MECHANICS OF SOLIDS

LAB MANUAL

Subject Code: A30085
Regulations: R13 – JNTUH
Class: II Year I Semester (MECH.)

Prepared By

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COMPUTER SCIENCE AND ENGINEERING

Program Outcomes	
PO1	Capability to apply the knowledge of mathematics, science and engineering in the field of mechanical engineering.
PO2	An ability to analyze complex engineering problems to arrive at relevant conclusion using knowledge of mathematics, science and engineering.
PO3	Competence to design a system, component or process to meet societal needs within realistic constraints.
PO4	To design and conduct research oriented experiments as well as to analyze and implement data using research methodologies.
PO5	An ability to formulate solve complex engineering problem using modern engineering and information Technology tools.
PO6	To utilize the engineering practices, techniques, skills to meet needs of the health, safety, legal, cultural and societal issues.
PO7	To understand impact of engineering solutions in the societal context and demonstrate the knowledge for sustainable development.
PO8	An understanding and implementation of professional and ethical responsibilities.
PO9	To function as an effective individual and as a member or leader in multi disciplinary environment and adopt in diverse teams.
PO10	An ability to assimilate, comprehend, communicate, give & receive instructions to present effectively with engineering community and society.
PO11	An ability to provide leadership in managing complex engineering projects at multidisciplinary environment and to become a Technocrat.
PO12	Recognition of the need and an ability to engage in lifelong learning to keep abreast with technological changes.
Program Specific Outcomes	
PSO1	To produce engineering professional capable of synthesizing and analyzing mechanical systems including allied engineering streams.
PSO2	An ability to adopt and integrate current technologies in the design and manufacturing domain to enhance the employability.
PSO3	To build the nation, by imparting technological inputs and managerial skills to become technocrats.

MECHANICS OF SOLIDS LAB SYLLABUS

ATTAINMENT OF PROGRAM OUTCOMES & PROGRAM SPECIFIC OUTCOMES

Exp. No.	Experiment	Program Outcomes Attained	Program Specific Outcomes Attained
1	**Direct Tension Test**	PO1, PO2, PO3, PO5	PSO1, PSO2
2	**Torsion Test**	PO1, PO2, PO3, PO5	PSO1, PSO2
3	**Hardness Test** **B) Brinell's Hardness Test** **B) Rockwell Hardness Test**	PO1, PO2, PO3, PO5	PSO1, PSO2
4	**Test on Springs**	PO1, PO2, PO3, PO5	PSO1, PSO2
5	**Compression Test on Cube**	PO1, PO2, PO3, PO5	PSO1, PSO2
6	**Impact Test**	PO1, PO2, PO3, PO5	PSO1, PSO2
7	**Punch Shear Test**	PO1, PO2, PO3, PO5	PSO1, PSO2
Content Beyond Syllabi			
1	**Deflection of beams** **c) Cantilever** **d) Simply Supported**	PO1, PO2, PO3, PO5	PSO1, PSO2
2	**Non Destructive Testing**	PO1, PO2, PO3, PO5	PSO1, PSO2

MECHANICS OF SOLIDS LABORATORY

OBJECTIVE:

In this laboratory, students will have the opportunity to apply loads to various materials under different equilibrium conditions. The student will perform tests on materials in tension, compression, torsion, bending, and impact. These conditions and/or constraints are designed to reinforce classroom theory by having the student perform required tests, analyze subsequent data, and present the results in a professionally prepared report.

The machines and equipment used to determine experimental data include universal testing machines, torsion equipment, spring testing machine, compression testing machine, impact tester, hardness tester, etc. Data will be collected using Dial indicators, extensometers, strain gages and strain indicator equipment, as well as load and strain readouts on the machinery and graphing capabilities to print relevant plots for analysis.

OUTCOMES:

Upon the completion of Mechanicsl of Solids practical course, the student will be able to:

1. **Determine** the youngs modulus for ductile materials.
2. **Analyze** the various points on stress strain diagram.
3. **Calculate** the modulus of rigidity of ductile materials.
4. **Calculate & Compare** the hardness values for various materials.
5. **Experiment** on a spring to interpret the stiffeness and shear modulus.
6. **Apply** the concept of impact loading and to determine impact values for various materials.
7. **Analyse** the compression strength of different materials
8. **Determine** the shear stress of different materials.

EXPERIMENT 1

1.1 AIM: To determine ultimate tensile stress of a metal.

1.2 OBJECTIVE: To conduct a tensile test on a mild steel specimen and determine the following:

(i) Limit of proportionality

(ii) Elastic limit

(iii) Yield strength

(iv) Ultimate strength

(v) Young's modulus of elasticity

(vi) Percentage elongation

(vii) Percentage reduction in area.

