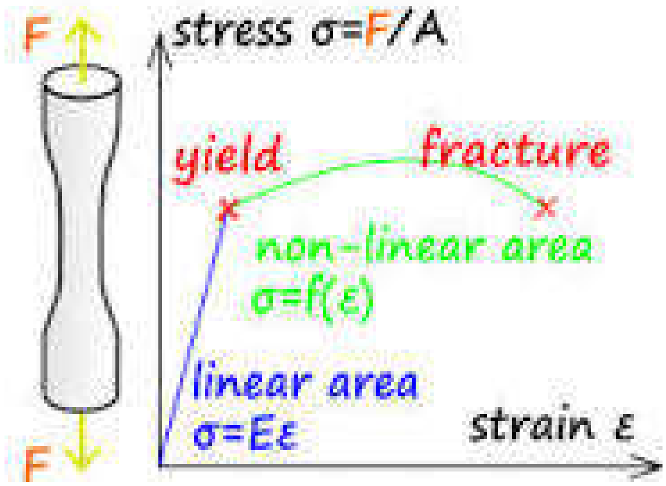
Definition of Mechanics of Materials:-

Strength of materials, also called **mechanics of materials**, is a subject which deals with the behavior of solid objects subject to stresses and strains.



List of Experiments Performed in Strength of materials Lab:

1. Layout of strength of materials lab.

2. Study of small instruments.

3. To perform direct shear test on plain steel bars and punching shear test on plate.

4. To carry out compression test on wooden cubes when load is applied parallel to grains and perpendicular to grains.

5. To perform tension test on deformed steel bars.

6. To perform tension test on steel bars using shemardow Rockwell hardness testing machine.

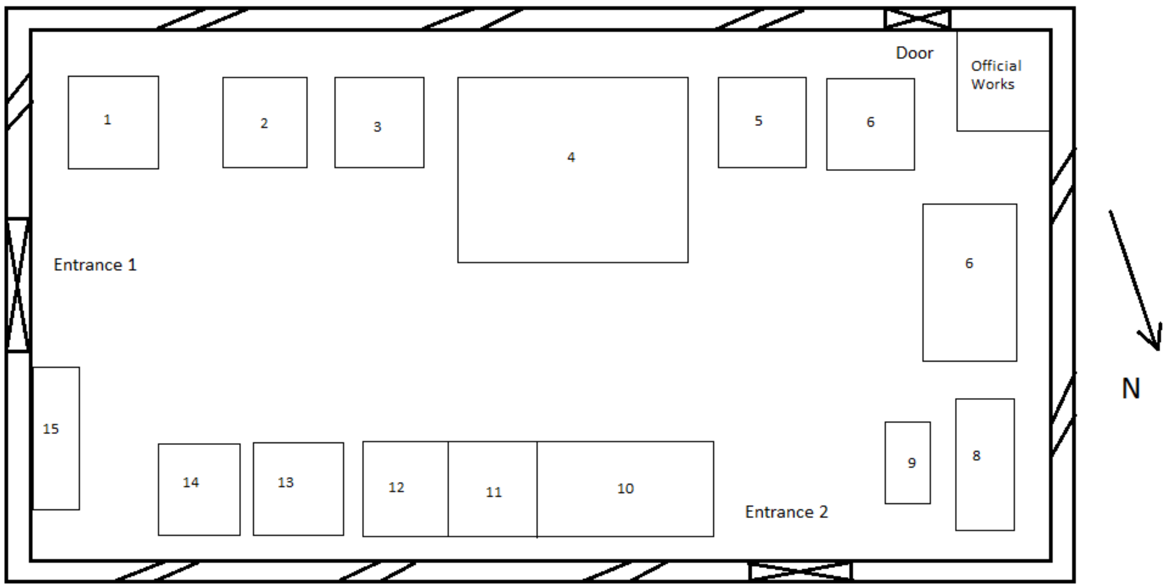
7. To perform bending test on wooden beam.

8. To perform impact test on different steel sample.

Job # 1:

Statement:

To prepare layout of strength of materials lab.



1. 10 ton Buckton UTM
2. Denison UTM
3. Shimadzu UTM
4. Tables and chairs/ class sitting
5. Avery torsion machine
6. Charpy impact testing machine
7. 100ton buckton UTM
8. Models of structures
9. Sitting chair and table
10. Trusses models
11. Avery Rockwell hardness testing machine
12. Gauge tools
13. Shimardzu fatigue testing machine
14. Brinal hardness testing machine
15. Bricks models

Description:

10 ton Buckton UTM:

A universal testing machine can perform the compression, tension and bend test.

Uses:

It can be used for tension and shear test.

Least count: 0.01 ton

Denison UTM:

Uses: It can be used for testing compression, tension and bending.

Least count: It has different scale. If scale will be 10 tons then least count will be 0.01tons.

The lower part is fixed and the upper part will be movable.

Shimadzu UTM:

Uses: It can be used for testing compression, tension and bending.

Its maximum capacity will be **500kN.**

It has 6 scales:

- 10kN L.C = 0.01 per div
- 25 kN L.C = 0.025 per div
- 50 kN L.C = 0.05 per div
- 100 kN L.C = 0.10 per div
- 250 kN L.C = 0.25 per div
- 500 kN L.C = 0.5 per div

Avery torsion machine:

Uses: It is used to perform torsion tests.

