallic specimen the values of modulus of rigidity can be found out through observation made during experiment by using torsion equation.

$$T/G = C\alpha/L$$

**Procedure:**

1. Measure the diameter and length of the given rod.
2. The rod is fixing in to the grip of machine.
3. Set the pointer on the torque measuring scale.
4. The handle of machine is rotate in one direction.
5. The torque and angle of test are noted for five degree.
6. Now the handle is rotated in reverse direction and rod is taken out.

**Formula:**

Modulus of Rigidity (C) = $\frac{TL}{J\propto}$ in N/mm$^2$ where, $\propto$ $-angle\ of\ degree$

Shear stress (t) = $\frac{TR}{L}$ in N/mm$^2$

**Observation:**

Diameter of the specimen = mm

Gauge length of the specimen = mm

**Tabulation:**

| S.NO | Angle Of Twist | Twist in Rod | Torque | | Modulus of Rigidity (N/mm$^2$) | Shear Stress (N/mm$^2$) |
|---|---|---|---|---|---|---|
| | | | N-M | N-MM | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

**Precautions:**

1. The specimen should be prepared in proper dimensions.
2. The specimen should be properly to get between the jaws.
3. Take reading carefully.
4. After breaking specimen stop to m/c.

**Result:**

Modulus of Rigidity of the specimen is =----------------------------- $N/m^2$

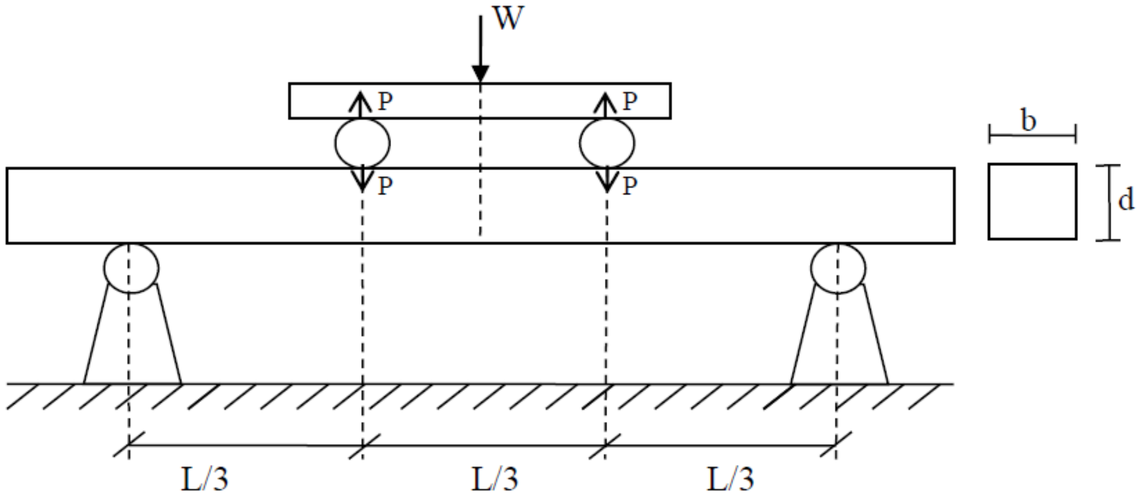
**VIVA QUESTIONS:**

1. What is torsional bending?
2. What is axial load?
3. Define: Column and strut.
4. What are the types of column failure?
5. What is slenderness ratio (buckling factor)? What is its relevance in column?

# 4. BENDING TEST ON WOOD UNDER TWO POINT LOADING

**Object:** To study the behaviour of given specimen of wood subjected to pure bending and to determine the Young's modulus of elasticity and modulus of rupture (bending).

**Apparatus:** Universal Testing Machine, Dial gauge, M.S Plate, Wood Specimen, Rollers.




**Procedure:**

- Observe the specimen and measure its cross sectional dimensions.
- Select a suitable span.
- Mark the mid span point and two-point loading locations at 1/3 span distances. Mark the cross section lines at these locations.
- Select a proper range of loading (i.e. 0 to 4 tonnes).
- Move the adjustable blocks and fix them at positions corresponding to selected span.
- Place the specimen over the roller supports. Place two more rollers at two-point loadingpositions and M.S. plate over them.
- Move the middle cross head to suitable position close to M.S. plate.
- Move the lower cross head and establish a slight contact between M.S. plate and theloading element fixed to the middle cross head.
- Fix the dial gauge suitably to measure the central deflection (i.e. maximum deflection)of the wooden beam. Adjust the dial gauge to read zero.
- Start applying the load gradually. Note down the dial gauge readings at regular loadintervals of 40 kg. Remove the dial gauge after about 10 readings.
- Continue loading up to failure and record the load at failure. Switch off the machine and release the load. Remove the specimen and observe the type of failure.

**Observations and Calculations before the test**:

1. Type of wood : ________________
2. Cross sectional dimensions = b x d = ________ cm x _________ cm.
3. Span = L = ______________________ cm.
4. Moment of inertia of the beam cross section about the neutral axis = $I = \frac{bd^3}{12}$ = ____________________ $cm^4$.
5. Section modulus = $Z = \frac{bd^2}{6}$ = ___________________ $cm^3$.
6. Least count of the dial gauge = ____________________ cm
7. Capacity of the dial gauge = ____________________ cm

**Tabulation:**

| Total Load W, kg | Load $P = \frac{W}{2}$, kg | Dial gauge readings, Divisions | Central deflection δ, cm | Remarks |
|---|---|---|---|---|
| | | | | |

**Calculation:**

1. Type of failure : ________________
2. Young's modulus of elasticity of given wood

$$= E = \frac{23}{648}\left(\frac{dP}{d\delta}\right)\frac{L^3}{I} = \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ kg/cm}^2.$$

$$= \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ GPa.}$$

where $\left(\frac{dP}{d\delta}\right)$ is the slope of the straight line portion of load vs. deflection curve.

3. Maximum bending moment = $M_f = \left(\frac{P_f L}{3}\right)$ = ________________ kg-cm

where $P_f$ is the load at failure.

4. Modulus of rupture (bending) = $\sigma_f = \frac{M_f}{Z}$ = ________________ $kg/cm^2$.

= MPa.

**Result:**

1. Young's Modulus of given wood = ----------- $kg/cm^2$
2. Maximum bending moment = ------------ kg-cm
3. Modulus of rupture (bending) = ------------ $kg/cm^2$

# 5. SHEAR TEST ON MILD STEEL

**Object:** To conduct shear test on given specimen under single and double shear.

**Apparatus:** Universal Testing Machine with single and double shear chuck, Mild Steel Rod, Vernier caliper.

**Theory:**
In actual practice when a beam is loaded the shear force at a section always comes to play along with bending moment. It has been observed that the effect of shearing stress as compared to bending stress is quite negligible. But sometimes, the shearing stress at a section assumes much importance in design calculations.

Universal testing machine is used for performing shear, compression and tension. There are two types of UTM.

1. Screw type
2. Hydraulic type.

Hydraulic machines are easier to operate. They have a testing unit and control unit connected to each other with hydraulic pipes. It has a reservoir of oil, which is pumped into a cylinder, which has a piston. By this arrangement, the piston is made to move up. Same oil is taken in a tube to measure the pressure. This causes movement of the pointer, which gives reading for the load applied.

**Procedure:**

1. Measure the diameter of the hole accurately.
2. Insert the specimen in position and grip one end of the attachment in the upper portion and the other end in the lower portion.
3. Switch on the main switch on the universal testing machine.
4. Bring the drag indicator in contact with the main indicator.
5. Gradually move the head control lever in left hand direction till the specimen shears.
6. Note down the load at which specimen shears.
7. Stop the machine and remove the specimen.