1.3 APPARATUS:

(i) Universal Testing Machine (UTM)

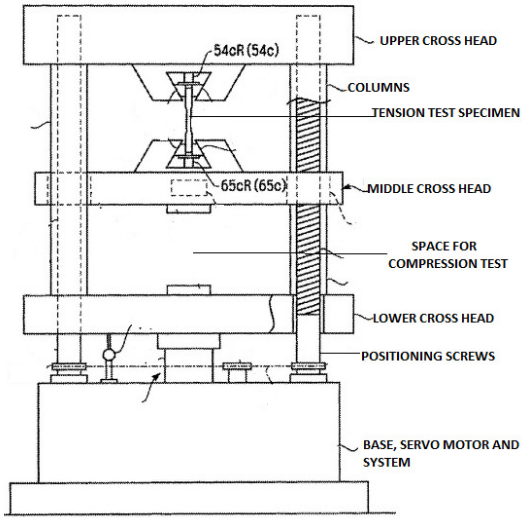
(ii) Mild steel specimens

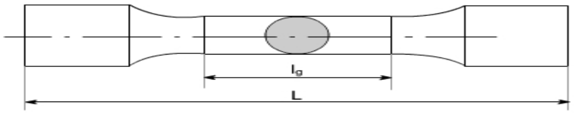
(iii) Graph paper

(iv) Scale

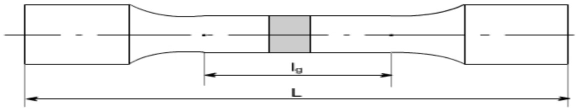
(v) Vernier Caliper

1.4 DIAGRAM:





[specimen with circular X-section]



[specimen with rectangular X-section]

1.5 M/C SPECIFICATIONS:

Capacity: 400 KN.

Model: UTK-40.

SR.No: 2013/1073.

Mfd. By: Krystal Equipments, Ichalkaranji, M.H, India.

1.6 THEORY:-The tensile test is most applied one, of all mechanical tests. In this test ends of test piece are 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 elastically deformed solid will return to its original from 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 which solid undergoes plastic deformation is termed plastic. The stress below which the deformations essentially entirely elastic is known as the yield strength of material. In some material the onset of plastic deformation is denoted by a sudden drop in load indicating 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 a maximum and then begins to decrease. This stage the "ultimate strength"' which is defined as the ratio of the load on the specimen to original cross-sectional area, reaches a maximum value. Further loading will eventually cause 'neck' formation and rupture.

1.7 PROCEDURE:-

1) Measure the original length and diameter of the specimen. The length may either be length of gauge section which is marked on the specimen with a preset punch or the total length of the specimen.

2. Insert the specimen into grips of the test machine and attach strain-measuring device to it.
3. Begin the load application and record load versus elongation data.
4. Take readings more frequently as yield point is approached.
5. Measure elongation values with the help of dividers and a ruler.
6. Continue the test till Fracture occurs.
7. By joining the two broken halves of the specimen together, measure the final length and diameter of specimen.

<u>1.8 DESCRIPTION OF UTM AND EXTENSOMETER:</u>

LOADING UNIT:-

It consists of main hydraulic cylinder with robust base inside. The piston which moves up and down. The chain driven by electric motor which is fitted on left hand side. The screw column maintained in the base can be rotated using above arrangement of chain. Each column passes through the main nut which is fitted in the lower cross head. The lower table connected to main piston through a ball & the ball seat is joined to ensure axial loading. There is a connection between lower table and upper head assembly that moves up and down with main piston. The measurement of this assembly is carried out by number of bearings which slides over the columns. The test specimen each fixed in the job is known as 'Jack Job'. To fix up the pecimen tightly, the movement of jack job is achieved helically by handle.

CONTROL PANEL:-

It consists of oil tank having a hydraulic oil level sight glass for checking the oil level. The pump is displacement type piston pump having free plungers those ensure for continuation of high pressure. The pump is fixed to the tank from bottom. The suction & delivery valve are fitted to the pump near tan Electric motor driven the pump is mounted on four studs which is fitted on the right side of the tank. There is an arrangement for loosing or tightening of the valve. The four valves on control panel control the oil stroke in the hydraulic system. The loading system works as described below. The return valve is close, oil delivered by the pump through the flow control valves to the cylinder & the piston goes up. Pressure starts developing & either the specimen breaks or the load having maximum value is controlled with the base dynameters consisting in a cylinder in which the piston reciprocates. The switches have upper and lower push at the control panel for the downward & upward movement of the movable head. The on & off switch provided on the control panel & the pilot lamp shows the transmission of main supply.

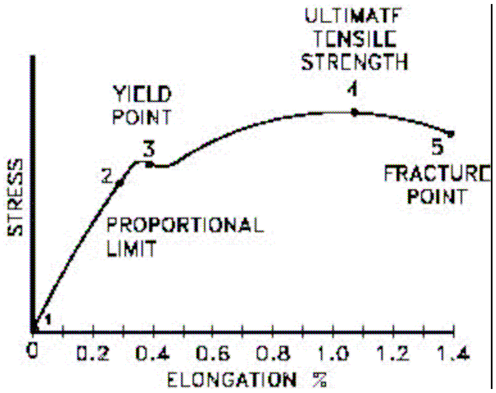
1.9 METHOD OF TESTING:-

Initial Adjustment: - before testing adjust the pendulum with respect to capacity of the test i.e. 8 Tones; 10 Tones; 20 Tones; 40 Tones etc. For ex: - A specimen of 6 tones capacity gives more accurate result of 10 Tones capacity range instead of 20 Tones capacity range. These ranges of capacity are adjusted on the dial with the help of range selector knob. The control weights of the pendulum are adjusted correctly. The ink should be inserted in pen holder of recording paper around the drum & the testing process is started depending upon the types of tests.

