# Shantilal Shah Engineering College,
# Sidsar Campus,
# Bhavnagar

## APPLIED MECHANICS DEPARTMENT

LABORATORY MANUAL
OF

# MECHANICS OF SOLIDS

[3130608]

**Shantilal Shah Engineering College,**
**Sidsar Campus, Bhavnagar**

# CERTIFICATE

This is to certify that Mr/Mrs. ________________________________ Of
Name of Student in CAPITAL Letter – Surname First

__________ year student having Enrollment No. _______________ has/have
II^nd

completed their Term work successfully and satisfactorily in the subject of

Mechanics of Solids [3130608] on Date___________ For the term ending
Date of Submitted

_____________________ in Civil Department.
Write the End Date of Term

Sign of Faculty

Date: _________________

Sign of Head of Department

Date: ______________________

# INDEX

| Expt. No: 1 | To Verify The Law of Parallelogram of Forces |
|---|---|
| Date: | |

**AIM: TO VERIFY THE LAW OF PARALLELOGRAM OF FORCES.**

**OBJECTIVES: -**

After completing the experiment you will be able to,

- Verify the Law of Parallelogram of Forces
- To interpret the relation between the Analytical and Graphical method.

**APPRATUS & EQUIPMENT:**

Parallelogram of forces Apparatus (Wooden board fixed to the wall with two frictionless pulleys), Pans and Weight box (or Slotted Weight and Hangers), Strings, Scale, pins& Drawing paper.

**THEORY:**

The law of parallelogram of forces states that if two forces acting at a point be represented in magnitude and direction by the adjacent side of a parallelogram, the diagonal of the parallelogram passing through the point of intersection represents the resultant force in magnitude and direction.

**PROCEDURE:**

1) Fix a drawing sheet on the board of the apparatus with the help of drawing pins.
2) Weight the pan carefully, note the weight of the pan
3) Pass two long string over the pulleys and attach pans at the end of string
4) Attach a third string with pan, at the joint of two strings
5) Place different weight in three pans. Wait till the pans come to rest.
6) Mark at least two point of the position of each thread.
7) Take at least three sets of reading record in tubular form.
8) Remove the drawing sheet and draw lines from the respective points marked.
9) Using suitable scale represent the weights on the respective lines.

10) Point ‘O’ represent the joint of all forces and ‘OA’, ‘OB’, ‘OC’ represents three forces to the Scale.

11) Complete the parallelogram ‘OABC’ and joint ‘OC’ which represents the resultant force.

**MATHEMATICALLY:**

If OA=P and OB=Q the angle between them is the resultant R is given by

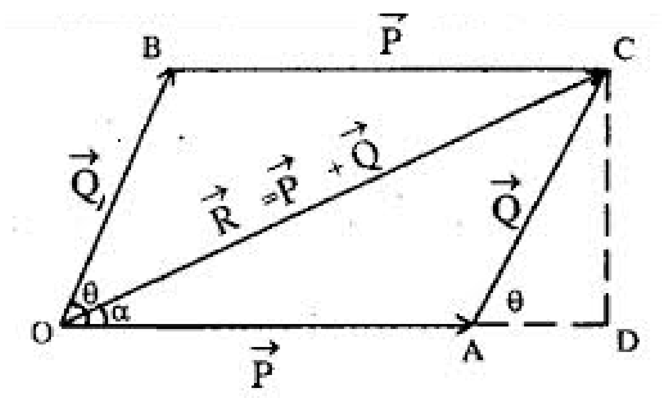
$$R = \sqrt{P^2 + Q^2 + 2PQ\ COS\theta\theta}$$

The angle between the resultant and force P

$$tan\alpha = \frac{Qsin\theta}{P + Qcos\theta}$$

**PRECAUTIONS:**

- The pulley should be free to move i.e. there should not be any friction in pulleys.
- Weight in pan should be placed gently.
- Position of forces should be marked carefully (at least two points should be marked)




Parallelogram Law of vectors

**OBSERVATION TABLE: -**

| # | Weight in PAN | | | Angle between P & Q ($\theta$) (Degree) | Value of Resultant Force (R) by | |
|---|---|---|---|---|---|---|
| | PAN – 1 + Weight of Pan (P) (gms) | PAN – 2 + Weight of Pan (Q) (gms) | PAN – 3 + Weight of Pan (R) | | Calculation (gms) | Graphically (gms) |
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |

**CALCULATION:**

**RESULT:**

**CONCLUSIONS**

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| **Expt. No:** 2<br>**Date:** | **Equilibrium Of Coplanar Concurrent Forces** |

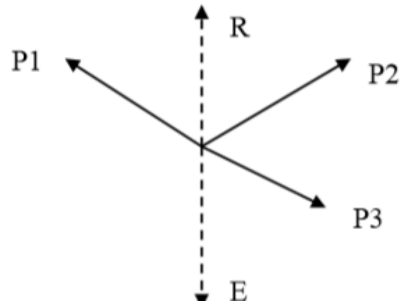
**AIM: To verify the conditions of equilibrium of a body under the action of coplanar- concurrent forces using universal force table by analytically and graphically. To find out resultant of coplanar concurrent force system by analytically and graphically.**

**APPARATUS REQUIRED:** Universal force table with Pulleys, Adjusting Foot Screw, Central Ring, Strings and Weights.

**Experimental set up**

## THEORETICAL BACKGROUND:

- **Coplanar force System:** All the forces of a system lie in the same plane**.**
- **Concurrent force System:** All the forces of a system pass through a common point or line of action of all the forces meets at one common point.
- **Equilibrium:** When there are number of forces acting on a particle/ body, then the particle /body is said to be in equilibrium if it is at rest condition under the application of forces.
- **Resultant (R):** A single force that is equivalent to a given force system or which can produce the same effect as the given force system on a rigid body, is called the resultant of the force system.




**(In 'R' is a single force that produce the effect on a rigid body same as the $P_1$, $P_2$ & $P_3$ produce the effect on a rigid body)**

- **Equilibrant (E):**

  The equilibrant of force system is a single force having its magnitude equal to that of the resultant of the force system but opposite in direction, and along the same line of action, so that when it is applied to the body, it brings the system in equilibrium.

  (In 'E' is the equilibrant force having the magnitude R of the force system but opposite in direction along the same line of action)

- **Equilibrium of System of forces:**

  If a system of forces acting on a particle is to be in equilibrium, the sum of components of each force in X and Y directions must be zero. I.e. when resultant of a force system acting on a particle is zero.

## ANALYTICAL METHOD / RESOLUTION OF FORCES:

The $P_1$, $P_2$, $P_3$, and $P_4$ are the four coplanar concurrent forces acting on a plate at an angle of $\theta_1$, $\theta_2$, $\theta_3$, and $\theta_4$ with respect to positive X-axis measured in anticlockwise direction then the magnitude of resultant is given by,

$$R^2 = (\sum F_x{}^2 + \sum F_y{}^2)$$

And its direction is given by,

$$\theta = \tan^{-1} (\sum F_y / \sum F_x)$$

Where,

$\sum F_x = P_1\cos\theta_1 + P_2\cos\theta_2 + P_3\cos\theta_3 + P_4\cos\theta_4 + \ldots\ldots\ldots\ldots\ldots$

($\sum F_x$ is summation of all forces along positive X-axis) (i.e. Horizontal component of forces)

$\sum F_y = P_1\sin\theta_1 + P_2\sin\theta_2 + P_3\sin\theta_3 + P_4\sin\theta_4 + \ldots\ldots\ldots\ldots\ldots$

($\sum F_y$ is summation of all forces along positive Y-axis) (i.e. Vertical component of forces)

**Analytical Conditions of Equilibrium for Coplanar Concurrent Force System:**

1. Algebraic sum of forces along X-axis must be zero. i.e. $\Sigma F_x = 0$
2. Algebraic sum of forces along Y-axis must be zero. i.e. $\Sigma F_y = 0$

(If the forces are in equilibrium then the value of resultant (R) is zero i.e. $\Sigma F_x = 0$ & $\Sigma F_y = 0$.)