**Formula:**

$$\text{Shear strength} = \frac{Maximum\ Shear\ Strength}{Area\ of\ the\ Specimen}$$

**Observation and Tabulation:**

Diameter of the specimen (d) =

Cross sectional area of the Double shear = $\frac{2\,\pi d^2}{4}$ =

Shear load taken by specimen at the time of failure (P) =

**Result:**

The shear strength of the given metal specimen = -------N/mm$^2$

## VIVA QUESTIONS:

1. Define: Shear strength.
2. Define: Shear Chuck.
3. How to calculate the shear strength of the specimen?

# 6. IMPACT TEST ON MILD STEEL

## I) IZOD TEST:

**Object:** To determine the impact strength of the given material using Izod impact test.

**Apparatus:** Impact tester, Specimen, Vernier caliper/Scale, Specimen Fitter.

**Theory:**

An impact test signifies toughness of material that is ability of material to absorb energy during plastic deformation. Static tension tests of un notched specimens do not always reveal the susceptibility of a metal to brittle fracture. This important factor is determent by impact test. Toughness takes into account both the material. Several engineering material have to with stand impact or suddenly loads while in service. Impact strengths are generally lower as compared to strengths achieved under slowly applied loads of all types of impact tests, the notched bar test are most extensively used. Therefore, the impact test measures the energy necessary to fracture a standard notched bar by applying an impulse load. The test measures the notch toughness of material under shocking loading. Values obtained from these tests are not of much utility to design problems directly and are highly arbitrary. Still it is important to note that it provides a good way of comparing toughness of various materials or toughness of same material under different conditions. This test can also be used to assess the ductile brittle transition temperature of the material occurring due to loweringof temperature.

**Specification:**

i. Impact capacity = 164joule
ii. Least count of capacity (dial) scale = 2joule
iii. Weight of striking hammer = 18.7 kg.
iv. Swing diameter of hammer = 1600mm.
v. Angle of hammer before striking = 90°
vi. Distance between supports = 40mm.
vii. Striking velocity of hammer = 5.6m/sec.
viii. Specimen size = 75x10x10 mm.
ix. Type of notch = V-notch
x. Angle of notch = 45°
xi. Depth of notch = 2 mm.

**Procedure:**

1. Raise the swinging pendulum weight and lock it.
2. Release the trigger and allow the pendulum to swing.
3. This actuates the pointer to move in the dial.

4. Note down the frictional energy absorbed by the bearings.
5. Raise the pendulum weight again and lock it in position.
6. Place the specimen in between the simple anvil support keeping the "U" notch in the direction opposite to the striking edge of hammer arrangement.
7. Release the trigger and allow the pendulum to strike the specimen at its midpoint.
8. Note down the energy spent in breaking (or) bending the specimen.
9. Tabulate the observation.

**Formula:**

$$\text{Impact strength of the specimen} = \frac{Energy\ Absorbed}{Cross\ sectional\ area} \text{ in N/mm}^2$$

**Observation and Tabulation:**

Area of the given sample specimen = -------- $mm^2$

| S.No | Material Used | Energy absorbed by force (A) (J) | Energy spent to break the specimen (B) (J) | Energy absorbed by the specimen (A-B) J | Impact Strength $J/mm^2$ |
|---|---|---|---|---|---|
| | | | | | |

**Precaution:**

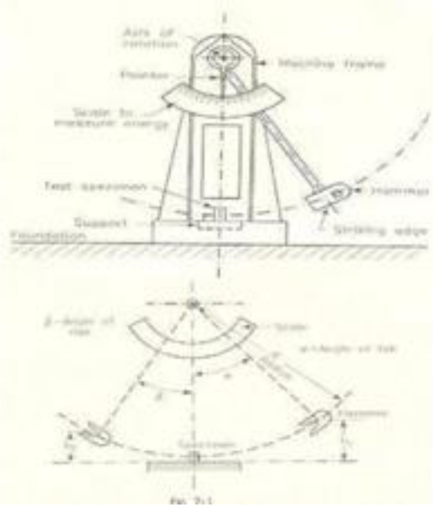
- The specimen should be prepared in proper dimensions.
- Take reading more frequently.
- Make the loose pointer in contact with the fixed pointer after setting the pendulum.
- Do not stand in front of swinging hammer or releasing hammer.
- Place the specimen proper position.

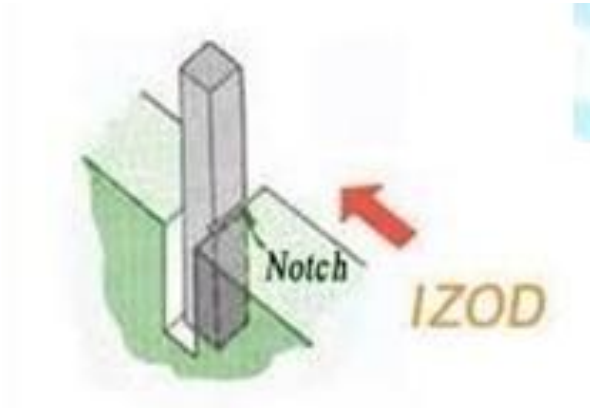
**Result:**

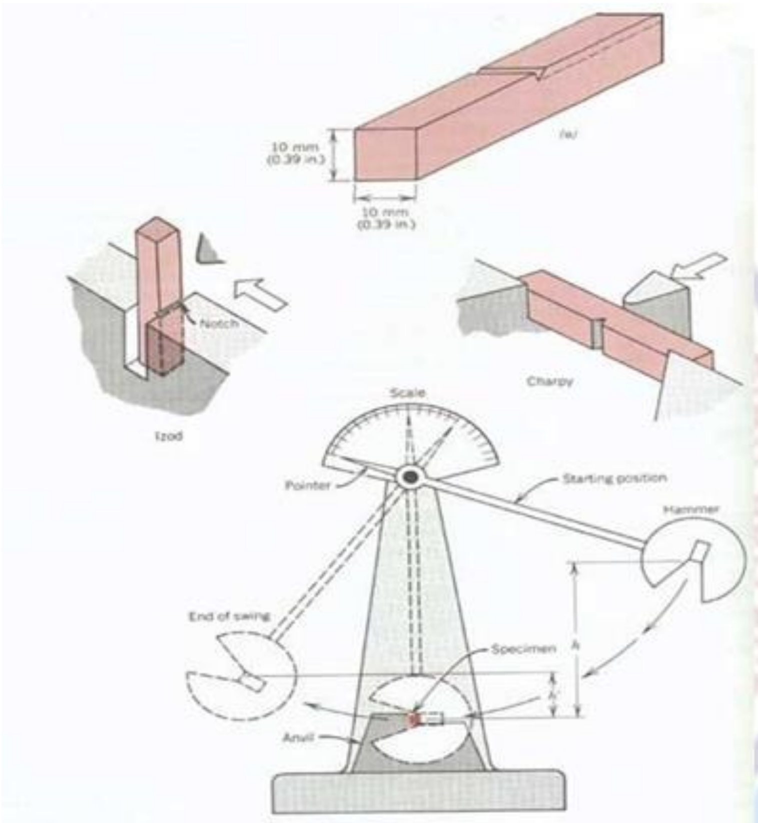
The impact strength of the given specimen = ----------------------------J/$mm^2$.

**VIVA QUESTIONS:**

1. Who postulated the theory of curved beam?
2. What is the shape of distribution of bending stress in a curved beam?
3. Where does the neutral axis lie in a curved beam?
4. What is the nature of stress in the inside section of a crane hook?
5. Where does the maximum stress in a ring under tension occur?






## II) CHARPY TEST:

**Object:** To determine the impact strength of the given material using Charpy impact test.

**Apparatus:** Impact tester, Specimen, Vernier caliper/Scale, Specimen Fitter.

**Theory:**

An impact test signifies toughness of material that is ability of material to absorb energy during plastic deformation. Static tension tests of un notched specimens do not always reveal the susceptibility of a metal to brittle fracture. This important factor is determent by impact test. Toughness takes into account both the material. Several engineering material have to with stand impact or suddenly loads while in service. Impact strengths are generally lower as compared to strengths achieved under slowly applied loads of all types of impact tests, the notched bar test are most extensively used. Therefore, the impact test measures the energy necessary to fracture a standard notched bar by applying an impulse load. The test measures the notch toughness of material under shocking loading. Values obtained from these tests are not of much utility to design problems directly and are highly arbitrary. Still it is important to note that it provides a good way of comparing toughness of various materials or toughness of same material under different conditions. This test can also be used to assess the ductile brittle transition temperature of the material occurring due to loweringof temperature.