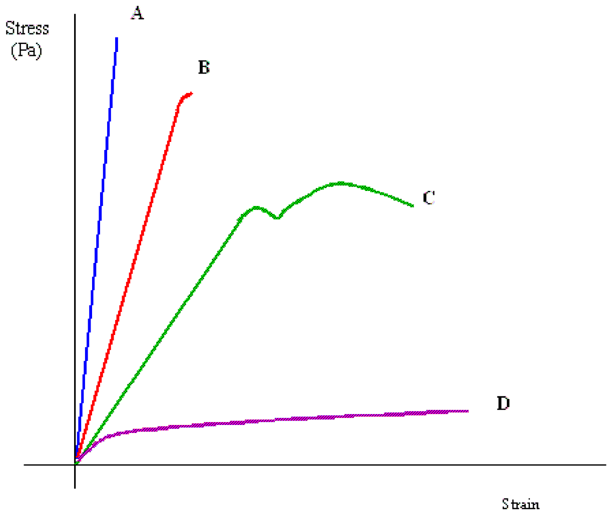
EXTENSOMETER:-

This instrument is an attachment to Universal / Tensile Testing Machines. This measures the elongation of a test place on load for the set gauge length. The least count of measurement being 0.01 mm, and maximum elongation measurement up to 3 mm. This elongation measurement helps in finding out the proof stress at the required percentage elongation.

WORKING OF THE INSTRUMENT:-The required gauge length(between 30to 120) is set by adjusting the upper knife edges (3) A scale (2) is provided for this purpose . Hold the specimen in the upper and lower jaws of Tensile / Universal Testing Machine. Position the extensometer on the specimen. Position upper clamp (4) to press upper knife edges on the specimen. The extensometer will be now fixed to the specimen by spring pressure. Set zero on both the dial gauges by zero adjust screws (7). Start loading the specimen and take the reading of load on the machine at required elongation or the elongation at required load. Force setter accuracies mean of both the dial gauge (8) readings should be taken as elongation. It is very important to note & follow the practice of removing the extensometer from the specimen before the specimen breaks otherwise the instrument will be totally damaged. As a safety, while testing the instrument may be kept hanging from a fixed support by a slightly loose thread.



A) Stress-strain graph of Mild Steel



C) Stress-strain graphs of different materials.

- Curve **A** shows a **brittle** material. This material is also strong because there is little strain for a high stress. The fracture of a brittle material is sudden and catastrophic, with little or no plastic deformation. Brittle materials crack under tension and the stress increases around the cracks. Cracks propagate less under compression.

- Curve **B** is a **strong** material which is not ductile. Steel wires stretch very little, and break suddenly. There can be a lot of elastic strain energy in a steel wire under tension and it will "whiplash" if it breaks. The ends are razor sharp and such a failure is very dangerous indeed.
- Curve **C** is a **ductile** material
- Curve **D** is a **plastic** material. Notice a very large strain for a small stress.The material will not go back to its original length.

1.10 OBESERVATIONS:

A) Original dimensions

Gauge Length = ------------

Diameter = ---------

Area = --------------

B) Final Dimensions:

Gauge Length = -------------------

Diameter = -----------------

Area = -----------------------

1.11 TABULATION:- (Cross check 'E' with reference table 1.0)

S.No.	Extension (mm)		Load, N		Average Load	Young's Modulus E, N/mm^2
	Left	Right	Left	Right		
1						
2						
3						
4						
5						

(i) **Limit of proportion** = $\frac{\text{Load at limit of proportionality}}{\text{Original area of cross-section}}$ N/mm^2

(ii) Elastic limit = $\frac{\text{load at elastic limit}}{\text{Original area of c/s}}$ N/mm^2

(iii) Yield strength = $\frac{\text{Yield load}}{\text{Original area of cross-section}}$ N/mm^2

(iv) Ultimate strength = Maximum tensile load N/mm^2

Original area of cross-section

(v) Young's modulus, E =

$$\frac{\text{stress below proportionality limit}}{\text{Corresponding strain}} \quad \text{N/mm}^2$$

(vi) % of elongation **=**

$$\frac{\text{Final length (at fracture) – original length}}{\text{Original length}} \quad \%$$