## GRAPHICAL METHOD:

**Statement of Law of Polygon:**

**"When more than two coplanar and concurrent forces acting at a point are represented by the sides of a polygon taken in order, in direction and magnitude, the closing line of the polygon taken in opposite order, represents the resultant in direction and magnitude".**

Law of polygon is used to find the magnitude of unknown force graphically. Resultant of more than two coplanar concurrent forces can be found with the help of this law & for that first draw the space diagram and then draw the force polygon.

**Graphical Conditions of Equilibrium:** Force polygon should close which indicates that there is no motion of translation.

## ASSUMPTIONS:

1. Pulleys are frictionless.
2. Strings are knotless.

## PROCEDURE:

**A) To verify the condition of equilibrium for Coplanar Concurrent Force System:**

1. Level the Universal force table with the help of sprit level / adjusting foot screw.
2. Apply four known weights and adjust pulleys such that center of ring coincides with central pivot.
3. Note down the value of weights $P_1$, $P_2$, $P_3$ and $P_4$ & their respective angle $\theta_1$, $\theta_2$, $\theta_3$ and $\theta_4$ made by strings with the positive X-axis in anti-clock wise direction.
4. Repeat the procedure and take number of observations.
5. Check the condition of equilibrium.

**B) To find out resultant of coplanar concurrent force system:**

1. Clamp the pulleys at desired angles and apply four known weights.
2. Note down the value of weights $P_1$, $P_2$, $P_3$ and $P_4$ & their respective angle $\theta_1$, $\theta_2$, $\theta_3$ and $\theta_4$ made by strings with the positive X-axis in anti-clock wise direction.
3. Verify the magnitude and direction of resultant force by analytically &graphically.
4. Draw space diagram by drawing the angles as measured on force table and show the respective forces and give Bow's notations. Then draw force (vector) diagram with suitable scale to solve the problem graphically. Verify the magnitude and direction of resultant force by graphically and check the condition of equilibrium.

## OBSERVATION TABLE:

**To verify the condition of equilibrium for Coplanar Concurrent Force System:**

| Sr. No | Magnitude of Forces | | | | Anti clock wise angle w. r. t. Positive X– Axis (degree) | | | | $\Sigma F_x$ (gms) | $\Sigma F_y$ (gms) | Resultant 'R' (gms) | Graphically Resultant 'R' (gms) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $P_1$ (gm) | $P_2$ (gm) | $P_3$ (gm) | $P_4$ (gm) | $\theta_1$ | $\theta_2$ | $\theta_3$ | $\theta_4$ | | | | |
| 1 | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | |

## CALCULATIONS:

**RESULT: -**

**CONCLUSIONS**

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| Expt. No: | 3 | Equilibrium of Parallel Force System – Simply Supported Beam |
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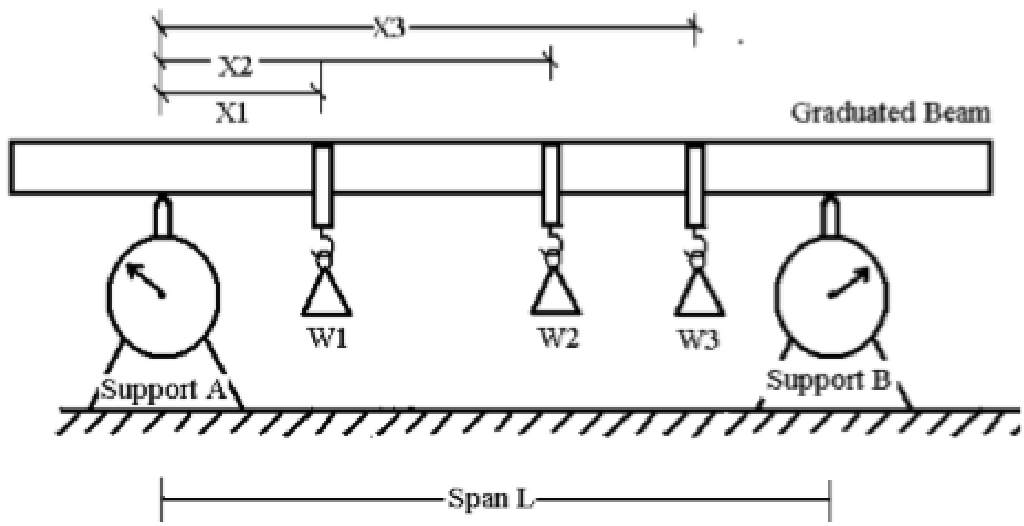
| Date: | | |

**AIM: To verify the conditions of equilibrium of a rigid body under the action of coplanar non-concurrent, parallel force system with the help of a simply supported beam.**

**To compared the values of the support reactions between Experimental, Analytical & Graphical.**

**APPARATUS REQUIRED:** Graduated beam, standard weights and hooks.

**Experimental set up:**




**Non-concurrent, Parallel forces are acting on a Simply Supported Beam**

**THEORETICAL BACKGROUND:**

- **Parallel Force System** : Forces which are acting parallel to each other in direction are called parallel force system.
- **Non-concurrent Force System** : Forces whose line of action not meets at a single point are called non-concurrent force system.
- **Beam** : is a structural member having cross-sectional dimensions very smaller than its length and is subjected to transverse loads (load acting perpendicular to the longitudinal axis of the beam).
- **Beam is an example of Coplanar Non-concurrent Force System under the equilibrium condition.**

### Analytical Conditions of Equilibrium for Coplanar Non-concurrent Force System:

1. Algebraic sum of forces along X-axis must be zero. i.e. ΣH=0.
2. Algebraic sum of forces along Y-axis must be zero. i.e. ΣV=0.
3. Algebraic sum of moments of forces about any point must be zero . i.e. ΣM=0.

### Graphical Conditions of Equilibrium:

1. Force polygon should close which indicates that there is no motion of translation.
2. Funicular polygon should close which indicates that there is no motion of rotation.