**Specification:**

- Impact capacity = 300joule
- Least count of capacity (dial) scale = 2joule
- Weight of striking hammer = 18.7 kg.
- Swing diameter of hammer = 1600mm.
- Angle of hammer before striking = 160°
- Distance between supports = 40mm.
- Striking velocity of hammer = 5.6m/sec.
- Specimen size = 55x10x10 mm.
- Type of notch = V-notch
- Angle of notch = 45°
- Depth of notch = 2 mm.

**Procedure:**

1. Raise the swinging pendulum weight and lock it.
2. Release the trigger and allow the pendulum to swing.
3. This actuates the pointer to move in the dial.
4. Note down the frictional energy absorbed by the bearings.
5. Raise the pendulum weight again and lock it in position.
6. Place the specimen in between the simple anvil support keeping the ”U” notch in the direction opposite to the striking edge of hammer arrangement.
7. Release the trigger and allow the pendulum to strike the specimen at itsmidpoint.
8. Note down the energy spent in breaking (or) bending the specimen.
9. Tabulate the observation.

**Formula:**

$$\text{Impact strength of the specimen} = \frac{\textit{Energy Absorbed}}{\textit{Cross sectional area}} \text{ in N/mm}^2$$

**Observation and Tabulation:**

Area of the given sample specimen = -------- mm$^2$

| S.No | Material Used | Energy absorbed by force (A) (J) | Energy spent to break the specimen (B) (J) | Energy absorbed by the specimen (A-B) J | Impact Strength J/mm$^2$ |
|---|---|---|---|---|---|
| | | | | | |

**Precaution:**

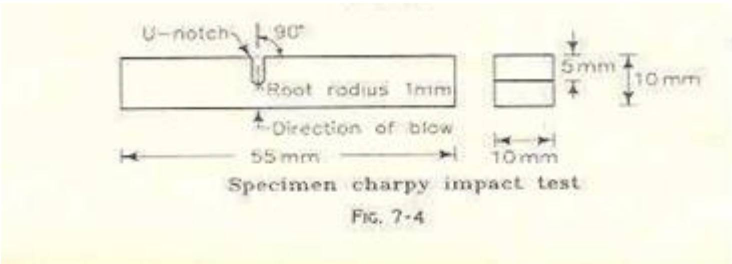
- The specimen should be prepared in proper dimensions.
- Take reading more frequently.
- Make the loose pointer in contact with the fixed pointer after setting the pendulum.
- Do not stand in front of swinging hammer or releasing hammer.
- Place the specimen proper position.

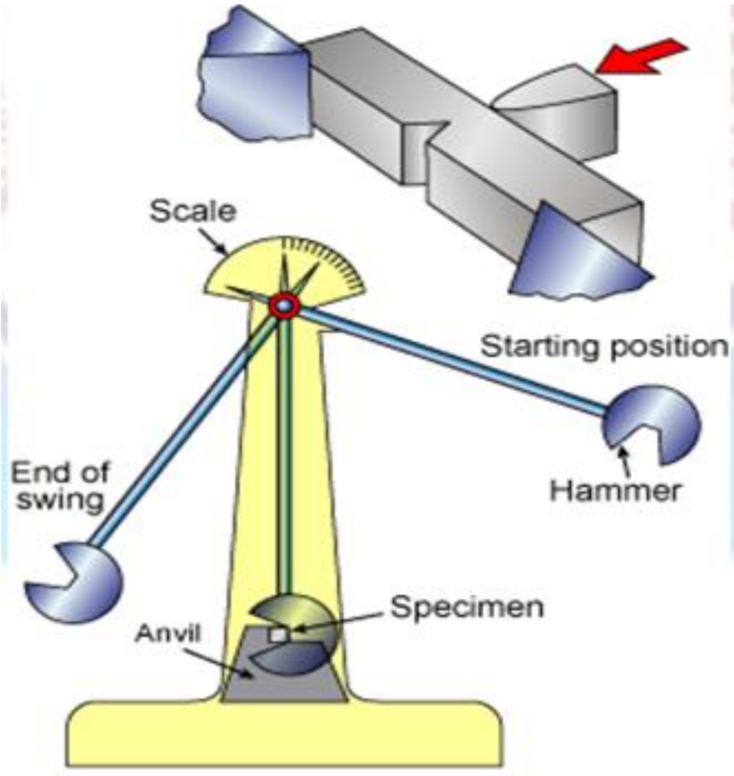
**Result:**

The impact strength of the given specimen = ----------------------------J/mm$^2$.

**VIVA QUESTIONS:**

1. What are the planes along which the greatest shear stresses occur?
2. Define: Strain Energy
3. Define: Unit load method.
4. Give the procedure for unit load method.




Impact test specimen (Charpy)

# 7. HARDNESS TEST ON FERROUS AND NON-FERROUS METALS

## I) BRINELL'S HARDNESS TEST:

**Object:** To find the Brinell Hardness number for the given metal specimen.

**Apparatus:** Brinell hardness apparatus, Diamond Indentor, MS specimen, Brinell microscope.

**Theory:**

Hardness represents the resistance of material surface to abrasion, scratching and cutting, hardness after gives clear identification of strength. In all hardness testes, a define force is mechanically applied on the test piece for about 15 seconds. The indentor, which transmits the load to the test piece, varies in size and shape for different tests. Common indenters are made of hardened steel or diamond. In Brinell hardness testing, steel balls are used as indentor. Diameter of the indentor and the applied force depend upon the thickness of the test specimen, because for accurate results, depth of indentation should be less than 1/8 of the thickness of the test pieces. According to the thickness of the test piece increase, the diameter of the indentor and force are changed.

**Description:**

It consists of pressing a hardened steel ball into a test specimen. In this usually a steel ball of Diameter D under a load 'P' is forced in to the test piece and the mean diameter 'd' of the indentation left in the surface after removal of load is measured. According to ASTM specifications a 10 mm diameter ball is used for the purpose. Lower loads are used for measuring hardness of soft materials and vice versa. The Brinell hardness is obtained by dividing the test load 'P' by curved surface area of indentation. This curved surface is assumed to be portion of the sphere of diameter 'D'.

**Specifications:**

- Usual ball size is 10 mm $\pm$ 0.0045 mm. Some times 5 mm steel ball is also used. It shall be hardened and tempered with a hardness of at least 850 VPN. (Vickers Pyramid Number). It shall be polished and free from surface defects.
- Specimen should be smooth and free from oxide film. Thickness of the piece to be tested shall not be less than 8 times from the depth of indentation.
- Diameter of the indentation will be measured n two directions normal to each other with an accuracy of $\pm$ 0.25% of diameter of ball under microscope provided with cross tables and calibrated measuring screws.

**Procedure:**

1. Specimen is placed on the anvil. The hand wheel is rotated so that the specimen along with the anvil moves up and contact with the ball.

2. The desired load is applied mechanically (by gear driven screw) and the ball presses into the specimen.
3. The diameter of the indentation made in the specimen by the pressed ball is measured by the use of a micrometer microscope, having transparent engraved scale in the field of view.
4. The indentation diameter is measured at two places at right angles to each other, and the average of two readings is taken.
5. The Brinell Hardness Number (BHN) which is the pressure per unit surfacearea of the indentation is noted down.

**Formula:**

Brinell hardness number (BHN) = $\frac{2P}{\{\pi D\ (D-\sqrt{(D^2-d^2)})\}}$

Where,

P - Load applied in Kgf.
D - Diameter of the indenter in mm.
d - Diameter of the indentation in mm

**Observation and Tabulation:**

| **S.No.** | **Material** | **Load in Kgf** | **Diameter Of the Indenter in mm** | **Diameter of the indentationin mm** | | | **Brinell Hardness Number (BHN)** |
|---|---|---|---|---|---|---|---|
| | | | | **1** | **2** | **3** | |
| | | | | | | | |
| | | | | | | | |

**Precautions :**

1. Brinell test should be performed on smooth, flat specimens from which dirt and scale have been cleaned.
2. The test should not be made on specimens so thin that the impression shows through the metal, nor should impressions be made too close to the edge of the specimen.