(vii) **% of reduction in area** =

$$\frac{\text{Original area-area at fracture}}{\text{Original area}} \quad \%$$

1.12 RESULT:-

i) Average Breaking Stress =

ii) Ultimate Stress =

iii) Average % Elongation =

iv) Modulus of Elasticity, E =

1.13 GRAPH:

1. Stress Vs Strain

1.14 PRECAUTIONS:-

1. If the strain measuring device is an extensometer it should be removed before necking begins.

2. Measure deflection on scale accurately & carefully.

1.15 Reference Table 1.0: Properties of Materials (Ref. Adopted from MIT)

MATERIAL	Type	Cost ($/kg)	Density (ρ, Mg/m^3)	Young's Modulus (E, GPa)	Shear Modulus (G, GPa)	Poisson's Ratio (μ)	Yield Stress (σ_y, MPa)	UTS (σ_f, MPa)	Breaking strain (ε_f, %)	Fracture Toughness (K_c, MN m$^{-3/2}$)	Thermal Expansion (α, 10^{-6}/C)
Alumina (Al_2O_3)	ceramic	1.90	3.9	390	125	0.26	4800	35	0.0	4.4	8.1
Aluminum alloy (7075-T6)	metal	1.80	2.7	70	28	0.34	500	570	12	28	33
Beryllium alloy	metal	315.00	2.9	245	110	0.12	360	500	6.0	5.0	14
Bone (compact)	natural	1.90	2.0	14	3.5	0.43	100	100	9.0	5.0	20
Brass (70Cu30Zn, annealed)	metal	2.20	8.4	130	39	0.33	75	325	70.0	80	20
Cermets (Co/WC)	composite	78.60	11.5	470	200	0.30	650	1200	2.5	13	5.8
CFRP Laminate (graphite)	composite	110.00	1.5	1.5	53	0.28	200	550	2.0	38	12
Concrete	ceramic	0.05	2.5	48	20	0.20	25	3.0	0.0	0.75	11
Copper alloys	metal	2.25	8.3	135	50	0.35	510	720	0.3	94	18
Cork	natural	9.95	0.18	0.032	0.005	0.25	1.4	1.5	80	0.074	180
Epoxy thermoset	polymer	5.50	1.2	3.5	1.4	0.25	45	45	4.0	0.50	60
GFRP Laminate (glass)	composite	3.90	1.8	26	10	0.28	125	530	2.0	40	19
Glass (soda)	ceramic	1.35	2.5	65	26	0.23	3500	35	0.0	0.71	8.8
Granite	ceramic	3.15	2.6	66	26	0.25	2500	60	0.1	1.5	6.5
Ice (H_2O)	ceramic	0.23	0.92	9.1	3.6	0.28	85	6.5	0.0	0.11	55
Lead alloys	metal	1.20	11.1	16	5.5	0.45	33	42	60	40	29
Nickel alloys	metal	6.10	8.5	180	70	0.31	900	1200	30	93	13
Polyamide (nylon)	polymer	4.30	1.1	3.0	0.76	0.42	40	55	5.0	3.0	103
Polybutadiene elastomer	polymer	1.20	0.91	0.0016	0.0005	0.50	2.1	2.1	500	0.087	140
Polycarbonate	polymer	4.90	1.2	2.7	0.97	0.42	70	77	60	2.6	70
Polyester thermoset	polymer	3.00	1.3	3.5	1.4	0.25	50	0.7	2.0	0.70	150
Polyethylene (HDPE)	polymer	1.00	0.95	0.7	0.31	0.42	25	33	90	3.5	225

Polypropylene	polymer	1.10	0.89	0.9	0.42	0.42	35	45	90	3.0	85
Polyurethane elastomer	polymer	4.00	1.2	0.025	0.0086	0.50	30	30	500	0.30	125
Polyvinyl chloride (rigid PVC)	polymer	1.50	1.4	1.5	0.6	0.42	53	60	50	0.54	75
Silicon	ceramic	2.35	2.3	110	44	0.24	3200	35	0.0	1.5	6
Silicon Carbide (SiC)	ceramic	36.00	2.8	450	190	0.15	9800	35	0.0	4.2	4.2
Spruce (parallel to grain)	natural	1.00	0.60	9	0.8	0.30	48	50	10	2.5	4
Steel, high strength 4340	metal	0.25	7.8	210	76	0.29	1240	1550	2.5	100	14
Steel, mild 1020	metal	0.50	7.8	210	76	0.29	200	380	25	140	14
Steel, stainless austenitic 304	metal	2.70	7.8	210	76	0.28	240	590	60	50	17
Titanium alloy (6Al4V)	metal	16.25	4.5	100	39	0.36	910	950	15	85	9.4
Tungsten Carbide (WC)	ceramic	50.00	15.5	550	270	0.21	6800	35	0.0	3.7	5.8

1.16 PRE LAB QUESTIONS

1. Define Hook’s law
2. Define elastic and plastic limit of a material.
3. Explain young’s modulus?
4. Define gauge length.
5. Define mechanical properties of a materials.
6. Define proof stress.

1.17 POST LAB QUESTIONS

1. What is the youngs modulus for steel, aluminium, brass, etc.
2. What is ultimate tensile stress for steel, aluminium, etc.
3. Identify upper & lower yield, proportional limit, fracture point on a σ-□ curve.

EXPERIMENT 2

2.1 OBJECTIVE: To conduct torsion test on mild steel or cast iron specimen to determine modulus of rigidity.

2.2 APPARATUS:

1. A torsion test machine along with angle of twist measuring attachment.
2. Standard specimen of mild steel or cast iron.
3. Steel rule.
4. Vernnier caliper or a micrometer.