## CALCULATION OF SUPPORT REACTION:

### ANALYTICAL METHOD :

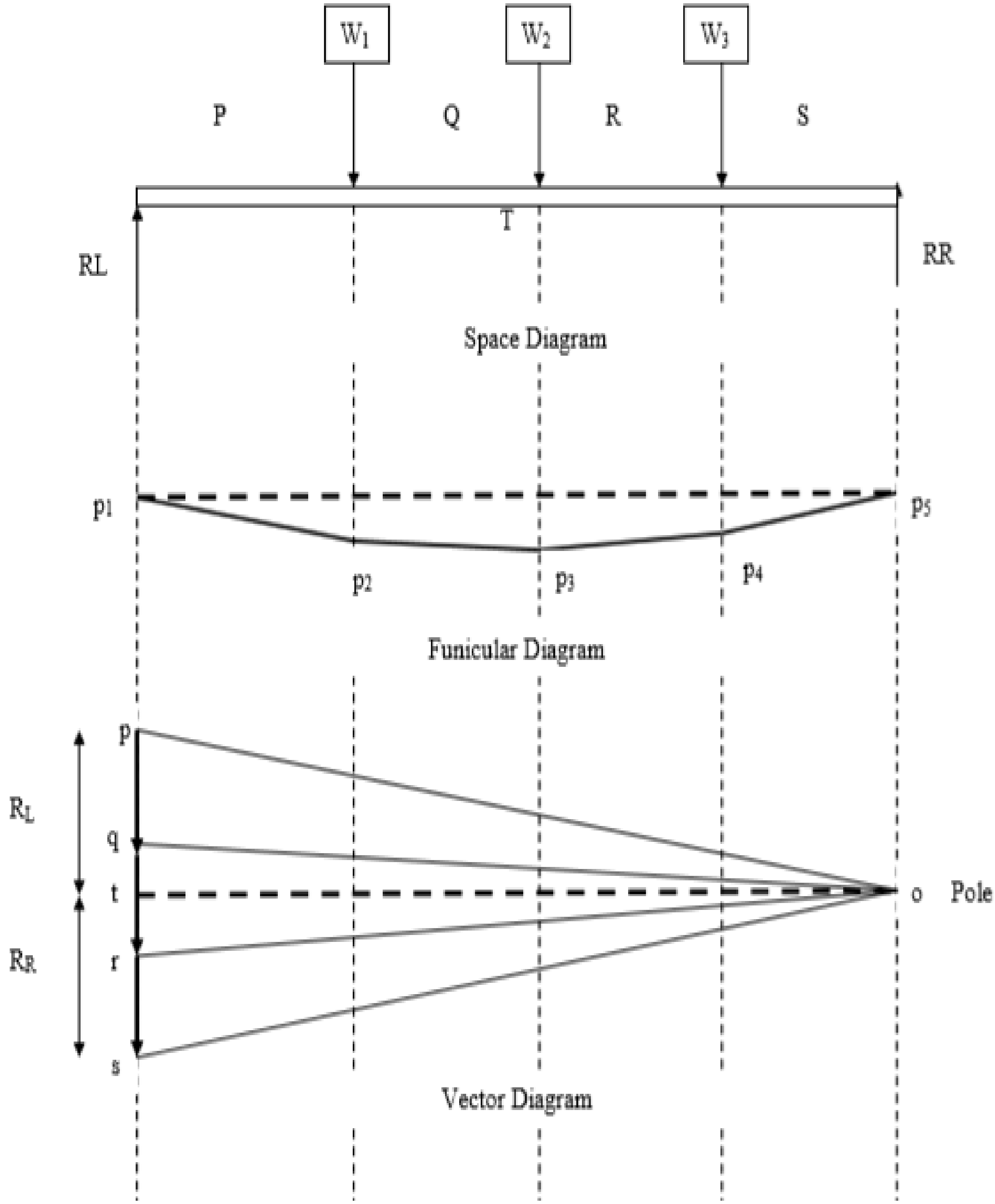
1. Apply ΣM @ any one support = 0 for finding the vertical support reaction at one support.
2. Apply ΣV=0 for finding the remaining vertical support reaction.
3. Apply ΣH=0 for finding the horizontal support reaction.

### GRAPHICAL METHOD:

1. Draw the space diagram of the beam, and name all the loads according to Bow's notation.

2. Construct Vector diagram. For that select some suitable point 'p' and draw 'pq' parallel and equal to load W1 to some scale. Similarly through 'q' draw 'qr' parallel and equal to load W2 and through 'r' draw 'rs' parallel and equal to load W3 to the scale. Select any suitable point 'o' and join 'op','oq', 'or' and 'os'.

3. Construct funicular diagram. For that select any point 'p1' on the line of action of the reaction 'RL'. Through 'p1' draw 'p1p2' parallel to 'op' intersecting the line of action of the load W1 at p2.Similarly, draw 'p2p3','p3p4 and 'p4p5' parallel to 'pq' , 'or' and 'os' respectively. Join p1 with p5 and through o draw a line 'ot' parallel to this line. Now the lengths 'tp' and 'st', in the vector diagram, give the magnitude of the reaction RL and RR respectively to the scale.


W1
W2
W3
P
Q
R
S
T
RL
RR
Space Diagram
p1
p5
p2
p3
p4
Funicular Diagram
p
q
t
r
s
RL
RR
o
Pole
Vector Diagram

## ASSUMPTIONS:

The set up of the dial gauge of apparatus has been done such that, the self weight of the beam is not to be considered in calculations.

## PROCEDURE:

1. Place the beam in its position on a selected value of the span.
2. Note down the initial readings shown by the spring balance at reaction points. Here, readings may be observed zero. Because the set up of the dial gauge of apparatus has been done such that, the weight of the beam will not to be observed.
3. Suspend several weights on the beam and note the magnitude of the loads and their distance from the left support.
4. Observe the readings shown by spring balance at the reaction points.
5. Calculate the experimental value of the support reactions by deducting initial readings from the final reading.
6. Verify the condition of equilibrium for the coplanar non-concurrent force system.
7. Calculate the values of the support reactions by analytically as well as graphically.

## OBSERVATION TABLE:

| # | Applied Load (gms) | | | Observation Reactions By Experimental | | | | Distance of Load From left Support | | | Length of Beam | ΣH | ΣV | ΣM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $W_1$ | $W_2$ | $W_3$ | $R_R$ | | $R_L$ | | $X_1$ (cm) | $X_2$ (cm) | $X_3$ (cm) | L (cm) | | | |
| | | | | Initial | Final | Initial | Final | | | | | | | |
| | | | | | | | | | | | | | | |
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## CALCULATIONS:

**To verify the condition of equilibrium for coplanar non-concurrent force system:**

**To Calculate Support Reaction By Analytically:**

**RESULT: -**

| # | Experimentally (gms) | | Analytically (gms) | | Graphically (gms) | |
|---|---|---|---|---|---|---|
| | $R_L$ | $R_R$ | $R_L$ | $R_R$ | $R_L$ | $R_R$ |
| | | | | | | |
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**CONCLUSIONS**

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| **Expt. No:** | **4** | **Determination of member forces in a triangular truss** |
| **Date:** | | |

**AIM:** Determination of member force in a triangular truss

**OBJECTIVE:** after completing this experiment we will be able to understand

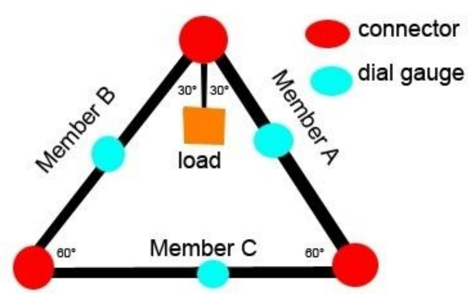
Types of nature of forces in loaded frame and

To compare them with theoretical values using roof truss apparatus.

**APPARATUS REQUIRED:**

Apparatus consists of triangular roof truss (Each member is fitted with a calibrated leaf spring balance), weights hangers, weights, measuring rape and divider for measuring angles

**Experimental set up:**




**THEORETICAL BACKGROUND:**

A truss is defined as a structure that is made of straight rigid bars joined together at their ends by pin or welding and subjected loads only at joints or nodal points. The assumptions made are

A. The truss is statically determinate

B. The loads are applied only at joints

C. Members are two force member

D. The weights of the members are negligibly small compared to the loads carried by the whole truss

We have the following necessary condition for stability

$$m + R = 2j$$

Where,

m = total number of truss members

j = total number of joints

R = number of reactions (equal to 3 generally)

The trusses may be of types.

a) Perfect Truss

b) Imperfect Truss.