It has fixed head and twisting head.

Manufacturer is W & t Avery Ltd Birmingham England.

Scales:

It has four different scales

- 0-1500 pound inch
- 0-3000 pound inch
- 0-7500 pound inch
- 0-15000 pound inch

Charpy impact testing machine:

Impact load:

Sudden application of significant magnitude of load for a very short interval of time.

It can perform test under two conditions:

Tension

Bending

Capacity: Its capacity is 0-170 degree.

It is operated manually.

<u>100 ton Buckton UTM:</u>

The manufacturer is Buckton Manufacturer.

Capacity: Its maximum capacity is 200000 lbs

And 1ton = 2000lb

<u>Models:</u>

Models of different includes plate girders and beck bridges.

Truss models:

It includes fink roo truss, bridge truss and joints of trusses.

Rockwell Hardness testing machine:

Hardness:

Resistance to plastic deformation or penetration is known as hardness.

Manufacturer is W & T Avery Ltd Birmingham England.

Mostly two types of penetrations are used:

- Steel ball 1/16 in diameter for low carbon steel
- Diamond cone for high carbon steel

Brinell hardness testing machine:

This machine is used to measure the hardness of the material.

Shimadzu fatigue testing machine:

Fatigue: Repeating loading which causes reversal of stresses in material is called fatigue.

Job #: 2

Statement:

Study of instruments in strength of materials lab.

Objective :

The main objective of this job is to make students well aware of instruments they will be using in their field and specially in mechanics of materials lab.

Instruments :

1-Vernier scale

2-Screw gauge

3-Spring divider

4-Dial gauge

5-Deflection gauge

6-Baty's extensometer

7-Internal caliper

8-Outside caliper

Description:

Vernier scale :

This device is used to measure internal , external diameters and depths. It has two scales , one is main scale and other is vernier scale . least count of this instrument is 0.05mm . it has two jaws lower jaws for measuring external diameters and lengths and upper jaws are for internal diameters .

Method : check the zero error if so note it . measure the diameters and lengths using upper and lower jaws and note down the reading and apply correction.

Screw gauge :

This device is used to measure internal diameters . It has two scales , one is main scale and other is circular scale . least count of this instrument is 0.01mm . it has a rotating screw which is used to open and close jaws for measuring external diameters.

Method : check the zero error if so note it . measure the diameters and note down the reading and apply correction.

Spring divider :

This device is used to measure lengths and internal diameters . In ancient days this instrument was used to measure length instead of ruler or measuring tapes.

Method : we loose the jaws first by rotating screws in anticlockwise direction and place inside / outside the pipe whose internal / external diameter is to measured and tight the jaws than , after that we measure the dimensions by placing divider's pointing jaws on scale.

Baty's extensometer :

This instrument is used to measure extension in the bars. The least count of this instrument is 0.001mm .

Method : we place bar in jars of this device and than tight it with the help of screws and apply load on the both sides and extension measured using this device.

Inside caliper :

This instrument is used to measure internal diameters of any pipe tube etc.

Method : we loose the jaws first by rotating screws in anticlockwise direction and place inside the pipe whose internal diameter is to measured and tight the jaws than , after that we measure the dimensions by placing calliper's pointing jaws on scale.

Outside caliper :

This instrument is used to measure external diameters of any pipe tube etc.

Method : we loose the jaws first by rotating screws in anticlockwise direction and place outside the pipe whose external diameter is to measured and tight the jaws than , after that we measure the dimensions by placing calliper's pointing jaws on scale.

Deflection gauge :

This device is used to measure any deflections in beams or slabs etc. least count of this device is 0.001" . this device is available in both manually operated and electrically operated system. .

Method : place the gauge under a member in which bending deflection is to measured and apply a load , after some time note down the reading on gauge in inches.

Deflection = L.C * divisions

Dial gauge :

This gauge is also used to find deflections. Its least count is 0.0025” and it is manually operated.

Method : place the gauge under a member in which bending deflection is to measured and apply a load , after some time note down the reading on gauge in inches.

Deflection = L.C * divisions

Job # 3

Statement:

To perform the direct shear test on plain steel bars and punching shear test on plates.

Objective:

- To know about the performance of plain steel bars when direct shear test is applied.
- To know about the performance of steel plate when punching shear test is applied.

Related theory:

Shear stress:

Shear stress is a stress state where the stress is parallel to the surface of the material, as opposed to normal stress when the stress is vertical to the surface

Types: It may be following two types

Direct shear stress:

The test which is used to measure the shear strength properties of soil or rock material, or of discontinuities in soil or rock masses or metal structures.

It may be :

- **Single shear stress**

Single shear stress = $\frac{Force}{Area}$

- **Double shear stress**

Double shear stress=$\frac{Force}{2\ X\ Area}$

Induced shear stress:

Shearing stress induced due to a force which acts at an angle to the area being sheared is called induced shear stress.