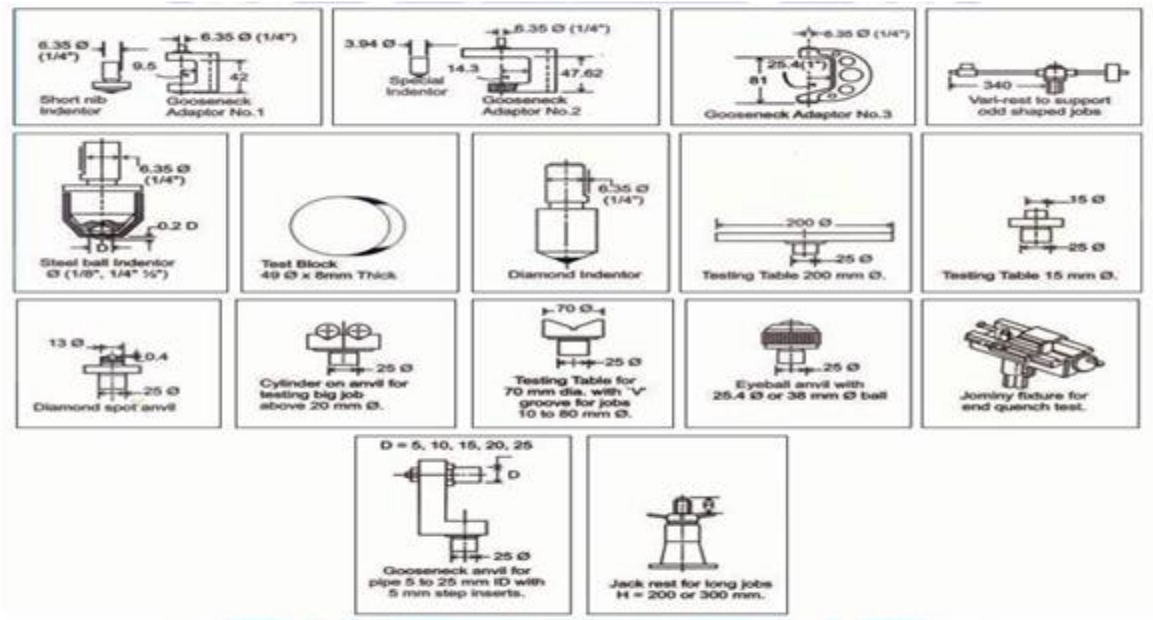
**Result:**

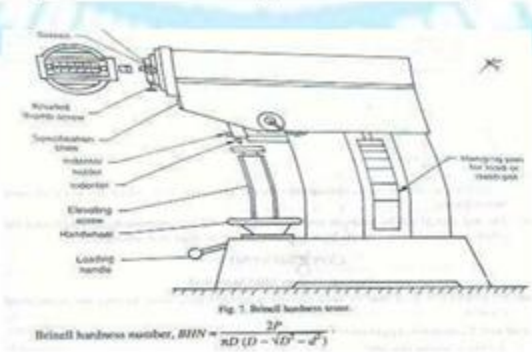
Thus the Brinell hardness of the Given Specimen is

- Mild Steel = -----------------------BHN
- EN 8 = -----------------------BHN
- EN 20 = -----------------------BHN

**VIVA QUESTIONS:**

1. Define buckling factor and buckling load.
2. Define safe load.
3. State Hooke's law.
4. Define Factor of Safety.
5. State the tensile stress & tensile strain.



## II) ROCKWELL'S HARDNESS TEST:

**Object:** To find the Rockwell Hardness number for the given metal specimen.

**Apparatus:** Rockwell hardness apparatus, Ball indentor, MS bar / Cast-iron Specimen, Microscope.

**Theory:**

In Rock well hardness test consists in touching an indenter of standard cone or ball into the surface of a test piece in two operations and measuring the permanent increase of depth of indentation of this indenter under specified condition. From it Rockwell hardness is deduced. The ball (B) is used for soft materials (e.g. mild steel, cast iron, Aluminum, brass. etc.) and the cone (C) for hard ones (High carbon steel. etc.)

HRB means Rockwell hardness measured on **B scale**

HRC means Rock well hardness measured on **C scale**

**Procedure:**

1. Clean the surface of the specimen with an emery sheet.
2. Place the specimen on the testing platform.
3. Raise the platform until the longer needle comes to rest.
4. Release the load.
5. Apply the load and maintain until the longer needle comes to rest.
6. After releasing the load, note down the dial reading.
7. The dial reading gives the Rockwell hardness number of the specimen.
8. Repeat the same procedure three times with specimen.
9. Find the average. This gives the Rockwell hardness number of the given specimen.

**Precautions:**

- The specimen should be clean properly.
- Take reading more carefully and correct.
- Place the specimen properly.
- Jack adjusting wheel move slowly.

**Observation and Tabulation:**

Name of the Indentor:

| S.No. | Material | Scale | Load (kgf) | Rockwell hardness Number | | | Rockwell hardness Number (Mean) |
|---|---|---|---|---|---|---|---|
| | | | | 1 | 2 | 3 | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

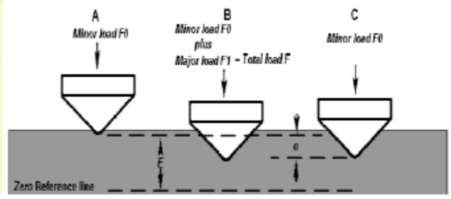
**Result:**

Rockwell hardness number of the given material is ------------

**VIVA QUESTIONS:**

1. Define Stress.

2. Define strain.
3. Define Modulus of Elasticity.
4. State Bulk Modulus.
5. Define poison’s ratio.




## III) VICKER’S HARDNESS TEST:

**Object:** To find the Vicker Hardness number for the given metal specimen.

**Apparatus:** Vicker hardness apparatus, Diamond indentor, MS bar / Cast-iron Specimen.

**Theory:**

Very Hard materials (e.g. Mild steel, case hardened steel, etc,) can be tested by the Vicker’s method. If the moderately hard materials like Brass, Copper and Aluminium are tested in this machine, the indentor makes a deep impression. Hence, a proper indentation cannot be made on the specimen and a correct value of the hardness cannot be obtained for these materials by V. H. Test.

**VHN =** Load Sloping or pyramidal area of indentation

This test is similar to Brinell hardness test similar relationship and eliminates most of the errors. A regular pyramid having a square base and smoothened off diamond point is pressed in the material to be tested under a load „F‟. The produced impression is projected onto a focusing screen and the diagonals of the impression are measured by means of the measuring equipment. Due to small impressions, it is very suitable for testing polished and hardened material surfaces. This test is rapid, accurate.

Hardness is the property of the material by which it offers resistance to scratch or indentation. It is the most important property, as the material is subjected to friction and scratch. By this experiment we can determine the Hardness of the given material.

**Specification:**

1 Maximum application of load = 50 kg-f
2 Method of load application = Push button
3 Least measuring indentation length= 0.001mm

**Procedure:**

1. Clean the surface at the specimen
2. Fix the indenter in the hardness tester and switch on the power supply.
3. Place the specimen with cleaned surface facing the indenter on the anvil at work table.
4. Focus the work piece surface for clean visibility by rotating the hand wheel at the work table upwards and downwards.
5. Select the load specified (P) push button available on the right side at the hardness tester.
6. Actuate the electric push button (Green Button) at the front for loading, the loading lever starts moving up words and reaches the study position.
7. Now release the loading lever slowly and bring it to the downward position.
8. For major reading adjust the display at the indentation made by the indenter to coincide with the micrometer on the display screen.
9. For major (minor) reading adjust the movable side at the micrometer and note down the total reading.
10. The measurement is to be made for two opposite corners of the diagonal indentation denoted as (l).
11. Repeat the above procedure for different material.