An imperfect truss may be classified

i) Redundant

ii) Deficient

A truss is known as perfect or imperfect truss according to satisfy the condition for stability equation.

- m = 2j – R → Perfect Truss
- m > 2j – R → Redundant Truss
- m < 2j 0 R → Deficient Truss

Perfect Truss:

A perfect truss may be simply supported of cantilever type. The theoretical analysis of forces in mangnitude and is done by the following methods.

a) Methods of joints in which equilibrium conditions are ΣH=0, ΣV=0

b) Method pf section in which equilibrium conditions are ΣM=0

c) Graphical method (Maxwell's Method)

A roof truss can be examined by the resolution of forces (Joint Method). As it is simple arrangement therefore method of joint is better as it is quicker and easy method to find reactions in members of simple truss.

## TEST SET-UP:

A roof truss apparatus is hinged at one end and roller supported on the other end. There are two arms (rafter) named AB and AC. Both are pin-jointed at A. since the hinged end B cannot move, therefore arm AB is called "Fixed arm", while the arm AC is known as "Variable arm" because the roller end C can move away. Both arms AB and AC are equipped with spring mounted arrangement.

## PROCEDURE:

The stepwise procedure to conduct experiment is given as follows.

1. First of all, an external load "W" is apply at joint of fixed arm AB and variable arm AC. Consequently the arm AB and AC undergo deformation which can be noted from graduated scale.
2. Under the effect of external load "W" the roller support C moves rightwards. Hence the sring BC extends in length. Which indicates that BC has undergone tension. The tensile force is noted from the corresponding spring balance.

3. The applied load "W" is now changed t and the corresponding forces in AB and BC spring balance are measured each time.
4. Above experiment is repeated 4 to 5 times by changing the applied load and so on, and reading in AB and BC member are recorded each time.

## OBSERVATION TABLE:

| # | Load (W) | | Observed force (F) | | Theoretical force (F) | |
|---|---|---|---|---|---|---|
| | In kg | In N | In fixed arm (N) | In Variable arm (m) | In fixed arm (N) | In Variable arm (m) |
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## CALCULATIONS:

**RESULT: -**

**CONCLUSIONS**

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| Expt. No: | 5 | To Verify Velocity Ratio for Differential Wheel And Axle Apparatus |
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| Date: | | |

**AIM: TO STUDY THE MACHINE AND TO DETERMINE MECHANICAL ADVANTAGES, VELOCITY RATIO, FRICTION, THE LAW OF MACHINE, AND EFFICIENCY OF THE WHEEL AND DIFFERENTIAL AXEL.**

**APPRATUS & EQUIPMENT:** Differential Wheel and Axle apparatus, Weight set – 10 kg, 5 kg,1 kg, 500 gm, 250 gm…., Measuring Tape - 1 Nos., Pans - 2 Nos. etc……

**OBJECTIVE:** After completing this experiment student will be able

1. To understand concept of Mechanical Advantages, Velocity Ratio, Efficiency, Frictional Losses.
2. To derive equation of law of machine for wheel and differential axel
3. Differential reversible and non-reversible machine.

**THEORY:**

**DIFFERENTIAL WHEEL AND AXLE APPARATUS**

Wheel and differential axel is a simple machine which use in different forms in many of the machine parts to reduce the magnitude of effort to be applied.

This simple machine consist one effort wheel, one smaller axel, and one bigger axel. The rotation of effort wheel rotates both the axis. The rope is wound in such a manner that it wounds the bigger axel and simultaneously unwinds on the smaller axel. The load is raised by means of a attach block carried by the rope wound on the two axels and moved by the rope.

If,

X = Distance Moved By Load, Y = Distance Moved By Effort, W = Load To Be Lift, P = Effort To Applied

Than

$$Mechanical\ Advantages\ (M.A.) = \frac{\text{Load to be Lift (W)}}{\text{Effort to Applied (P)}}$$

$$Velocity\ Ratia\ (V.R.) = \frac{\text{Distance moved by Effort (Y)}}{\text{Distance Moved by Load (X)}}$$

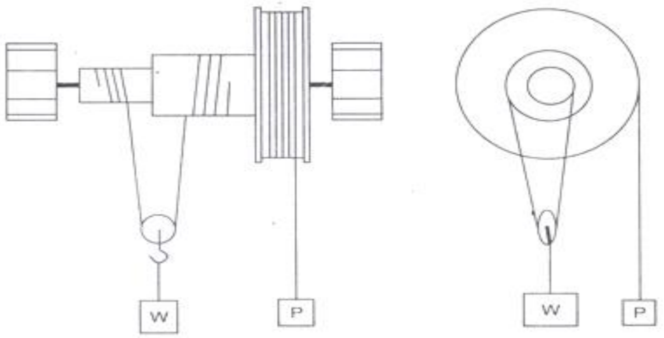
$$Efficiency\ of\ Machine\ (\acute{\eta}) = \frac{\text{Mechanical Advantage (M. A. )}}{\text{Velocity Ratia (V. R. )}} \text{ X } 100\%$$

$$Ideal\ Load\ (Wi) = \text{ Effort to Applied (P)} X\ Velocity\ Ratio$$

$$Load\ Loss\ in\ Friction\ (Wf) = Wi - W$$

$$Ideal\ Effort\ (Pi) = \frac{\text{Load to be Lift (W)}}{\text{Velocity Ratio (V. R. )}}$$

$$Effort\ Loass\ in\ Frction\ (Pf) = P - Pi = P - \frac{\text{Load to be Lift (W)}}{\text{Velocity Ratio (V. R. )}}$$




**PROCEDURE:**

1) Find velocity ratio using D, d1, d2, check the velocity ratio by measuring the distance moved effort and load from ground level in one revolution.

2) Weight the attach block and put a known weight in the pan

3) Go on adding fractional weight on effort end the applied weight is gently raised with uniform velocity.

4) Note effort and load repeat the above procedure for at least five readings.

5) Plot graph of W-P, and find law of machine p= mW+C

6) Calculation max efficiency and max mechanical advantages.

**OBSERVATION DATA: -**

1) Diameter Of the effort wheel (D) = ____________________________ mm

2) Diameter of bigger axel (d1) = _____________________________ mm

3) Diameter of smaller axel (d2) = _____________________________ mm

4) Velocity Ratio (V.R.) = (2 X D) = _________________________________ mm

**OBSERVATION TABLE: -**

| Sr No | Load W kg | Effort P kg | Initial Distance In (m) | | Final Distance | | Distance moved by load x = (L2-L1) | Distance moved by effort Effort y = (E2-E1) | Mechanical advantage MA=W/P | Velocity Ratio Vr=y/x | Efficiency (η) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Load pan (L1) | Effort pan (E1) | Load pan (L2) | Effort pan (E2) | | | | | |
| | | | | | | | | | | | |
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**CALCULATION:**

**RESULT:**

**CONCLUSION:**

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| **Expt. No:** | **6** | **To Verify Velocity Ratio For Single Purchase Crab** |
|---|---|---|
| **Date:** | | |

**AIM: TO STUDY THE MACHINE AND TO DETERMINE MECHANICAL ADVANTAGE, VELOCITY RATIO,**

**FRICTION, THE LAW OF MACHINE AND EFFICIENT OF THE SINGLE PURCHASE CRAB.**

**APPRATUS & EQUIPMENT:** Single purchase crab machine, Weight set-10 kg, 5 kg, 500 gm, 250 gm…., Measuring Tape - 1 Nos., Pans - 2 Nos.