Procedure:

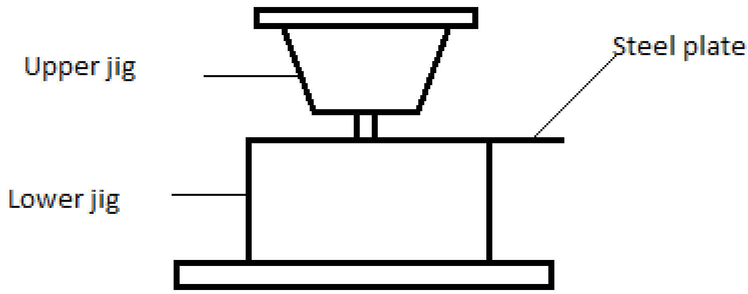
Steel bar

Take the samples of plane steel bars first. Place it between the jaws of the UTM. Then operate the machine. Operation of the machine will be manual. One person will rotate the wheel, while the other person will be focusing on the scale. Then we starts applying the load on steel bar.

The moment where it breaks, we have to note the reading very carefully. Because a jerk will occur and may cause error in noting the reading. Then note the reading and put the values in the tables. Calculate the shear strength first in the steel bars.

Steel plate:

In the same way place the testing steel plate in another UTM. And apply the load . note the reading when it breaks. Put this value of load in table and find the shear strength for steel plate in the same way.



OBSERVATIONS AND CALCULATIONS:

For steel bar

Sr #.	Test sample	Shear load		Diameter (mm)			Average Diameter	Area	Shear strength	
		Tons	N	D_1	D_2	D_3	(mm)	(mm^2)	Mpa	Psi
1	Steel bar	1.073	9550	6.5	6.55	6.7	6.58	34.03	280.84	40733.2

For steel plate

Sr #.	Test sample	Shear load		Diameter (mm)		Average Diameter	Plate thickness	Area	Shear strength	
		Tons	N	D_0	D_1	(mm)	(mm)	(mm^2)	Mpa	Psi
1	Steel bar	2.6	23140	14.9	15.2	15.05	2.1	9.28	233.06	33803.3

Precuations:

- Note the reading carefully
- Jerk may cause error in noting
- Reduce personal error by keeping eye in the front of scale

Result:

The direct shear strength of bar = 40733.2 Psi

The punching shear strength of plate = 33803.3 Psi

Job # 4

Statement:

To carry out compression test on wooden cubes when load is applied

i) Parallel to grains
ii) Perpendicular to grains

Objective:

To know about effect of compression test on wooden cubes in two different orientations.

Related Theory:

Modulus of elasticity: The ratio of the stress applied to a body or substance to the resulting strain within the elastic limit also called elastic modulus.

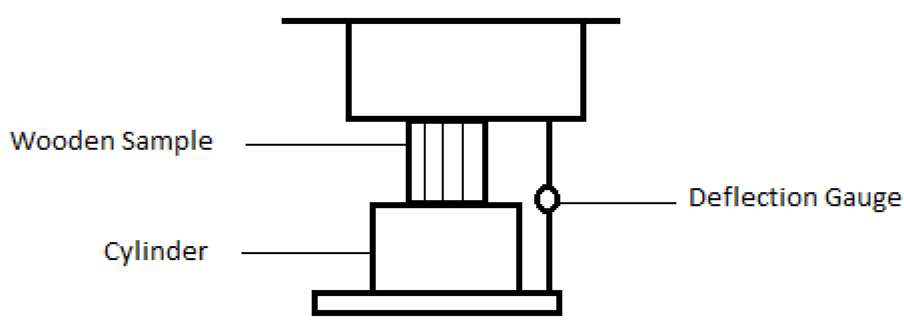
Modulus of stiffness: Force required to produce deformation is called modulus of stiffness.

Stress: Force per unit area is called stress.

Strain: The ratio of change in quantity to original quantity is called strain.

Procedure:

Take the wooden samples. Measures all the dimensions of the cube. Then find out the area of the surface on which the compression is applied. Now place the wooden cube in compression machine. Apply the load and note down the reading carefully. Apply deflection gauge. First of all apply load parallel to the grains. Put the all values in the table and then find out the deformation. Then repeat the same process for different orientation in which grains are perpendicular to the applying loading.



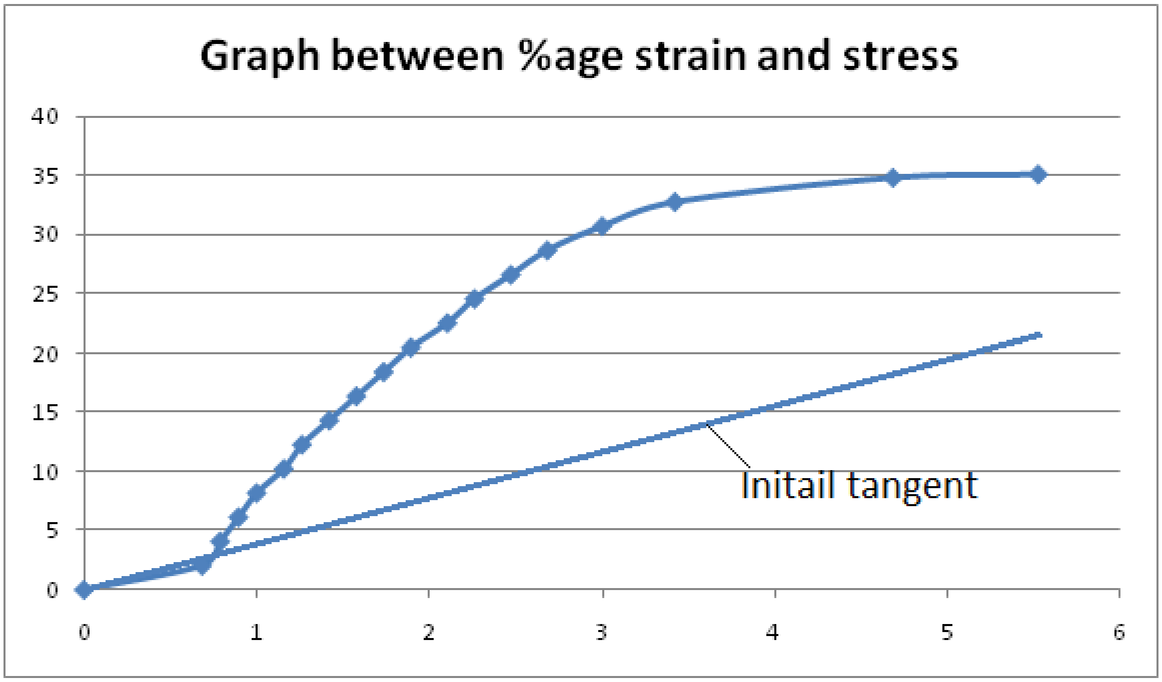
Dimensions:

Specimen	Length(L)	Width(W)	Height(H)
	mm	mm	mm
Parallel to load	50.2	48.7	48.3
Perpendicular to load	49.4	48.5	50.4

OBSERVATIONS AND CALCULATIONS:

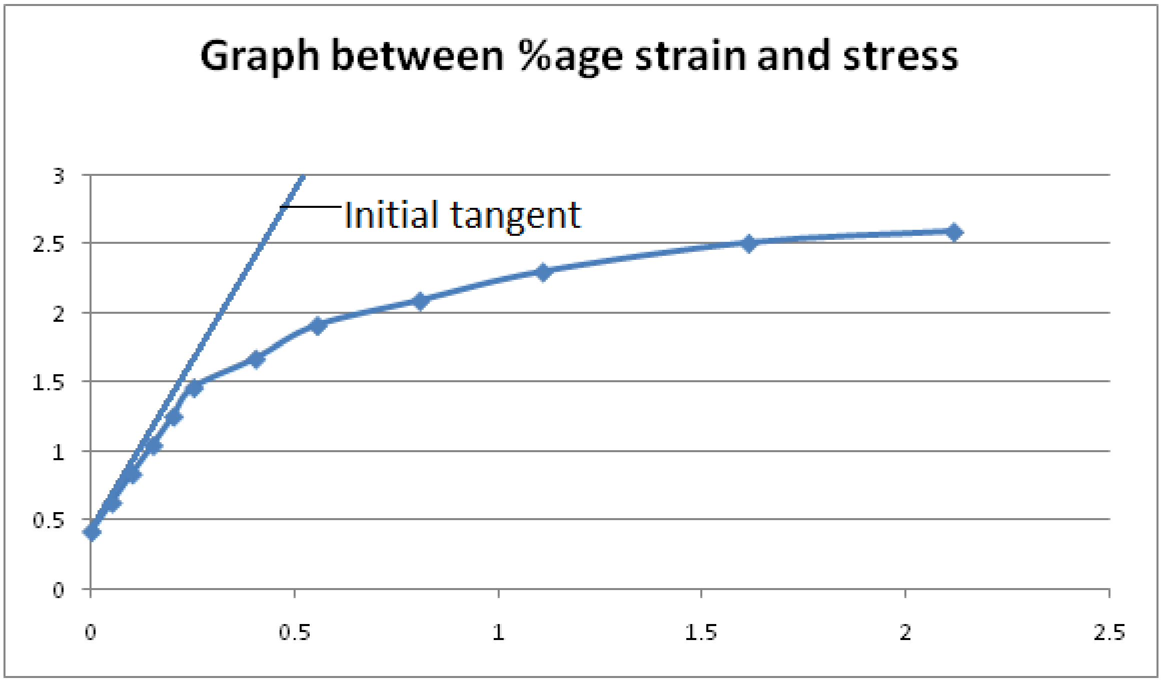
When load is parallel to grains

Sr #	Load P(kN)	Deflection gauge reading	Deformation(mm)	%age strain	σ=P/A	k=P/σ
1	0	100	0	0	0	-
2	5	113	0.3302	0.68364	2.0452	15.142
3	10	115	0.381	0.78882	4.0904	26.246
4	15	117	0.4318	0.89399	6.1356	34.738
5	20	119	0.4826	0.99917	8.1808	41.442
6	25	122	0.5588	1.15693	10.226	44.738
7	30	124	0.6096	1.26211	12.271	49.212
8	35	127	0.6858	1.41987	14.316	51.035
9	40	130	0.762	1.57764	16.361	52.493
10	45	133	0.8382	1.7354	18.406	52.686
11	50	136	0.9144	1.89316	20.452	54.68
12	55	140	1.016	2.10352	22.497	54.133
13	60	143	1.092	2.26128	24.542	54.943
14	65	147	1.193	2.47163	26.58	54.447
15	70	151	1.295	2.68198	28.632	54.037
16	75	157	1.447	2.99751	30.678	51.802
17	80	165	1.651	3.41821	32.723	48.455
18	85	189	2.26	4.68033	34.768	37.6
19	85.7	205	2.667	5.52173	35.054	32.133