2.3 Torsion testing machine:

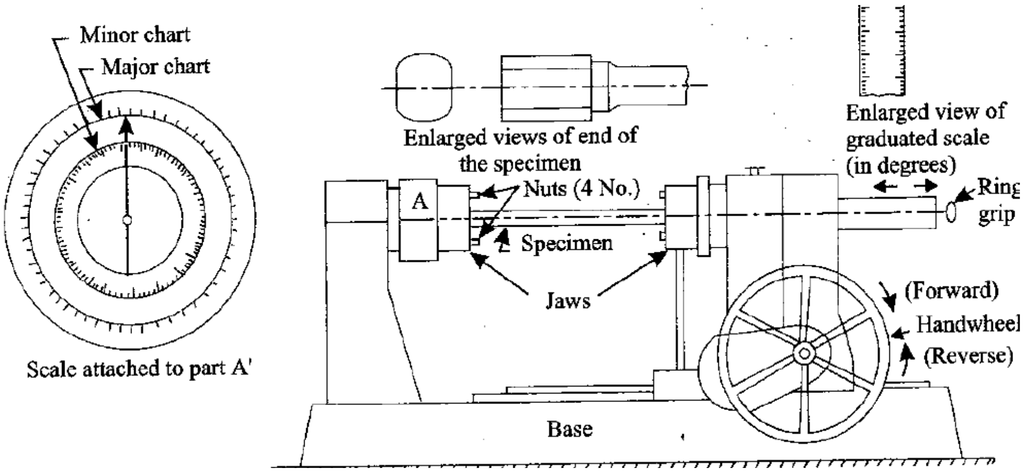
2.4 M/C SPECIFICATIONS:

Capacity: Torque Range: 0-10 Kg-m.

Model: TTM-10..

SR.No: 2001/1012.

Mfd. By: Macro Testing Machines, Ichalkaranji, M.H, India.



2.5 THEORY:

For transmitting power through a rotating shaft it is necessary to apply a turning force. The force is applied tangentially and in the plane of transverse cross section. The torque or twisting moment may be calculated by multiplying two opposite turning moments. It is said to be in pure torsion and it will exhibit the tendency of shearing off at every cross section which is perpendicular to the longitudinal axis.

2.6 Torsion equation:

Torsion equation is given by below

$$T/J = \tau/R = G\theta/L$$

$$G = TL/J\theta \text{ N/mm}^2$$

T= maximum twisting torque (N mm)

J = polar moment of inertia (mm^4) = $\pi d^4/32$

τ = shear stress (N/mm^2)

G = modulus of rigidity (N/mm^2)

θ = angle of twist in radians

L= length of shaft under torsion (mm)

2.7 Assumptions made for getting torsion equation

1. The material of the shaft is uniform throughout.
2. The shaft, circular in section remain circular after loading.
3. Plane sections of shaft normal to its axis before loading remain plane after the torque have been applied.
4. The twist along the length of the shaft is uniform throughout.
5. The distance between any two normal-sections remains the same after the application of torque.
6. Maximum shear stress induced in the shaft due to application of torque does not exceed its elastic limit.

2.8 PROCEDURE:-

1. Select the driving dogs to suit the size of the specimen and clamp it in the machine by adjusting the length of the specimen by means of a sliding spindle.
2. Measure the diameter at about three places and take the average value.
3. Choose the appropriate range by capacity change lever
4. Set the maximum load pointer to zero.
5. Set the protractor to zero for convenience and clamp it by means of knurled screw.
6. Carry out straining by rotating the hand wheel in either direction.
7. Load the machine in suitable increments.
8. Then load out to failure as to cause equal increments of strain reading.
9. Plot a torque- twist (T- θ) graph.
10. Read off co-ordinates of a convenient point from the straight line portion of the torque twist (T-θ) graph and calculate the value of G by using relation.

2.9 OBESERVATIONS:-

Gauge length of the specimen, L = ………

Diameter of the specimen, d = ………

Polar moment of inertia, J = $\pi d^4/32$ = ……..

2.10 TABULATION: (Cross check 'G' with reference table 1.0)

Sl. No.	Torque, Kg-cm	Torque, N - mm	Angle of twist		Modulus Rigidity, G N/mm^2	Average G, N/mm^2
			Degrees	Radians		

2.11 RESULT :-

Thus the torsion test on given mild steel specimen is done and the modulus of rigidity is ------------- N/mm^2

2.12 GRAPH:

1. Torque Vs Angle of Twist

2.13 PRECAUTIONS:-

1) Measure the dimensions of the specimen carefully

2) Measure the Angle of twist accurately for the corresponding value of Torque.

3) The specimen should be properly to get between the jaws.

4) After breaking specimen stop to m/c.

2.14 Viva Questions

7. Define torque.
8. Give the expression for torque.
9. Define modulus of rigidity.
10. Give the values of G for different materials.