**OBJECT:** After completing this experiment, student will be able

a. To understand concept of M.A, V.R, efficiency, frictional losses
b. To derive equation of law of machine for wheel and differential axel
c. Different reversible and non- reversible machine.

**THEORY:**

**SINGLE PURCHASE CRAB**

Single purchase crab is a simple machine which use for lifting out water well, in electric cranes for reducing the speed etc.

Single purchase crab consist a load drum, a effort wheel, one spur wheel and one pinion the rotation of the effort wheel or handles moves the pinion which gears with the spur wheel and the load is raised by the rope wound on the axel of spur wheel.

If,

X = Distance Moved By Load, Y = Distance Moved By Effort, W = Load To Be Lift, P = Effort To Applied

Than

$$Mechanical\ Advantages\ (M.A.) = \frac{\text{Load to be Lift (W)}}{\text{Effort to Applied (P)}}$$

$$Velocity\ Ratia\ (V.R.) = \frac{\text{Distance moved by Effort (Y)}}{\text{Distance Moved by Load (X)}}$$

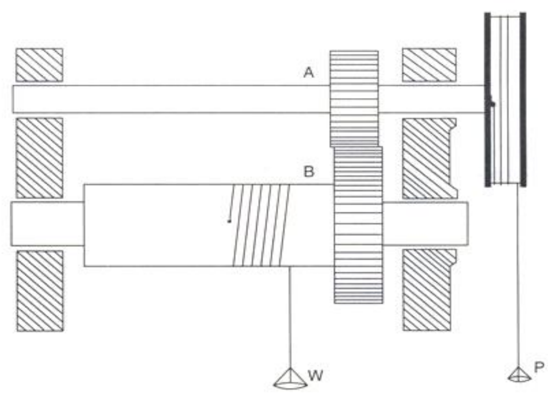
$$Efficiency\ of\ Machine\ (\acute{\eta}) = \frac{\text{Mechanical Advantage (M.A.)}}{\text{Velocity Ratia (V.R.)}}\ \text{X 100\%}$$

$$Ideal\ Load\ (Wi) = \text{ Effort to Applied (P)} X\ Velocity\ Ratio$$

$$Load\ Loss\ in\ Friction\ (Wf) = Wi - W$$

$$Ideal\ Effort\ (Pi) = \frac{\text{Load to be Lift (W)}}{\text{Velocity Ratio (V.R.)}}$$

$$Effort\ Loass\ in\ Frction\ (Pf) = P - Pi = P - \frac{\text{Load to be Lift (W)}}{\text{Velocity Ratio (V.R.)}}$$




**PROCEDURE:**

1) Find velocity ratio using D, d, T1, T2. Check the velocity ratio by measuring the distance moved by effort and load from ground level in one revolution.

2) Weight the attach block and put a known weight in the pan.

3) Go on adding fractional weight on effort end so that the applied weight is gently raised with uniform velocity.

4) Note effort and repeat the above procedure for at least five readings.

5) Plot graph of W- P , and find law of machine P = mW+C

6) Calculation max efficiency and max mechanical advantage.

**OBSERVATION DATA: -**

1) Diameter Of the effort wheel (D) = ________________________________ mm

2) Diameter Of the load drum (d) = ______________________________________ mm

3) No. of teeth on pinion (T1) = ______________________

4) No. of teeth on spur wheel (T2) = _____________________

5) Velocity ratio = (D X T2) / (d X T1)

**OBSERVATION TABLE: -**

| Sr No | Load W kg | Effort P kg | Initial Distance In (m) | | Final Distance | | Distance moved by load x = (L2-L1) | Distance moved by effort Effort y = (E2-E1) | Mechanical advantage MA=W/P | Velocity Ratio Vr=y/x | Efficiency (η) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Load pan (L1) | Effort pan (E1) | Load pan (L2) | Effort pan (E2) | | | | | |
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**CALCULATION:**

**RESULT:**

**CONCLUSION:**

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| **Expt. No:** 7<br>**Date:** | **To Verify Velocity Ratio For Double Purchase Crab** |

**AIM: TO STUDY THE MACHINE AND TO DETERMINE MECHANICAL ADVANTAGE, VELOCITY RATIO,**

**FRICTION, THE LAW OF MACHINE AND EFFICIENT OF THE DOUBLE PURCHASE CRAB.**

**APPRATUS & EQUIPMENT:** Double purchase crab machine, Weight set-10 kg, 5 kg, 500 gm, 250 gm…., Measuring Tape - 1 Nos., Pans - 2 Nos.

**OBJECT:** After completing this experiment, student will be able

d. To understand concept of M.A, V.R, efficiency, frictional losses
e. To derive equation of law of machine for wheel and differential axel
f. Different reversible and non- reversible machine.

**THEORY:**

**DOULE PURCHASE CRAB**

Double purchase crab is a simple machine which use for lifting out water well, in electric cranes for reducing the speed etc.

The apparatus consists of two pairs of spur gear and pinion, alternately meshing each other. The effort wheel is mounted over the shaft of first pinion and load axle is mounted over the shaft of second spur gear.

If,

X = Distance Moved By Load, Y = Distance Moved By Effort, W = Load To Be Lift, P = Effort To Applied

Than

$$Mechanical\ Advantages\ (M.A.) = \frac{\text{Load to be Lift (W)}}{\text{Effort to Applied (P)}}$$

$$Velocity\ Ratia\ (V.R.) = \frac{\text{Distance moved by Effort (Y)}}{\text{Distance Moved by Load (X)}}$$

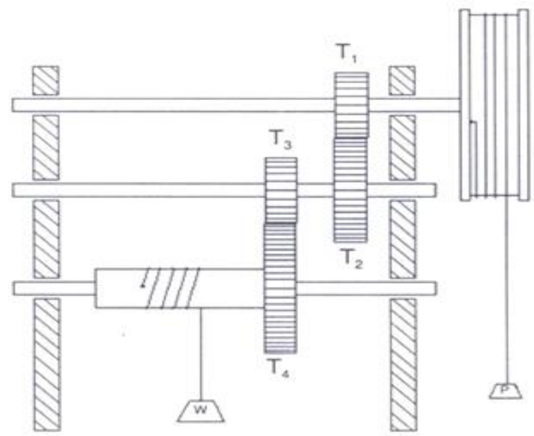
$$Efficiency\ of\ Machine\ (\acute{\eta}) = \frac{\text{Mechanical Advantage (M. A.)}}{\text{Velocity Ratia (V. R.)}} \text{ X } 100\%$$

$$Ideal\ Load\ (Wi) = \text{ Effort to Applied (P)} X\ Velocity\ Ratio$$

$$Load\ Loss\ in\ Friction\ (Wf) = Wi - W$$

$$Ideal\ Effort\ (Pi) = \frac{\text{Load to be Lift (W)}}{\text{Velocity Ratio (V. R.)}}$$

$$Effort\ Loass\ in\ Frction\ (Pf) = P - Pi = P - \frac{\text{Load to be Lift (W)}}{\text{Velocity Ratio (V. R.)}}$$




**PROCEDURE:**

1) Lubricate all bearings and contact surfaces well before performing the experiment.
2) Wind string on effort wheel and load drum separately. Arrangement should be such that when effort string end is brought down, load string end must go up.
3) Put some weight at the end of load string. Now put some weight in pan at effort end.
4) Go on increasing this weight till the effort pan, moves down.
5) Repeat five times the above procedure.
6) Calculate MA, VR, N, n, pf, wf.
7) Dr aw graph W-p, W-MA, W-n, W-pf and formulate law of machine.