**Observation and Tabulation:**

| Sl.No. | Specimen Material | Load on Pin(P) Kg. | Speed (Rpm) | | | | Frictionl Force(F) Kg. | Co-efficient of friction ( F/P) |
|---|---|---|---|---|---|---|---|---|
| | | | | $W_1$ gm. | $W_2$ gm | δW (w1-w2) gm | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

## Calculation:

1. Co-efficient of Friction = $\frac{\text{Frictional force(F)}}{\text{Load on Pin (P)}}$

2. Surface Speed (n) = $\frac{\pi dN}{1000}$ m/min where, d= Dia od Disk(mm)
   N= Disc speed in RPM

3. Wear Rate = $\frac{\delta W}{n}$ gr/m/min

**Result:** Vicker's hardness Number of given specimen is

1. Mild steel = ------------VHN

2. Hardened mild steel = --------VHN

# 8. TEST ON BRICKS, TILES AND CONCRETE BLOCKS

**Object:** To determine the water absorption of bricks, tiles and concrete block.

**Apparatus:** Weighing Balance, Specimen of given material, hot oven.

**Procedure:**

- Measure the dimensions of the bricks to the nearest 1 mm.
- Dry the specimen in a ventilated oven at a temperature of 105 to 115$^{o}$C till it attains substantially constant mass.
- Cool the specimen to the room temperature and note down its mass (M1).
- Completely immerse the dried specimen in clean water at a temperature of 27 ± 2$^{o}$C for 24 hours.
- Take the specimen out of water and wipe out any traces of water with a damp cloth.
- Note down the mass of the specimen (M2), taking care to see that the process of measuring the mass takes not more than 3 minutes after the specimen is removed from water.
- Calculate the water absorption, percent by mass, after 24 hours of immersion in cold water using the formula.

  Water absorption = [(M2 – M1) / M1] x 100
- The water absorption for burnt clay building bricks when tested after immersion in cold water for 24 hours shall not be more than 20% by mass upto class 12.5 and 15% by mass for higher classes

**Observation:**

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

Average water absorption = --------------------

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

Average water absorption = --------------------

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

Average water absorption = --------------------

**Result:**

1. Water absorption of brick = -----------
2. Water absorption of tiles = -----------
3. Water absorption of concrete block = -----------

# 9. TEST ON FINE AGGREGATES

## I) MOISTURE CONTENT TEST:

**Object:** To determine the moisture content ( or surface moisture ) in fine aggregates by drying method

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

**Theory:**

The determination of moisture content of an aggregate is necessary in order to determine net water content ratio for a batch of concrete. High moisture content will increase effective water cement ratio to an appreciable extent and may even make the concrete weak unless a suitable allowance is made.

**Procedure:**

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

**Result:**

Moisture content in the given fine aggregate = _______%

**Tabulation:**

| | |
|---|---|
| Material | |
| Mass of tray and sample W1 gm | |
| Mass of tray and dry sample W2 gm | |
| Mass of empty tray W3 gm | |
| Moisture (by difference) W1-W2 = Wm gm | |
| Mass of dry aggregate W2-W3 = Wa gm | |
| Moisture content %w = (Wm/Wa ) *100 | |

## II) SPECIFIC GRAVITY TEST:

**Object:** To determine the specific gravity of a given aggregate sample.

**Apparatus:** Pycnometer, balance, glass rod, distilled water.

**Theory:**

The specific gravity of solids is frequently required for computation of several quantities such as void ratio, degree of saturation, unit weight. Specific gravity is defined as the ratio of unit weight of soil solids to the unit weight of water at the standard temperature.

**Procedure:**

1) Weigh about 250g of aggregate sample, clean the pycnometer and dry it.
2) After drying screw the cap of pycnometer and note down the mass of pycnometer as W1.
3) Pour the 250g of soil into the pycnometer and note down the mass of pycnometer along with the soil as W2g
4) Fill the pycnometer to half its height with distilled water and mix it thoroughly with glass rod to remove the entrapped air.
5) After removal of entrapped air again fill the pycnometer completely with distilled water and note down the mass of pycnometer along with soil and water W3g.
6) Empty the pycnometer and clean it thoroughly.
7) Again fill the pycnometer with distilled water to the hole of the conical cap and note down the mass of pycnometer along with water as W4g.
8) Repeat the test procedure for two or more samples.

**Tabulation and Calculation:**

| Sl.No | Description | Trail1 | Trail2 | Trail3 |
|---|---|---|---|---|
| 1 | Mass of empty pycnometer, W1g | | | |
| 2 | Mass of pycnometer + aggregate, W2g | | | |
| 3 | Mass of pycnometer + aggregate + water, W3g | | | |
| 4 | Mass of pycnometer+ water, W4g | | | |
| 5 | Specific gravity of aggregate, G | | | |
| 8 | Average Specific gravity of aggregate, G | | | |

Specific gravity of aggregate, G = $\frac{[W2 - W1]}{[W2 - W1] - [W3 - W4]}$

**Result:**

Average Specific Gravity of given sample of aggregate, G = --------------

## III) <u>BULK DENSITY TEST:</u>

**Object:** To determine the bulk density of a given aggregate sample.

**Apparatus:** Measuring jar, Balance, Cylindrical Containers.

**Theory:**

The bulk density clearly depends on how densely the aggregate is packed, and it follows that for a material of a given specific gravity the bulk density depends on the size distribution and shape of the particles .It is well know that in the metric system the density of a material is numerically equal to specific gravity although of coarse the latter is a ratio while density is expressed in Kg per litre. However in concrete practice, is to express the density in Kg per cubic meter is more common. When aggregate is be actually batched by volume it is necessary to know the weight of aggregate that would fill a continue of unit volume .This is known as bulk density of aggregate and this density is used to convert quantities by weight to quantities by volume .they are two types of bulk density viz Loose bulk density (Uncompacted) and Compacted bulk density.

**Procedure:**

- Depending on the size of the testing aggregate the size of the container is taken. The container is calibrated (i.e. empty weight and volume of container is measured). Let weight be W1 and volume be V.

- Then dried aggregate is filled in three layers into the container and each layer is compacted uniformly using tampering rod of 10mm diameter with round nosed (25 blows are given on each layer).
- After the aggregate is completely filled in container, weight of aggregate and container is measured. Let the weight be W2
- The compacted bulk density of the aggregate is given by the formula

$$\textbf{Bulk density } (\rho) = \frac{\textit{Weight of the aggregate}}{\textit{Volume of the Container}}$$

**LOOSE MASS DETERMINATION**

- Fill the container with aggregate over flow by means of showel the aggregate being discharged from a height not exceeding 50mm, above the top of the container.
- Level off the surface of the aggregate with a straight edge.
- Determine the net mass of aggregate in the container.
- Complete the unit mass of aggregate by dividing the next mass of aggregate in container by volume of container.
- Calculate the % of voids.

**Tabulation and Calculation:**

| Sl.No | Description | Trail1 | Trail2 | Trail3 |
|---|---|---|---|---|
| 1 | Empty weight of container, W1 gm | | | |
| 2 | Weight of the empty jar + loose sand,W2 gm | | | |
| 3 | Weight of empty jar + water, W3 gm | | | |
| 4 | Weight of jar + Fine aggregate + water, W4 | | | |

$$\textbf{Bulk Density in loose condition} = \frac{W2-W1}{W3-W1}$$

$$\textbf{\% of voids} = \frac{W4-W3}{W2-W1}$$

$$\textbf{Bulk Density of compacted aggregates} = \frac{W3-W1}{W2-W1}$$

**Result:**

1) Bulk Density of aggregate in loose condition = ----------- kg/$m^3$
2) Bulk Density of aggregate in compact condition = ---------- kg/$m^3$

## IV) SIEVE ANALYSIS:

**Object:** To determine fineness modulus and grain size distribution of the given fine aggregates

**Apparatus:** IS Sieve Set (4.75mm,2.36mm,1.18mm,600µm,300µm,150µm,75µm),Sieve Shaker, Balance.

**Theory:**

The sieve analysis is a simple test consisting of sieving a measured quantity of material through successively smaller sieves. The weight retained on each sieve is expressed as a percentage of the total sample. The sedimentation principle has been used for finding the grain size distribution of fine soil fraction: two methods are commonly used.viz, Pipette method and Hydrometer method of distribution of soil particles. Most of the methods for soil identification and classification are based on certain physical properties of the aggregate. The commonly used properties for classification are the grain size distribution. Grain size analysis also known as mechanical analysis .It determines the percentages of individual grain size present in the sample. The result of the test is of great value in soil classification. In mechanical stabilization of soil and for designing soil aggregate mixture the result of the gradation tests are used. Conclusions have also been made between the grain size distribution of soil and the general soil behaviour as sub grade material and the performance such as susceptibility to frost action. Pumping of rigid pavement etc. Sand is the fine aggregate used in mortar. Coarse aggregate that is the broken stone or gravel and the mixed aggregate which is the combination of coarse and fine aggregates are used in concrete. The coarse aggregate unless mixed with fine aggregates does not produce good quality concrete for construction works.