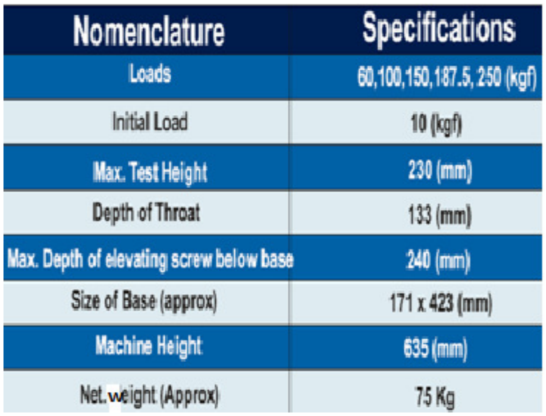
EXPERIMENT 3

EXPERIMENT NO – 03: HARDNESS TEST

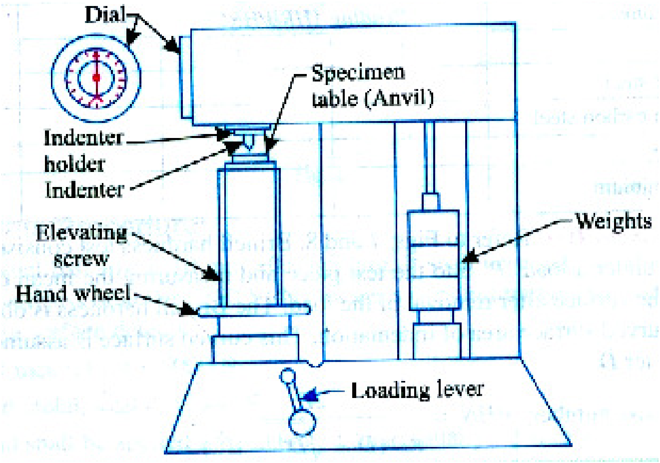
3.1 OBJECTIVE: - To conduct hardness test on mild steel, carbon steel, brass and aluminum specimens.

3.2 APPARATUS:- Hardness tester, soft and hard mild steel specimens, brass, aluminum etc.

3.3 DIAGRAM:-



Nomenclature	Specifications
Loads	60,100,150,187.5, 250 (kgf)
Initial Load	10 (kgf)
Max. Test Height	230 (mm)
Depth of Throat	133 (mm)
Max. Depth of elevating screw below base	240 (mm)
Size of Base (approx)	171 x 423 (mm)
Machine Height	635 (mm)
Net.weight (Approx)	75 Kg



3.4 THEORY: - The hardness of a material is resistance to penetration under a localized pressure or resistance to abrasion. Hardness tests provide an accurate, rapid and economical way of determining the resistance of materials to deformation. There are three general types of hardness measurements depending upon the manner in which the test is conducted:

a. Scratch hardness measurement,

b. Rebound hardness measurement
c. Indention hardness measurement.

In scratch hardness method the material are rated on their ability to scratch one another and it is usually used by mineralogists only. In rebound hardness measurement, a standard body is usually dropped on to the material surface and the hardness is measured in terms of the height of its rebound. The general means of judging the hardness is measuring the resistance of a material to indentation. The indenters usually a ball cone or pyramid of a material much harder than that being used. Hardened steel, sintered tungsten carbide or diamond indenters are generally used in indentation tests; a load is applied by pressing the indenter at right angles to the surface being tested. The hardness of the material depends on the resistance which it exerts during a small amount of yielding or plastic. The resistance depends on friction, elasticity, viscosity and the intensity and distribution of plastic strain produced by a given tool during indentation.

3A. BRINELL'S HARDNESS

3A.1. AIM :-

To determine the Brinell hardness of the given test specimen.

3A.2. APPARATUS:-

1. Brinell Hardness testing machine,
2. Specimen of mild steel / cast iron/ non ferrous metals
3. Brinell microscope.

3A.3. 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 testes. 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 1/8th 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. A hardness test can be conducted on Brinell testing m/c, Rockwell hardness m/c or vicker testing m/c. the specimen may be a cylinder, cube, thick or thin metallic sheet. A Brinell- cum-Rockwell hardness testing m/c along with the specimen is shown in figure. Its specification are as follows:

1. Ability to determine hardness upto 500 HB.
2. Diameter of ball (as indentor) used D = 2.5mm, 5mm, 10mm.
3. Maximum application load = 3000kgf.
4. Method of load application = Lever type
5. Capability of testing the lower hardness range = 1 HB on application of 0.5D2 load.

Indentation Hardness-A number related to the area or to the depth of the impression made by an indenter or fixed geometry under a known fixed load. This method consists of indenting the surface of the metal by a hardened steel ball of specified diameter D mm under a given load F kgf and measuring the average diameter d mm of the impression with the help of Brinell microscope fitted with a scale.

The Brinell hardness is defined, as the quotient of the applied force F divided by the spherical area of the impression.

HB = Load Applied (kgf.)/ Spherical surface area indentation (in mm.)