**OBSERVATION DATA: -**

1) Diameter Of the effort wheel (D) = **232.4** mm
2) Diameter Of the load drum (d) = **66.8** mm
3) No of teeth on pinion (T1) = 20
4) No of teeth on spur wheel (T2) = 100
5) No of teeth on pinion (T3) =20
6) No of teeth on spur wheel (T4) = 100
7) Velocity ratio (V.R.) = (T2 X T4 X D) / (T1 X T3 X d)

**OBSERVATION TABLE: -**

| Sr No | Load W kg | Effort P kg | Initial Distance In (m) | | Final Distance | | Distance moved by load x = (L2-L1) | Distance moved by effort Effort y = (E2-E1) | Mechanical advantage MA=W/P | Velocity Ratio Vr=y/x | Efficiency (η) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Load pan (L1) | Effort pan (E1) | Load pan (L2) | Effort pan (E2) | | | | | |
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**CALCULATION:**

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| Expt. No: | 8 | To Determine the Compressive Strength of the different Specimen. |
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| Date: | | |

**AIM: TO DETERMINE THE COMPRESSIVE STRENGTH OF MATERIALS SUCH AS MILD STEEL, CAST IRON, TIMER, BRICKS AND STUDY THEIR BEHAVIOR WHEN SUBJECT TO COMPRESSIVE LOAD UP TO FRACTURE.**

**APPRATUS & EQUIPMENT:** Universal Testing Machine, Foot rule, Vernier caliper.

**MATERIAL: Mild Steel Bar, cast Iron Bar, Timber and Brick**

**OBJECT:** After completing this experiment, student will be able

a. To understand concept of behavior of material under the Compressive load.
b. To known to load carrying capacity of material under the compressive load.
c. To understand the different types of failure of materials under compressive load.

**THEORY:**

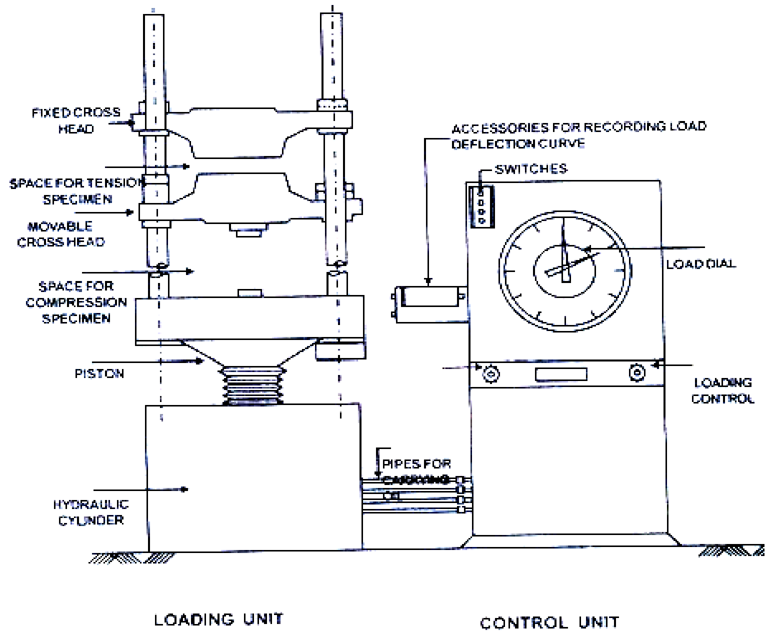
Generally brittle materials are having quite high compressive strength compared to its tensile strength. Brittle materials are such as materials which when subjected to tensile force, fail without considerable elongation because of its very low proportional limit.

The metal failed under the Compressive load either by bulging, Shearing or buckling. It depends upon the brittleness or ductility of metal. Generally bricks, stones, glass, concrete, etc. the compressive strength mainly depends on the slenderness ratio of the specimen.

***Slenderness Ratio*** is the ratio of effective length to minimum radius of gyration or least dimension of the specimen. If S.R. is less the compressive strength will be less. If S.R. is more, bending or buckling of the specimen will take place. The specimen is tested for its compressive strength only hence it should be in pure compression and no bending stress should developed. To satisfy this length to the Diameter ratio is generally kept up to two.

If (L / D) - ratio is more the ductile material. It will fail in the form of buckling and

If the (L / D) - ratio is less the metal specimen. It will fail by bulging under compressive load.




**PROCEDURE:**

**(A) PRELARATION OF SAMPLE BRICKS:**

1. Remove unevenness observed in the bed face to provide two smooth and parallel faces by grinding.
2. Immerse cement the sample in water at room temperature for 24 hours.
3. Prepare cement mortar (1:1) and fill the frog and all voids in the bed faces with it.
4. Store the sample prepared for 2 hours.

**(B) TESTING:**

1. Put the specimen of mild steel in the machine and apply the load gradually on it. Stop the loading when first cracks is observed on the surface of the specimen or it breaks.
2. Repeat for cast iron and for timer (parallel to the grain and perpendicular to grain)
3. Find out stress on each specimen in N/mm2.
4. Draw figures of specimen before and after testing.

**OBSERVATION TABLE: -**

| Sr.No. | Material | Size | Area ($mm^2$) | Load at Failure (N) | Compressive Strength ($N/mm^2$) |
|---|---|---|---|---|---|
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**CALCULATION:**