**Fineness Modulus**

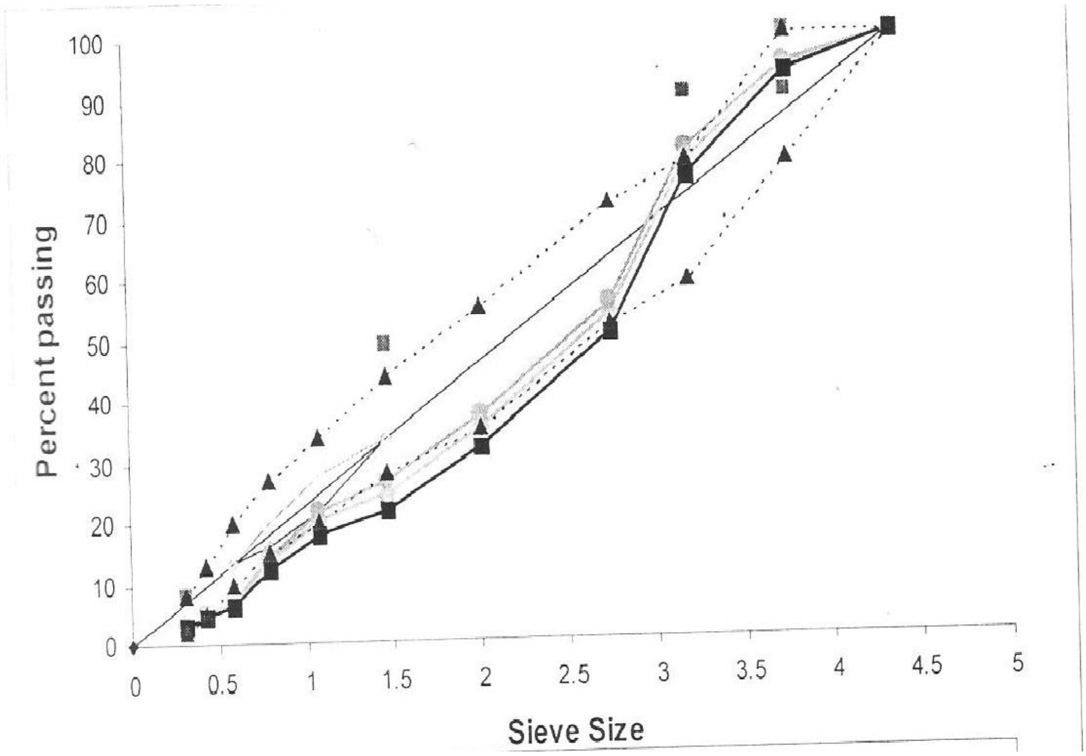
Fineness modulus is only a numerical index of finess giving some idea of the mean size of particles in the entire body of aggregate. The object of finding the fineness modulus is to grade the given aggregate for obtaining a most economical and workable mix.

| Type of Aggregate | Max size of aggregate in mm | Finess Modulus | |
|---|---|---|---|
| | | Min | Max |
| Fine aggregate | 4.75 | 2.00 | 3.5 |

**Procedure:**

- Take 1Kg of aggregate in a clean dry plate. from a sample of 10Kg, by quartering & breaking clay lamps if any
- Arrange the sieves in order of IS Sieve No: 4.75mm, 2.36mm, 1.18mm, 600µm, 300µm, 150µm, 75µm. Fix them in a Sieve Shaking machine with a pan at the bottom &Cover at the top.
- Keep the sand in the top Sieve Carry out the Sieving in the set of Sieves as arranged before for not less than 10minutes.
- Find mass retained on each Sieve & tabulate the reading in the observation sheet.
- The grain size greater than 75 micron is determined by sieving set of sieves of decreasing order. Sieve opening place one below the other and separating out the different size ranges. Two methods of sieve analysis are as follows
    - Wet sieving applicable to soil and
    - Dry sieving applicable only to soil which has negligible proportion of clay and silt.

$$\text{Fineness Modulus} = \frac{\text{Cumulative \% of weight retained on sieves}}{100}$$




**Tabulation and Calculation:**

| SL. NO | Sieve size | Weight of sand retained | Weight of sand passing | % weight of Sand retained | % weight of Sand Passing | Cumulative% weight of Sand retained |
|---|---|---|---|---|---|---|
| 1 | 4.75mm | | | | | |
| 2 | 2.36mm | | | | | |
| 3 | 1.18mm | | | | | |
| 4 | 600µm | | | | | |
| 5 | 425 µm | | | | | |
| 6 | 250 µm | | | | | |
| 7 | 150 µm | | | | | |
| 8 | 75 µm | | | | | |
| 9 | Pan | | | | | |

Weight of fine aggregates for sieving = _____________ gms

Fineness Modules = $\frac{\sum C}{100}$

**Result:**

Fineness Modules of aggregate = ---------------------

## V) BULKING OF AGGREGATES:

**Object:** To determine the bulking of fine aggregates and to draw curve between water content and bulking.

**Apparatus:** Balance, Cylindrical container, graduated cylinder, Beaker, Metal tray, Steel rule and Oven.

**Theory:**

In concrete mix design, the quantity of fine aggregates used in each batch should be related to know the volume of cement. The difficulty with measurement of fine aggregate by volume is the tendency of sand to vary s in bulk according to moisture content. The extent of this variation is given by this test.

If sand is measured by volume and no allowance is made for bulking the mix will be richer than specified because for given mass, moist sand occupies a considerable larger volume than the same mass of dry sand, as the particles are less closely packed when the sand is moist. If as usual the sand is measured by loose volume, it is necessary in such a 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 best, but a correction of the right order can easily be determined and should be applied in order to keep the concrete uniform.

This experiment is intended to cover the field method of determining the necessary adjustment for bulking of the aggregate.

**Procedure:**

- Put sufficient of the oven dry sand loosely into the container until it is about two third full. Level off the top of sand and weigh the container. Calculate the mass of sand by deducting the mass of container.
- Push a steel rule vertically down through the sand at the middle to the bottom and measure the height of the sand. Let it be ‘h’ in mm.
- Empty the sand out into a clean metal tray without any loss.
- Add 2 percent of water by mass of sand. Mix the sand and water thoroughly by hand.
- Put the wet sand loosely into the container without tamping it.

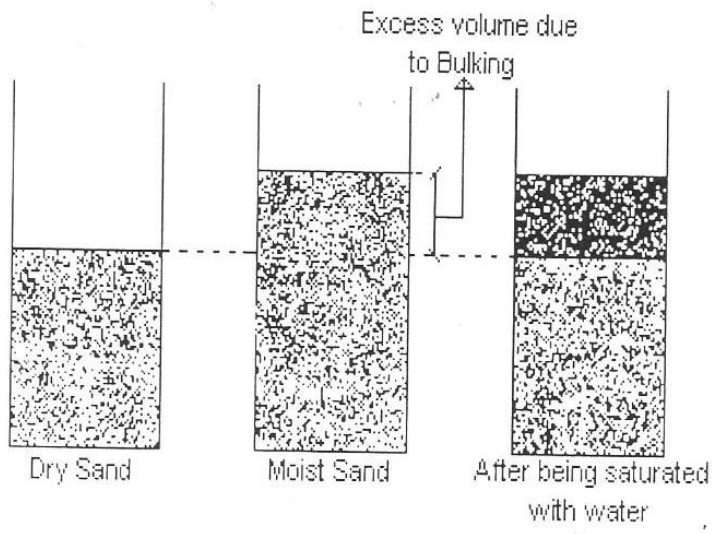
- Smooth and level the top surface of the moist sand and measure its depth at the middle with the steel rule. Let it be '$h_1$' in mm.