$= 2F / \pi D (D - \sqrt{D^2 - d^2})$ kg/mm^2

3A.4

PROOF:-

For any sphere of diameter "D" the surface area between any two parallel planes with distance "h" between them = $\Pi D \times h$

The spherical indentation in the Brinell hardness test is indicated by the portion A-C-B

A = Surface area of potion ACB of spheres = $\Pi D \times CE$

But CE = OC-OE

$= D/2 - \sqrt{(OA)^2 - (AE)}^2$

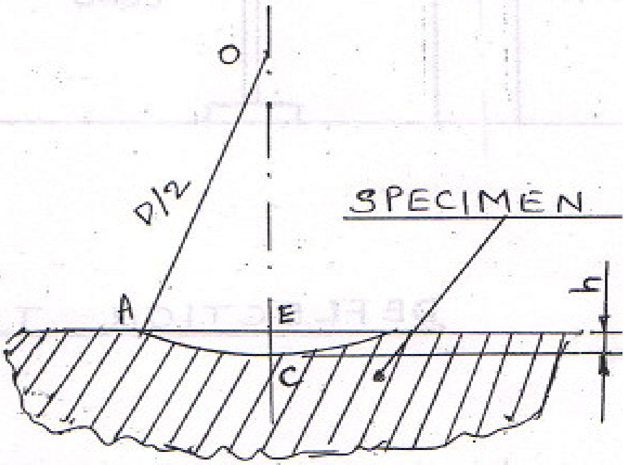
$= D/2 - \sqrt{(D/2)^2 - (d/2)^2}$

$= 1/2(D - \sqrt{(D^2 - d^2)}$

Area(A) = $\Pi D \times CE$

$= (\frac{\pi D}{2})(D - \sqrt{D^2 - d^2})$

Hardness =F/A= $^{2F}/_{\pi D}$ $(D - \sqrt{D^2 - d^2})$



3A.5. PROCEDURE:

1. Select the proper size of the ball and load to suit the material under test.
2. Clean the test specimen to be free from any dirt and defects or blemishes.
3. Mount the test piece surface at right angles to the axis of the ball indenter plunger.
4. Turn the platform so that the ball is lifted up.
5. By shifting the lever applies the load and waits for some time.
6. Release the load by shifting the lever.
7. Take out the specimen and measure the diameter of indentation by means of the Brinell microscope.
8. Repeat the experiments at other positions of the test piece.
9. Calculate the value of HB.

3A.6. OBSERVATIONS:

Test piece material =

Diameter of the ball, D =

Load section, P/D^2 =

Test load =

Load application time =

Least count of Brinell Microscope =

3A.7. TABULATION: (Cross check with reference tables)

S. No.	**Impression Diameter**			**Load Applied, Kg**	**Diameter of Ball, D mm**	**Average HB Kg/mm^2**
	d_1	**d_2**	**$(d_1+d_2)/2$**			
1						
2						
3						

3A.8. RESULT:-

The Brinell hardness number of the specimen is --------

3A.9. PRECAUTIONS:-

1. The surface of the test piece should be clean.
2. The testing machine should be protected throughout the test from shock or vibration.
3. The test should be carried out at room temperature.
4. The distance of the center of indentation from the edge of test piece should be at least 2.5 times the diameter of the indentation and the distance between the centres of the two adjacent indentations should be at least 4 times the diameter of the indentation.
5. The diameter of each indentation should be measured in two directions at right angles and the mean value readings used the purpose of determining the hardness number.

3B. ROCKWELL HARDNESS TEST

3B.1. AIM :

To study the Rockwell Hardness testing machine and perform the Rockwell hardness test**.**

3B.2. APPARATUS: -

1. Rockwell Hardness testing machine,
2. Specimen of mild steel or other material.

3B.3. THEORY: -

Hardness represents the resistance of material surface to abrasion, scratching and cutting, hardness after gives clear indication of strength. In all hardness tests, a define force is mechanically applied on the piece, varies in size and shape for different tests. Common indentors are made of hardened steel or diamond. Rockwell hardness tester presents direct reading of hardness number on a dial provided with the m/c. principally this testing is similar to Brinell hardness testing. It differs only in diameter and material of the indentor and the applied force. Although there are many scales having different combinations of load and size of indentor but commonly ‘C’ scale is used and hardness is presented as HRC. Here the indentor has a diamond cone at the tip and applied force is of 150 kgf. Soft materials are often tested in ‘B’ scale with a 1.6mm dia. Steel indentor at 60kgf. A hardness test can be conducted can be conducted on Brinell testing m/c, Rockwell hardness m/c or vicker testing m/c. The specimen may be a cylinder, cube, thick or thin metallic sheet. A Brinell-cum-Rocwell hardness testing m/c along with the specimen is shown in figure.

3B.4. Various scales in Rockwell hardness test are given below:-

Regular Rockwell Scales	Scale Symbol	Indenter Type. If a ball, diameter in millimeters (diameter in inches)	Preliminary force in newtons (kg-force)	Total force newtons (kgf)	Typical Applications
	A	Spheroconical diamond	98.07 (10)	588.4 (60)	Cemented carbides, thin steel, and shallow case hardened steel.
	B	Ball 1.588 (1/16”)	98.07 (10)	980.7 (100)	Copper alloys, soft steels, aluminum alloys, malleable iron, etc.