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**CONCLUSION:**

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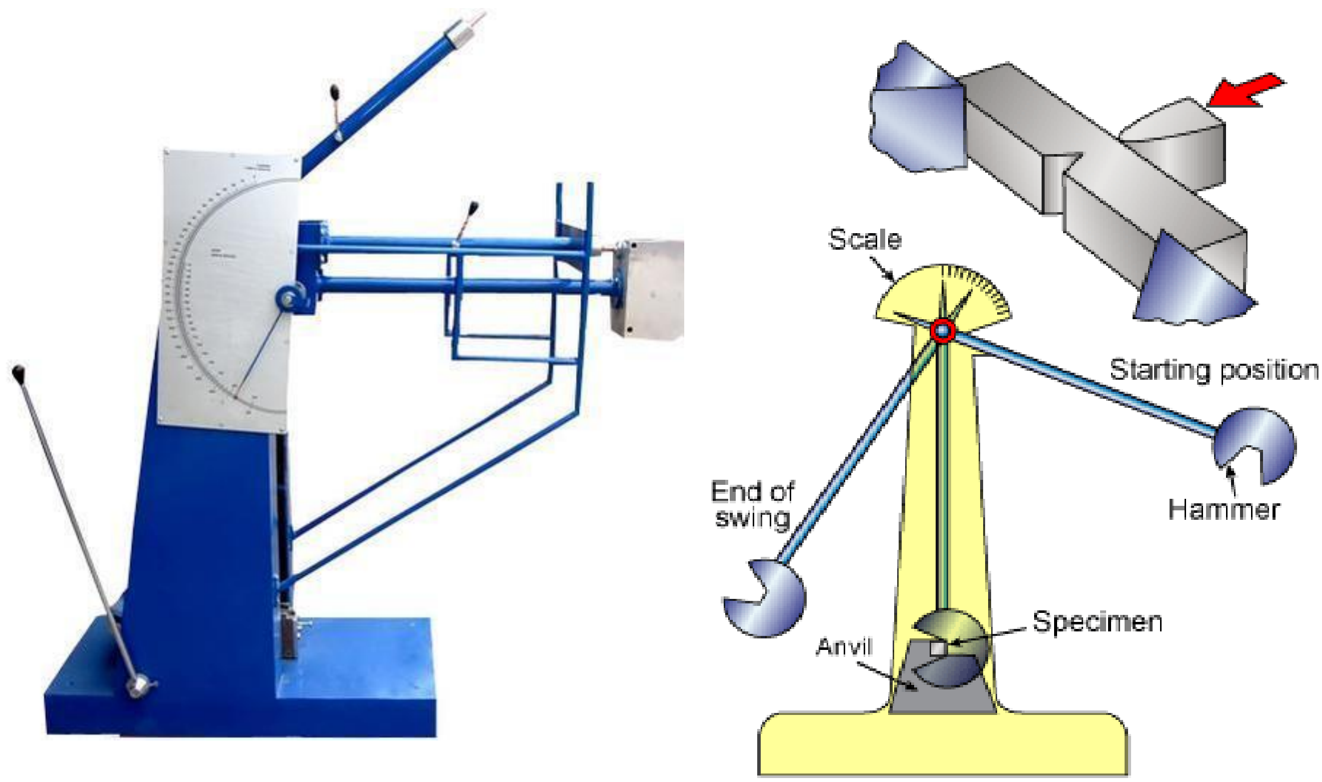
| **Expt. No:** | **9** | **Izod Impact Test** |
| **Date:** | | |

**AIM: To study the behavior of metals under impact load.**

**EQUIPMENT:** Izod Impact Testing Machine.




**Izod Impact Test Machine**

**SPECIMEN:** Mild steel, Aluminum and Brass.

**RELATED I.S. CODE: IS:** 1598 – 1997, Methods for Izod impact test on metals.

**THEORETICAL BACKGROUND:**

Impact loading suddenly applied force which must be absorbed by material. The test is particularly applicable for the ductile materials, as they can easily absorb the impact energy in a better way and in more amounts, whereas brittle materials are susceptible to break under impacts. Hence the test is not suitable for such material.

At ordinary temperature, a plain bar of ductile metal will not fracture under impact load in flexure. So a notched specimen is used. The use of notch causes high localized stress concentration. Which impact blow may be delivered though the use of

(i) Dropping weight (ii) Swinging pendulum and (iii) Rotation fly wheel

**SPECIMEN:** Specimen with notch at suitable position is used for carrying out the impact test on metals. For steel specimen, requirement is as follow:

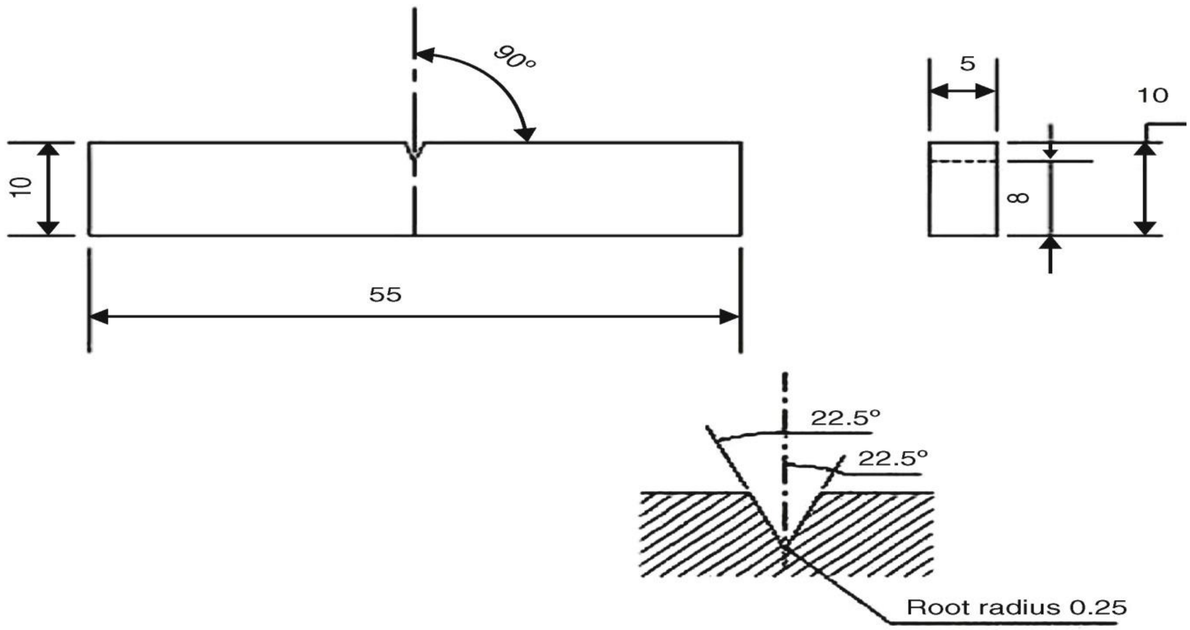



**Fig. Single Notch Square Specimen for Izod Impact Test Confirming to I.S. 1958 – 1960**

**PROCEDURE:**

1. Check the specimen for I. S. requirements.
2. Fix up the specimen tightly in the anvil that the longitudinal axis of the piece lies in the plane of swinging of swinging of hammer.
3. The notch will be positioned such that he plane of symmetry of notch coincides with the top surface of the grips.
4. Set the pointer to read the energy f the blow of the pendulum.
5. Release the pendulum and allow it to strike the test piece. Read indicator and from this reading deduct the energy lost and thus find out the impact value of specimen.
6. Study the fracture.

**PRECAUTIONS:**

1. It is not advisable to stand near or in front of the machine when the pendulum is to released.
2. Notch should be exactly in the line of action of the pendulum.
3. When specimen is being fitted, care should be taken that pendulum does not get released.

**APPLICATIONS:**

1. This test is basically designed so as to check the suitability of materials subjected to dynamic loads, e.g., vehicles traveling over bridges, hull of sheep subjected to waves or hammer falling on nail.
2. The ductile material like steel has more impact value and therefore has wide acceptability in structural and other mechanical application.

**LIMITATIONS**:

1. Energy lost due to friction between hammer and air bearing friction in indicator and pendulum is neglected.
2. To determine the impact resistance temperature should be between $32^0$ c to $38^0$c because temperature has a very marked effect on impact resistance of notched bar.