When load is perpendicular to grains

Sr #	Load P(kN)	Deflection gauge reading	Deformation(mm)	%age strain	σ=P/A	k=P/σ
1	0	100	0	0	0.417	-
2	1	101	0.0508	0.0503	0.626	29.52
3	2	102	0.0508	0.1	0.834	39.37
4	2.5	103	0.762	0.151	1.043	32.8
5	3	104	0.1016	0.201	1.252	29.53
6	3.5	105	0.127	0.251	1.46	27.55
7	4	108	0.2032	0.403	1.669	19.68
8	4.5	111	0.2794	0.554	1.187	16.1
9	5	116	0.4064	0.806	2.086	12.3
10	5.5	122	0.5588	1.108	2.295	9.842
11	6	132	0.8128	1.612	2.504	7.381
12	6.5	142	1.0668	2.116	2.587	5.811



Precuations:

- Avoid any personal error
- Jerk may cause error in noting the reading
- Note that reading where jerk just starts

Results:

The increase in compression will result in increase of deformation.

Job # 5

Statement:

To perform tension test on hot rolled deformed steel bar

Objective:

1. To determine different mechanical properties of steel

2. To study the stress strain behavior of mild steel

3. To check the adequacy of specimen according to ASTM standard

Apparatus:

1. 500 kN Shimadzu UTM
2. Extensometer
3. Spring divider
4. Vernier calipers
5. Weighing balance
6. Steel tape
7. Hot rolled deformed steel bar

Related theory:

Steel: Steel is an alloy of iron.

Carbon content in steel:

There is a significant effect of carbon content on the properties of resulting steel. The yield strength tends to be higher and the ductility tends to be lower with the increase of carbon content.

Type of steel	**Carbon content**
Low carbon steel	0.05 – 0.25
Mild steel	0.16 – 0.29
Medium carbon steel (MS)	0.3 – 0.59
High carbon steel	0.6 – 0.99
Ultra high carbon steel	1 – 2

Cast iron	2 – 5

Types of steel bars:

1. Plane steel bar
2. Hot rolled deformed steel bar
3. Cold worked/cold twisted/tor bar

Components of stress strain diagram:

- **Proportional limit: (P)**the maximum stress that may be developed during a simple tension test such that the stress is linear function of strain. There is no proportional limit for brittle materials.
- **Elastic limit: (E)** the maximum stress that may be developed during a simple tension test such that there is no permanent deformation when the load is entirely removed. Hooks law is not valid after E.L.
- **Yielding:** increase in strain without the corresponding increase in stress is called yielding. This may occur in certain types of materials such as mild steel just after the elastic limit.
- **Upper yield point: (U)** this is a point at which there is a sudden drop in stress (or load) with further strain.
- **Lower yield point: (L)** it is a point after which there is a significant extensionat almost constant load.
- **Strain hardening or work hardening:** after the completion of initial yielding, the stress again starts increasing with the increase of the strain up to a peak point on the stress strain curve. This behavior is call strain hardening and the material becomes harder in this zone.
- **Ultimate tensile strength:** maximum value of stress on stress strain diagram is called ultimate tensile strength. It is the point where the slope of the curve becomes zero. It is commonly considered as the maximum strength of the material.
- **Necking:** localized decrease in the cross sectional area of the sample after the ultimate strength is called necking. This continues up to rupture/failure.
- **Fracture or rupture:** this is the final point on stress strain curve at which the specimen breaks by a cup and cone formation. It is always less than the ultimate strength. For brittle materials the ultimate and rupture strength are almost same.
- **Plasticity:** it is the ability of a material to be permanently deformed by the application of load. The work done on the material within this range is not stored as a potential energy but is converted into heat and is dissipated to the environment.
- **Elastic range:** when the specimen is loaded up to the elastic limit and all the strains are recovered upon unloading, the material is said to be in elastic range. In this zone all the work done on the specimen is stored as potential energy, which brings specimen beck to its original shape after the removal of load.

- **Resilience:** the ability of a material to absorb energy in the elastic range (i.e without permanent deformation) is called resilience.
- **Modulus of resilience:** it is the amount of work done on a unit volume of material as a simple tensile force is increased from 0 to proportional limit. It is calculated as the area under the stress strain diagram from 0 to P.L.
- **Toughness:** the ability of a material to absorb energy in the plastic range (i.e. permanent deformation) is called toughness.
- **Modulus of toughness:** it is the amount of work done on a unit volume of material as a simple tensile force is increased from 0 to the failure of the specimen. It is calculated as the total area under the stress strain diagram.
- **Measures of ductility:**

1. % elongation

2. % decrease in area of cross section

All ductile materials are stronger in tension and compression but weak in shear.

All brittle materials are weak in tension and compression but strong in shear.

- **Methods of determining yield strength:**

1. Halting of machine method:

The stress may actually decrease momentarily resulting in upper and lower yield points. The yield point during a simple tension test can be observed by Halting of machine.

2.Offsetmethod:

For the materials that do not gave well-defined yield point, yield strength is determined by offset method. This consists of drawing a line parallel to the initial tangent of the stress strain diagram at0.2% (0.002 m/m or in/in) strain.

3.Luderlinemethod:

When the specimen yields, a pattern of fine lines appears on the polished surface, they roughly interact at right angle to each other and 45 degrees approximately to the longitudinal axis of the bar.4.