- Repeat the steps (1) and (2) of the above procedure with 2% of water by mass .

Go on increasing the percentage by one till bulking is maximum and a start falling down ultimately bulking is Zero. i.e. saturated sand occupies the same volume as dry sand.

$$\textbf{Percentage Bulking} = \frac{h1-h}{h} \text{ x100}$$

Diagram:




**Tabulation:**

| | |
|---|---|
| Material details | |
| Mass of container with oven dry aggregate (gm) | |
| Mass of empty container gm | |
| Mass of fine aggregate ( sand) , gm | |
| Height of dry sand h, mm | |

| Mass of sand ( ml) | %of water added | Water added in ml | Final volume ( height h1 | % Bulking = h1-h/h *100 |
|---|---|---|---|---|
| 250 | 2 | 5 | | |
| | | | | |
| | | | | |
| | | | | |

**Result:**

Bulking of fine aggregate = ____________________%

# 10. TEST ON COARSE AGGREGATES

## I) MOISTURE CONTENT TEST:

**Object:** To determine the moisture content (or surface moisture ) in coarse aggregates by drying method

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

**Theory:**

The determination of moisture content of an aggregate is necessary in order to determine net water content ratio for a batch of concrete. High moisture content will increase effective water cement ratio to an appreciable extent and may even make the concrete weak unless a suitable allowance is made.

**Procedure:**

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

**Result:**

Moisture content in the given coarse aggregate = _______%

**Tabulation:**

| | |
|---|---|
| Material | |
| Mass of tray and sample W1 gm | |
| Mass of tray and dry sample W2 gm | |
| Mass of empty tray W3 gm | |
| Moisture (by difference) W1-W2 = Wm gm | |
| Mass of dry aggregate W2-W3 = Wa gm | |
| Moisture content %w = (Wm/Wa ) *100 | |

## II) SPECIFIC GRAVITY AND WATER ABSORPTION TEST:

**Object:** To determine the specific gravity and water absorption of given coarse aggregates

**Apparatus:** Weighing balance, Oven, Wire basket, Container to store water and also to suspend the basket, Air tight container, Shallow tray, Absorbent clothes

**Theory:** The specific gravity of an aggregate is considered to be measure of strength (or) quality of the material. Stones having low specific gravity are generally weaker than those with higher specific gravity values. The specific gravity test helps in identification of stone. Water absorption gives an idea of strength of rock. Stones having more water absorption are more porous in nature and are generally considered unsuitable unless they are found to be acceptable based on strength, impact and hardness tests.

**Procedure:**

- Take about 5 Kg of aggregate sample.
- It is thoroughly washed to remove the finer particles and dust adhering to the aggregate.
- Pour the aggregate sample into the wire basket.
- Immerse the wire basket along the aggregate into the container which is filled with water.

- In order to remove the entrapped air the wire basket is lifted up and down for 25 times within the container.
- Then wire basket along the aggregate is kept in water container for about 24 hours.
- After 24 hours weigh the basket along the aggregate while suspended in water. Let the mass be W2 g.
- Remove the basket from water container.
- Transfers the aggregate samples to one of the dry absorbent clothe.
- Weigh the empty wire basket. Let the mass be W1 g.
- Then transfer the aggregate sample into another dry cloth and allow it dry for 10 minutes.
- Note down the mass of surface dried aggregate. Let the mass be W3 g.
- Thus the aggregate are placed in a shallow tray.
- The shallow tray is then kept in a oven for 24 hours at a temperature of 110°C.
- After 24 hours remove the shallow tray from the oven and cool it for 10 minutes.
- Note down the mass of oven dry aggregate. Let the mass be W4 g.
- Repeat the procedure for two more samples.
- Note down the mass of oven dry aggregate. Let the mass be W4 g.
- Repeat the procedure for two more samples.

**Tabulation and Calculation:**

| Items | Trail 1 | Trail 2 |
|---|---|---|
| Weight of empty wire basket, $W_1$ (g) | | |
| Weight of empty wire basket along the aggregate, $W_2$ (g) | | |
| Weight of saturated aggregate in water, ($W_2$-$W_1$), W (g) | | |
| Weight of surface dried aggregate, $W_3$ (g) | | |
| Weight of oven dry aggregate, $W_4$ (g) | | |
| Specific Gravity, G | | |
| Average Specific Gravity, G | | |
| Water Absorption, W (%) | | |
| Average Water Absorption, W (%) | | |

Weight of aggregate taken, W (g) =

Empty weight of wire basket, $W_1$ (g) =

Specific Gravity (G) = $\{W_4/W_3-(W_2-W_1)\}$

Water Absorption (W) (%) = $\{(W_3-W_4)/W_4\} * 100$

Where, $W_4$ = Weight of oven dry aggregate

$W_3$ = Weight of surface dried aggregate

$W_1$ = Weight of empty basket

$W_2$ = Weight of aggregate along the wire basket

**Result:**

Average Specific Gravity of given sample of aggregate, G =

Average Water Absorption of given sample of aggregate, W =

## III) <u>BULK DENSITY TEST:</u>

**Object:** To determine the bulk density of a given aggregate sample.

**Apparatus:** Measuring jar, Balance, Cylindrical Containers, Taming rod.

**Theory:**

The bulk density clearly depends on how densely the aggregate is packed, and it follows that for a material of a given specific gravity the bulk density depends on the size distribution and shape of the particles .It is well know that in the metric system the density of a material is numerically equal to specific gravity although of coarse the latter is a ratio while density is expressed in Kg per litre. However in concrete practice, is to express the density in Kg per cubic meter is more common. When aggregate is be actually batched by volume it is necessary to know the weight of aggregate that would fill a continue of unit volume .This is known as bulk density of aggregate and this density is used to convert quantities by weight to quantities by volume .they are two types of bulk density viz Loose bulk density (Uncompacted) and Compacted bulk density.

**Procedure:**

- Depending on the size of the testing aggregate the size of the container is taken. The container is calibrated (i.e. empty weight and volume of container is measured). Let weight be W1 and volume be V.
- Then dried aggregate is filled in three layers into the container and each layer is compacted uniformly using tampering rod of 10mm diameter with round nosed

(25 blows are given on each layer).

- After the aggregate is completely filled in container, weight of aggregate and container is measured. Let the weight be W2
- The compacted bulk density of the aggregate is given by the formula

$$\textbf{Bulk density } (\rho) = \frac{\textit{Weight of the aggregate}}{\textit{Volume of the Container}}$$

**LOOSE MASS DETERMINATION**

- Fill the container with aggregate over flow by means of showel the aggregate being discharged from a height not exceeding 50mm, above the top of the container.
- Level off the surface of the aggregate with a straight edge.
- Determine the net mass of aggregate in the container.
- Complete the unit mass of aggregate by dividing the next mass of aggregate in container by volume of container.
- Calculate the % of voids.

**Tabulation and Calculation:**

| Sl.No | Description | Trail1 | Trail2 | Trail3 |
|---|---|---|---|---|
| 1 | Empty weight of container, W1 gm | | | |
| 2 | Weight of the empty jar + loose sand,W2 gm | | | |
| 3 | Weight of empty jar + water, W3 gm | | | |
| 4 | Weight of jar + Fine aggregate + water, W4 | | | |

$$\textbf{Bulk Density in loose condition} = \frac{W2-W1}{W3-W1}$$

$$\textbf{\% of voids} = \frac{W4-W3}{W2-W1}$$

$$\textbf{Bulk Density of compacted aggregates} = \frac{W3-W1}{W2-W1}$$

**Result:**

3) Bulk Density of aggregate in loose condition = ------------ kg/$m^3$
4) Bulk Density of aggregate in compact condition = ---------- kg/$m^3$

## IV) SIEVE ANALYSIS:

**Object:** To determine fineness modulus and grain size distribution of the given fine aggregates

**Apparatus:** Balance, Weight box, I.S Sieve set and Sieve shaker

**Theory:**

The sieve analysis is a simple test consisting of sieving a measured quantity of material through successively smaller sieves .The weight retained on each sieve is expressed as a percentage of total samples. The sedimentation principle has been used for finding the grain size distribution of fine soil fraction: two methods are commonly used viz. Pipette method and Hydrometer method of distribution of soil properties. Most of the methods for soil identification and classification are based on certain physical properties of the aggregates. The commonly used properties for the classification are the grain size distribution. Grain size analysis is also known as mechanical analysis. It determines the percentages of the individual grain size present in the sample. The results of the test are of great value in soil classification. In mechanical stabilization of soil and for designing soil aggregates mixture the result gradation tests are used. Conclusions have also been made between the grain size distribution of soil and the general soil behaviors as a sub grade material and the performance such as susceptibility to frost action. Pumping of rigid pavement etc. Sand is the fine aggregate used in mortar. Coarse aggregate that is broken stone or gravel and the mixed aggregate which is the combination of coarse aggregate, unless mixed with fine aggregate does not produce good quality concrete for construction works.