**OBSERVATION TABLE**:

| Sr. No. | Material | Energy Losses (J) | Impact Value (N m) | Mode of Failure |
|---|---|---|---|---|
| 1. | Mild Steel | | | |
| 2 | Aluminum | | | |
| 3. | Brass | | | |

**CONCLUSIONS**

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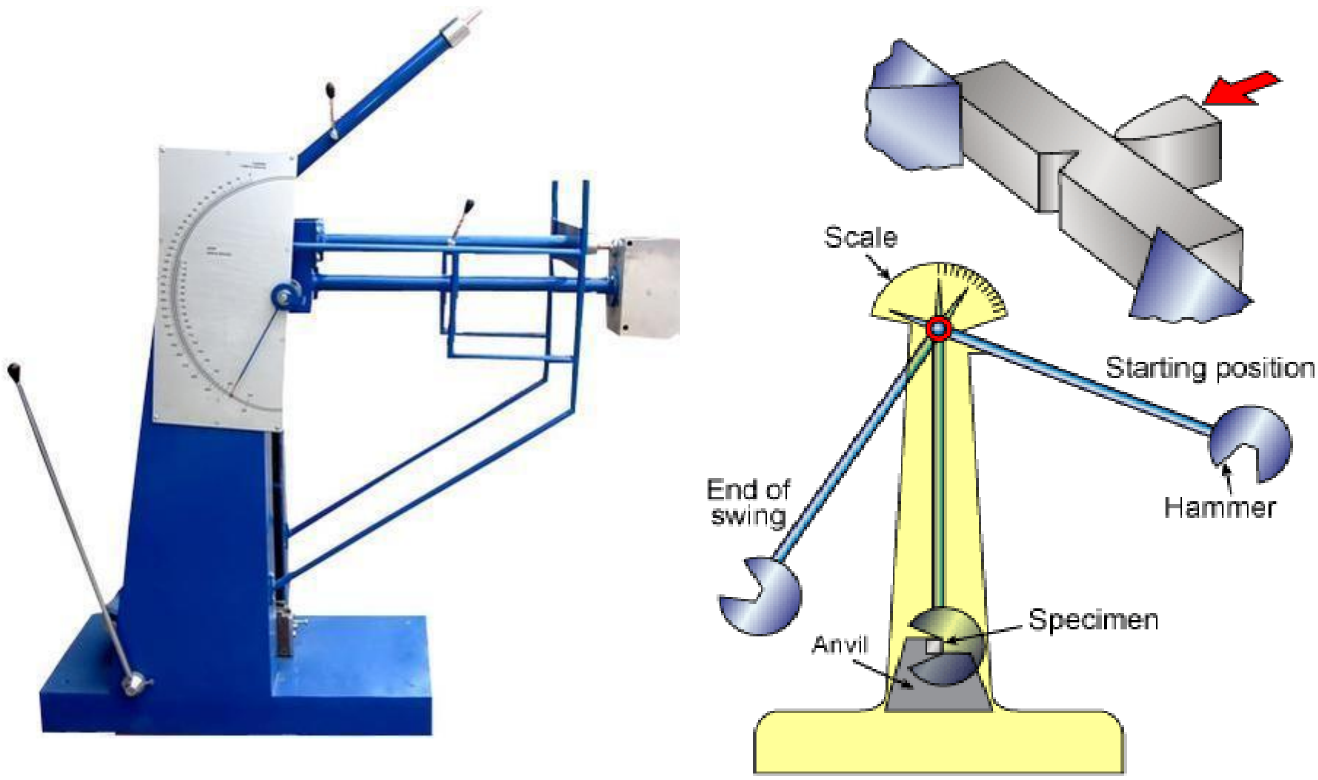
**Expt. No:** **10**

**Date:**

# CHARPY IMPACT TEST

**AIM: To study the behavior of metals under impact load.**

**EQUIPMENT:** Charpy Impact Testing Machine.




**Charpy Impact Test Machine**

**SPECIMEN:** Mild steel, Aluminum and Brass.

**RELATED I.S. CODE: IS:** 1598 – 1997, Methods for Charpy impact test on metals.

## THEORETICAL BACKGROUND:

Impact loading suddenly applied force which must be absorbed by material. The test is particularly applicable for the ductile materials, as they can easily absorb the impact energy in a better way and in more amount, whereas brittle materials are susceptible to break under impacts. Hence the test is not suitable for such material.

At ordinary temperature, a plain bar of ductile metal will not fracture under impact load in flexure. So a notched specimen is used. The use of notch causes high localized stress concentration. Which impact blow may be delivered though the use of

(i) Dropping weight (ii) Swinging pendulum and (iii) Rotation fly wheel

**SPECIMEN:** Specimen with notch at suitable position is used for carrying out the impact test on metals. For steel specimen, requirement is as follow:

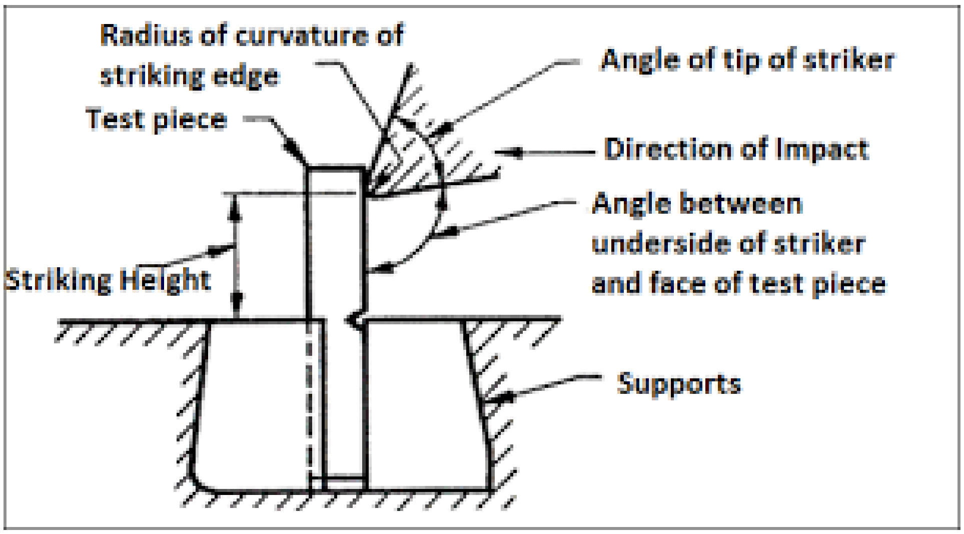



**Fig. Single Notch Square Specimen for Charpy Impact Test Confirming to I.S. 1958 – 1960**

**PROCEDURE:**

1. Check the specimen for I.S. requirements.
2. Fix up the specimen tightly in the anvil that the longitudinal axis of the piece lies in the plane of swinging of swinging of hammer.
3. The notch will be positioned such that he plane of symmetry of notch coincides with the top surface of the grips.
4. Set the pointer to read the energy f the blow of the pendulum.
5. Release the pendulum and allow it to strike the test piece. Read indicator and from this reading deduct the energy lost and thus find out the impact value of specimen.
6. Study the fracture.

**PRECAUTIONS:**

1. It is not advisable to stand near or in front of the machine when the pendulum is to released.
2. Notch should be exactly in the line of action of the pendulum.
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**APPLICATIONS:**

1. This test is basically designed so as to check the suitability of materials subjected to dynamic loads, e.g., vehicles traveling over bridges, hull of sheep subjected to waves or hammer falling on nail.
2. The ductile material like steel has more impact value and therefore has wide acceptability in structural and other mechanical application.

**LIMITATIONS**:

1. Energy lost due to friction between hammer and air bearing friction in indicator and pendulum is neglected.
2. To determine the impact resistance temperature should be between $32^0$ c to $38^0$c because temperature has a very marked effect on impact resistance of notched bar.

**OBSERVATION TABLE**:

| Sr. No. | Material | Energy Losses (J) | Impact Value (N m) | Mode of Failure |
|---|---|---|---|---|
| 1. | Mild Steel | | | |
| 2 | Aluminum | | | |
| 3. | Brass | | | |

**CONCLUSIONS**

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