4. Specific strain method

In this method simply 0.5% of the total strain is marked to determine the corresponding stress, which is yielding stress

Gauge length:

Length of the cylindrical portion of the test sample on which elongation is to be measured at any moment during the test.

a) Extensometer gauge length (L_e)
b) Original gauge length (L_0)
c) Final gauge length (L_U)

Elongation:
Increase in the original gauge length L_0 at the end of the test.
Extension:
Increase in the extensometer gauge length L_e at a given moment of the test.
Percentage elongation:
Elongation expressed as a % of the original gauge length

$$\frac{L_{U-L_0}}{L_0} \times 100$$

Neck area:
The reduced area of cross section at the point of breaking.
% reduction of an area:
Ratio of maximum change in cross sectional area which has occurred during the test to the original cross sectional area.

Procedure:

1. Measure the dimensions of a specimen Diameter, Total length of a specimen,

Cross sectional area Mark gage length at three different portions on the specimen, covering effective length of a specimen.(this is required so that necked portion will remain between any two points of gage length on the specimen.)

2. Grip the specimen in the fixed head of a machine. (Portion of the specimen has to be gripped as shown in the fig.7.
3. Fix the extensometer within the gauge length marked on the specimen. Adjust the dial of extensometer at zero.
4. Adjust the dial of a machine to zero, to read load applied.
5. . Select suitable increments of loads to be applied so that corresponding elongation can be measured from dial gauge.
6. . Keep speed of machine uniform. Record yield point, maximum load point, point of breaking of specimen.
7. Remove the specimen from machine and study the fracture observes type of fracture.
8. Measure dimensions of tested specimen. Fit the broken parts together and measure reduced diameter and final gage length.

OBSERVATIONS AND CALCULATIONS:

Specimen measurements
Original Length = 45.3 cm = 0.453 m
Mass = 445 g = 0.445 kg
Density = 7850 kg/m^3
Density = mass/volume

$$\rho = \frac{M}{AL}$$

From this equation A_{act}=original cross sectional area= 1.25×10^{-4} m^2=125 mm^2

Hence actual D = 12.61×10^{-3} m

Gauge length = 50 mm

Load (P)	**Extensometer/ Spring divider reading**	**Elongation ($\boldsymbol{\delta}$)**	**% strain $= \frac{\delta}{G.L} \times 100$**	**Stress=$\frac{P}{A_{act}}$**	**Remarks**
kN		**mm**		**MPa**	
0	0	0	0	0	Elastic zone
5	4	0.004	0.008	0.04	_
10	9	0.009	0.018	0.08	_
15	11	0.011	0.022	0.12	_
20	14	0.014	0.028	0.16	_
25	17	0.017	0.034	0.2	_
30	23	0.023	0.046	0.24	_
35	31	0.031	0.062	0.28	_
40	41	0.041	0.082	0.32	_
45	50	0.050	0.1	0.36	_
50	59	0.059	0.118	0.40	_
55	69	0.069	0.138	0.44	_
60	89	0.089	0.178	0.48	_
65	101	0.101	0.202	0.52	_
70	114	0.114	0.228	0.56	Yielding zone start

74.5	890	0.890	1.78	0.596	Strain hardening zone start
75	905	0.905	1.81	0.6	_
78	1216	1.216	2.432	0.624	_
80	1419	1.419	2.838	0.64	_
82	1666	1.666	3.332	0.656	_
84	1970	1.970	3.94	0.672	_
86	2350	2.350	4.7	0.688	_
86.7	2500	2.500	5	0.6936	_
88	_	54-50=4	8	0.704	_
89	_	55-50=5	10	0.712	_
90	_	57-50=7	14	0.72	_
91	_	57.5-50=7.5	15	0.728	_
91.5	_	_	_	0.732	Ultimate tensile strength reached and necking zone started
67.2	_	_	_	0.5376	Fracture/breaking load

Precuations:

- Avoid any personal error
- Note the reading carefully
- Use deflection gauge properly

Results:

After rupture or fracture the diameter becomes

D of cup = 8.50 mm

D of cone = 9 mm

D_{avg}= 8.75 mm

Rupture area = 60 mm^2

Modulus of elasticity = $\frac{stress}{strain} =$ **201.23GPa**

Nominal breaking stress = $\frac{breaking\ load}{original\ cross\ sectional\ area}$**= 0.732**

Actual breaking stress = $\frac{breaking\ load}{neck\ area}$**= 0.834**

% elongation = $\frac{change\ in\ length}{original\ length} \times \mathbf{100}$**= 15%**

% reduction in area = $\frac{change\ in\ area}{original\ area} \times \mathbf{100} =$ **9.72%**

Job # 6

Statement:

To perform impact test on different steel samples

Objective:

To determine the modulus of toughness of steel in tension and in bending.