**Fineness Modulus**

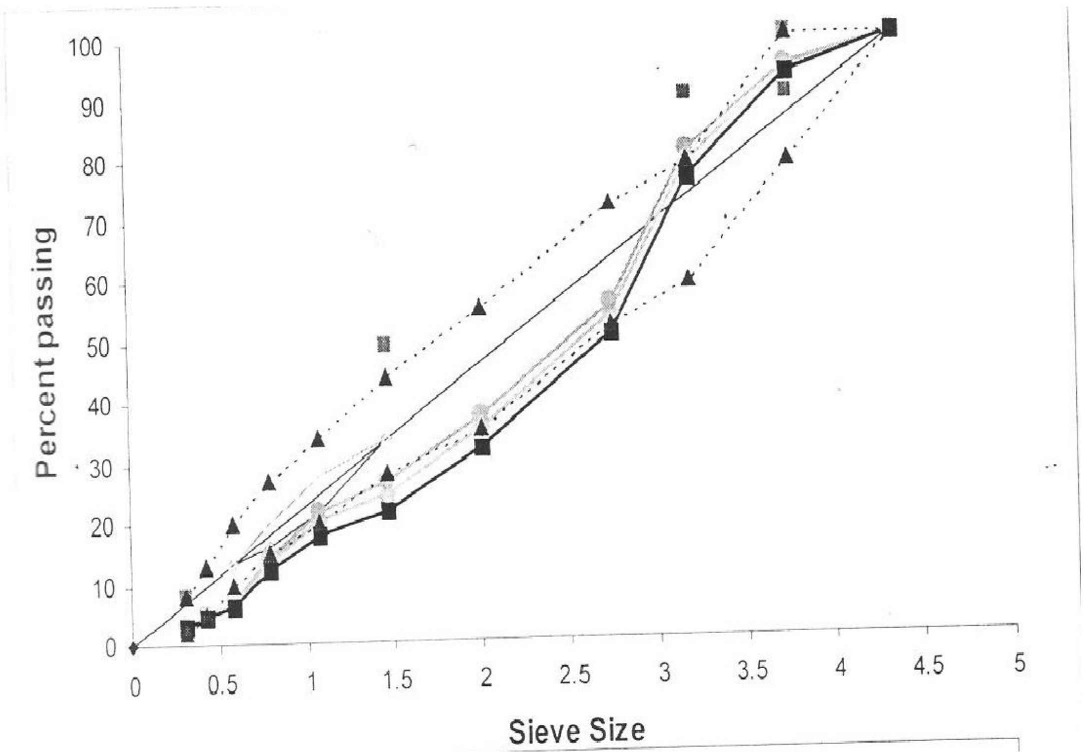
Fineness modulus is only a numerical index of finess giving some idea of the mean size of particles in the entire body of aggregate. The object of finding the fineness modulus is to grade the given aggregate for obtaining a most economical and workable mix.

| **Type of Aggregate** | **Max size of aggregate in mm** | **Finess Modulus** | |
|---|---|---|---|
| | | Min | Max |
| Coarse aggregate | 20 | 6.0 | 6.9 |
| | 40 | 6.9 | 7.5 |
| | 75 | 7.5 | 8.0 |

**Procedure:**

- Take 10 kg of coarse aggregates sample of 10 kg by quartering
- Arrange the sieves in descending order. Place the coarse aggregate in the top sieve.
- Fix them in the sieve shaking machine with the pan at the bottom and cover at the top and sieve it continuously for 10 min
- Find the mass of aggregates retained on each sieve In order and tabulate the result.

$$\text{Fineness Modulus} = \frac{\text{Cumulative \% of weight retained on sieves}}{100}$$



**Tabulation and Calculation:**

| Sl No | Sieve Size | Weight of CA retained (kgs) | % Weight Retained | Cumulative % retained | Cumulative % passing |
|---|---|---|---|---|---|
| 1 | 31.5mm | | | | |
| 2 | 25mm | | | | |
| 3 | 20mm | | | | |
| 4 | 12.5mm | | | | |
| 5 | 10mm | | | | |
| 6 | 8mm | | | | |
| 7 | 6.3mm | | | | |
| 8 | 4.75mm | | | | |
| 9 | Pan | | | | |

Weight of coarse aggregates for sieving = _____________ gms

Fineness Modules = $\frac{\sum C}{100}$

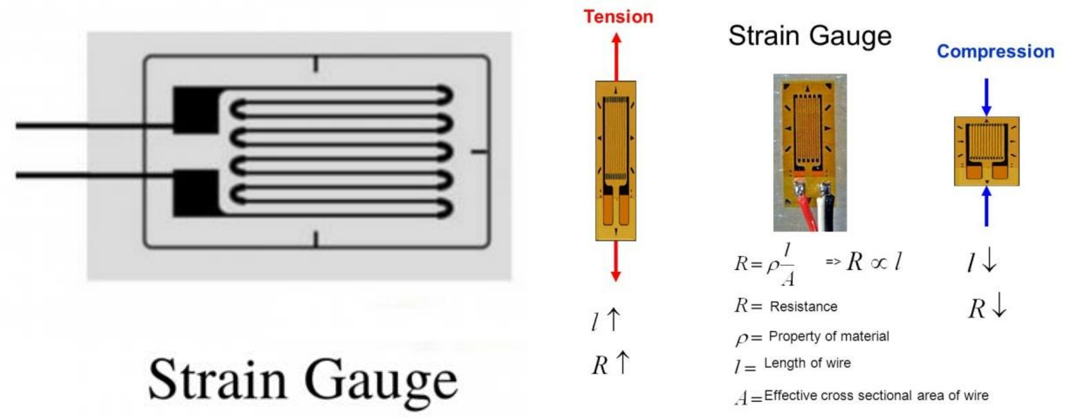
**Result:**

Fineness Modules of aggregate = ---------------------

# 11. DEMONSTRATION OF STRAIN GAUGE AND STRAIN INDICATOR

**Strain Gauge:** A Strain gauge is a sensor whose resistance varies with applied force; It converts force, pressure, tension, weight, etc., into a change in electrical resistance which can then be measured.

The strain gauge is one of the most important sensor of the electrical measurement technique applied to the measurement of mechanical quantities. As their name indicates, they are used for the measurement of strain. As a technical term "strain" consists of tensile and compressive strain, distinguished by a positive or negative sign. Thus, strain gauges can be used to pick up expansion as well as contraction. When external forces are applied to a stationary object, stress and strain are the result. Stress is defined as the object's internal resisting forces, and strain is defined as the displacement and deformation that occur.




The strain of a body is always caused by an external influence or an internal effect. Strain might be caused by forces, pressures, moments, heat, structural changes of the material and the like. If certain conditions are fulfilled, the amount or the value of the influencing quantity can be derived from the measured strain value. In experimental stress analysis this feature is widely used. Experimental stress analysis uses the strain values measured on the surface of a specimen, or structural part, to state the stress in the material and also to predict its safety and endurance. Special transducers can be designed for the measurement of forces or other derived quantities, e.g., moments, pressures, accelerations, displacements, vibrations and others. The transducer generally contains a pressure sensitive diaphragm with strain gauges bonded to it.

**Strain Indicator:** This is a battery powered strain indicator that measures strain using strain gauges in different settings (single linear or rosette) to obtain strain along a single orientation or to obtain principle strain axes using a rosette.