Apparatus:

1. Charpy impact testing machine

2. Steel samples, circular rod for tension test and specimen with square cross section for bending test

Related theory:

1. Toughness: The ability of material to absorb energy in plastic range as load is increased from 0 to failure.

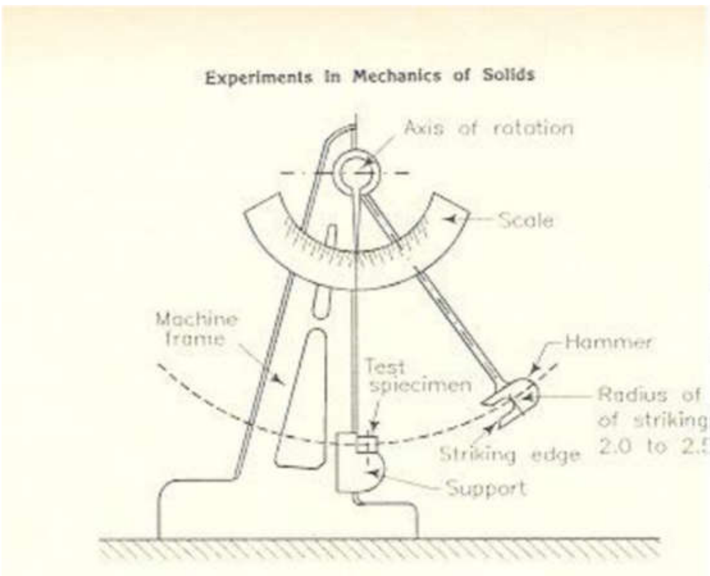
2. Modulus of toughness: It is the amount of work done on a unit volume of material as a simple tensile force is increased from 0 to failure.

3. Types of loads:

I. **Static load:** Loads which do not change their magnitude, direction and position. e.g. self weight of anything.
II. **Dynamic load:** The loads which change their magnitude, direction and position. e.g traffic load on roads, bridges.
III. **Impact load:** The sudden application of the significant magnitude of load in a short interval of time. e.g. earth quack produces impact load.

Procedure:

1. Measure the dimensions of a specimen. Also, measure the dimensions of the fork i.e its radius and mass.
2. Raise the hammer and note down initial reading from the dial, which will be energy to be used to fracture the specimen.
3. Place the specimen for test and see that it is placed center with respect to hammer. Check the position of notch.
4. Release the hammer and note the final reading. Difference between the initial and final reading will give the actual energy required to fracture the Specimen.
5. Repeat the test for specimens of other materials.
6. Compute the energy of rupture of each specimen.



Charpy impact testing apparatus

Absorbed energy by specimen:

$\Delta E = E_1 - E_2$

$= mgh_1 - mgh_2$

$= mg(h_1 - h_2)$ (1)

$h_1 = h_0 + R\sin(\vartheta_1 - 90)$

$= h_0 - R\cos\vartheta_1$ (2)

$h_2 = h_0 + R\sin(\vartheta_2 - 90)$

$= h_0 - R\cos\vartheta_2$ (3)

Putting equations 2 and 3 in equation 1

$\Delta E = mg(h_0 - RCos\vartheta_1 - h_0 + RCos\vartheta_2)$

$= mgR(Cos\vartheta_2 - RCos\vartheta_1)$

OBSERVATIONS AND CALCULATIONS:

Mass of fork = 22.9 kg

Radius of fork = 0.7 m = 700 mm

Volume for tension test specimen = 0.25in^3= 4096.775mm^3

Volume for bending test specimen = 0.335 in^3= 5489.6785 mm^3

Mass of specimen and hammer = 687g = 0.687 kg

1 in^3 = 16387.1 mm^3

Type of test	**Angle of fork (Degree)**		**$\Delta E = mgR(Cos\vartheta_2 - RCos\vartheta_1)$**	**Volume**	**MOT= $\frac{\Delta E}{V}$**
	Initial release θ_1	**Final release θ_2**	**Nmm**	**mm^3**	**MPa**
Tension	138	110	64970.93	4096.775	15.85
Bending	137	129	16045.17	5489.6785	2.922

Precuations:

- Avoid any personal error
- Note the reading carefully

Resut:

Tension= 15.85

Bending=2.922

Job # 7

Statement:

To perform bending test on a wooden beam

Objective:

1. To study the bending behavior of a wooden beam

2. To determine the modulus of rupture and modulus of elasticity of beam

Apparatus:

1. 10 ton Buckton UTM
2. Wooden beam
3. 3 deflection gages
4. Measuring tape

Related theory:

1. Bending moment:

The algebraic sum of moment of all the transverse forces acting on either the left or right side of any section about this section is called bending moment at this location.

2. Shear force:

A force which tends to slide one part of a section against the adjacent.

3. Elastic curve:

The deflected shape of the beam after the application of load (in elastic range).

4. Bending stress/ flexural stress:

The stresses caused by bending moment are known as bending or flexural stresses.

5. Bending formula/ flexural formula:

The relation between these stresses and the bending moment is expressed by flexural formula:

$$\sigma = \frac{My}{I}$$

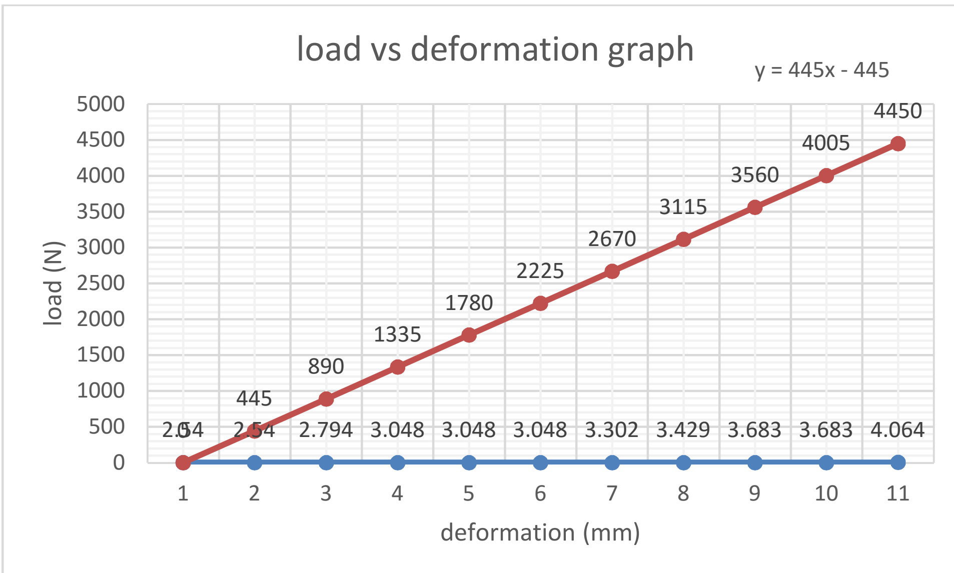
6. Modulus of rupture:

It is the maximum tensile stress which can be developed in the beam before failure.

OBSERVATIONS AND CALCULATIONS:

No of obs.	Load		Deflection gage reading				$\Delta = (\boldsymbol{Gc - mean}) \times \boldsymbol{L.C} \times \boldsymbol{25.4}$
			Gx	Gy	$\frac{\boldsymbol{Gx+Gy}}{\boldsymbol{2}}$	Gc	
	ton	N	in	in	in	in	mm
1	0	0	100	100	100	200	2.54
2	0.05	445	110	110	110	210	2.54
3	0.1	890	120	120	120	230	2.794
4	0.15	1335	130	130	130	250	3.048
5	0.2	1780	140	140	140	260	3.048
6	0.25	2225	150	150	150	270	3.048
7	0.3	2670	160	160	160	290	3.302
8	0.35	3115	190	190	190	325	3.429

9	0.4	3560	200	200	200	345	3.683
10	0.45	4005	220	220	220	365	3.683
11	0.5	4450	240	240	240	400	4.064



a = 150 mm

b = h = 50 mm

l = 500 mm

Slope from graph = $\frac{P'}{d}$ = 445

Maximum value of load = P = 2.05 tons = 18245 N

Finding modulus of elasticity:

$$E = \frac{3al^2}{4bh^3} \times \frac{P'}{d}$$

E = 2002.5MPa

Finding modulus of rupture:

$$\sigma_{max} = \frac{My}{I} = \frac{\frac{Pa}{2} \times \frac{h}{2}}{\frac{bh^3}{12}} = \frac{3Pa}{bh^2}$$

= 65.682 MPa

Precautions:

- Avoid any personal error
- Note the reading carefully

Result:

Modulus of elasticity = 2002.5MPa

Modulus of rupture = 65.682MPa

Job # 8

Statement:

To perform hardness test on a given steel specimens using Rockwell hardness testing machine:

Objective:

1. To check the hardness of materials
2. Indirect strength test of materials
3. Quality control in industries

Apparatus:

1. Shimadzu Rockwell hardness testing machine
2. Indenters steel balls and diamond cone

Related theory:

Hardness:

Hardness is the property of a material that enables it to resist plastic deformation, usually by penetration. However, the term hardness may also refer to resistance to bending, scratching, abrasion or cutting.

If there is more hardness, the material will be more brittle.

Hardness Test Methods:

1. Rockwell Hardness Test
2. Rockwell Superficial Hardness Test
3. Brinell Hardness Test
4. Vickers Hardness Test
5. Micro hardness Test
6. Moh's Hardness Test
7. Scleroscope hardness test

Indenters:

1. 1/16" dia steel ball for mild C steel sample
2. Diamond cone for high carbon steel sample

Procedure:

Rockwell Hardness Test (BS-891)

The Rockwell hardness test method consists of indenting the test material with a diamond cone or hardened steel ball indenter. The indenter is forced into the test material under a preliminary minor load usually 10 kg. When equilibrium has been reached, an indicating device, which follows the movements of the indenter and so responds to changes in depth of penetration of the indenter is set to a datum position. While the preliminary minor load is still applied an additional major load is applied with resulting increase in penetration. When equilibrium has again been reached, the additional major load is removed but the preliminary minor load is still maintained. Removal of the additional major load allows a partial recovery, so reducing the depth of penetration. The permanent increase in depth of penetration, resulting from the application and removal of the additional major load is used to calculate the Rockwell hardness number.

OBSERVATIONS AND CALCULATIONS:

Sr no.	Specimen	Type of indenter	Scale	Load (kg)		Hardness no.	Mean hardness
				Minor	**Major**		
1	Mild C steel	1/16" dia steel ball	B	10	90	HR 92.5 B	_
2		1/16" dia steel ball	B	10	90	HR 93 B	HR 93 B
3		1/16" dia steel ball	B	10	90	HR 93.5 B	_
Sr no.	**Specimen**	**Type of indenter**	**Scale**	**Load (kg)**		**Hardness no.**	**Mean hardness**
				Minor	**Major**		
1	High C steel	Diamond cone	C	10	140	HR 88 C	_
2		Diamond cone	C	10	140	HR 89 C	HR 88.33C

3		Diamond cone	C	10	140	HR 89.5 C	_

Precautions:

- Avoid any personal error
- Note the reading carefully

Result:

Hardness of Mild carbon steel = HR 93 B

Hardness of High carbon steel = HR 88.33C