	C	Spheroconical diamond (120^0)	98.07 (10)	1471 (150)	Steel, hard cast irons, pearlitic malleable iron, titanium, deep case hardened steel, and other materials harder than 100 on the Rockwell B scale.
	D	Spheroconical diamond	98.07 (10)	980.7 (100)	Thin steel and medium case hardened steel, and pearlitic malleable iron.
	E	Ball 3.175 (1/8)	98.07 (10)	980.7 (100)	Cast iron, aluminum and magnesium alloys, and bearing metals.
	F	Ball 1.588 (1/16)	98.07 (10)	588.4 (60)	Annealed copper alloys, and thin soft sheet metals.
	G	Ball 1.588 (1/16)	98.07 (10)	1471 (150)	Malleable irons, copper-nickel-zinc and cupronickel alloys.
	H	Ball 3.175 (1/8)	98.07 (10)	588.4 (60)	Aluminum, zinc, and lead.
	K	Ball 3.175 (1/8)	98.07 (10)	1471 (150)	Bearing metals and other very soft or thin materials. Use smallest ball and heaviest load that does not give anvil effect.
	L	Ball 6.350 (1/4)	98.07 (10)	588.4 (60)	
	M	Ball 6.350 (1/4)	98.07 (10)	980.7 (100)	
	P	Ball 6.350 (1/4)	98.07 (10)	1471 (150)	

	R	Ball 12.70 (1/2)	98.07 (10)	588.4 (60)	
	S	Ball 12.70 (1/2)	98.07 (10)	980.7 (100)	
	V	Ball 12.70 (1/2)	98.07 (10)	1471 (150)	
Superficial Rockwell Scales	15N	Spheroconical diamond	29.42 (3)	147.1 (15)	Similar to A, C and D scales, but for thinner gage material or case depth.
	30N	Spheroconical diamond	29.42 (3)	294.2 (30)	
	45N	Spheroconical diamond	29.42 (3)	441.3 (45)	
	15T	Ball 1.588 (1/16)	29.42 (3)	147.1 (15)	Similar to B, F and G scales, but for thinner gage material.
	30T	Ball 1.588 (1/16)	29.42 (3)	294.2 (30)	
	45T	Ball 1.588 (1/16)	29.42 (3)	441.3 (45)	
	15W	Ball 3.175 (1/8)	29.42 (3)	147.1 (15)	Very soft material.
	30W	Ball 3.175 (1/8)	29.42 (3)	294.2 (30)	
	45W	Ball 3.175 (1/8)	29.42 (3)	441.3 (45)	

15X	Ball 6.350 (1/4)	29.42 (3)	147.1 (15)
30X	Ball 6.350 (1/4)	29.42 (3)	294.2 (30)
45X	Ball 6.350 (1/4)	29.42 (3)	441.3 (45)
15Y	Ball 12.70 (1/2)	29.42 (3)	147.1 (15)
30Y	Ball 12.70 (1/2)	29.42 (3)	294.2 (30)
45Y	Ball 12.70 (1/2)	29.42 (3)	441.3 (45)

The table is adopted from Table 1 of Samuel R. Low. *Rockwell Hardness Measurement of Metallic Materials.* NIST Recommended Practice Guide. Special Publication 960-5. Washington: U.S.G.P.O. *2001*.

3B.5. Standards

ASTM E 18 - 2000, Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials.

ISO 6508-1 Metallic Materials - Rockwell hardness test (scales A, B, C, D, E, F, G, H, K, N, T) - Part 1: Test method, 1999-09-01

ISO 6508-2 Metallic Materials - Rockwell hardness test (scales A, B, C, D, E, F, G, H, K, N, T) - Part 2: Verification of testing machines, 1999-09-01

ISO 6508-3 Metallic Materials - Rockwell hardness test (scales A, B, C, D, E, F, G, H, K, N, T) - Part 3: Calibration of reference blocks, 1999-09-01

3B.6 Tensile strength and hardness for steels and non ferrous metals:

See Reference Tables (1-4)

3B.7 Rockwell-cum-Brinell's hardness tester

3B.8. PROCEDURE:-

1. Insert ball of dia. 'D' in ball holder of the m/c.
2. Make the specimen surface clean by removing dust, dirt, oil and grease etc.
3. Make contact between the specimen surface and the ball by rotating the jack adjusting wheel.
4. Push the required button for loading.
5. Pull the load release lever wait for minimum 15 second. The load will automatically apply gradually.
6. Remove the specimen from support table and locate the indentation so made.
7. Repeat the entire operation, 3-times.

3B.9. OBSERVATIONS:

Material of the specimen =

Thickness of test specimen =

Hardness scale used =

3B.10. TABULATION: (Cross check with reference tables)

S. No.	**Material**	**Rockwell Scale**			**Rockwell Number**			**Average**
		Scale	**Load**	**Indent**	**1**	**2**	**3**	
1								
2								
3								
4								

3B.11. RESULT:-

Rockwell hardness of given specimen is --------

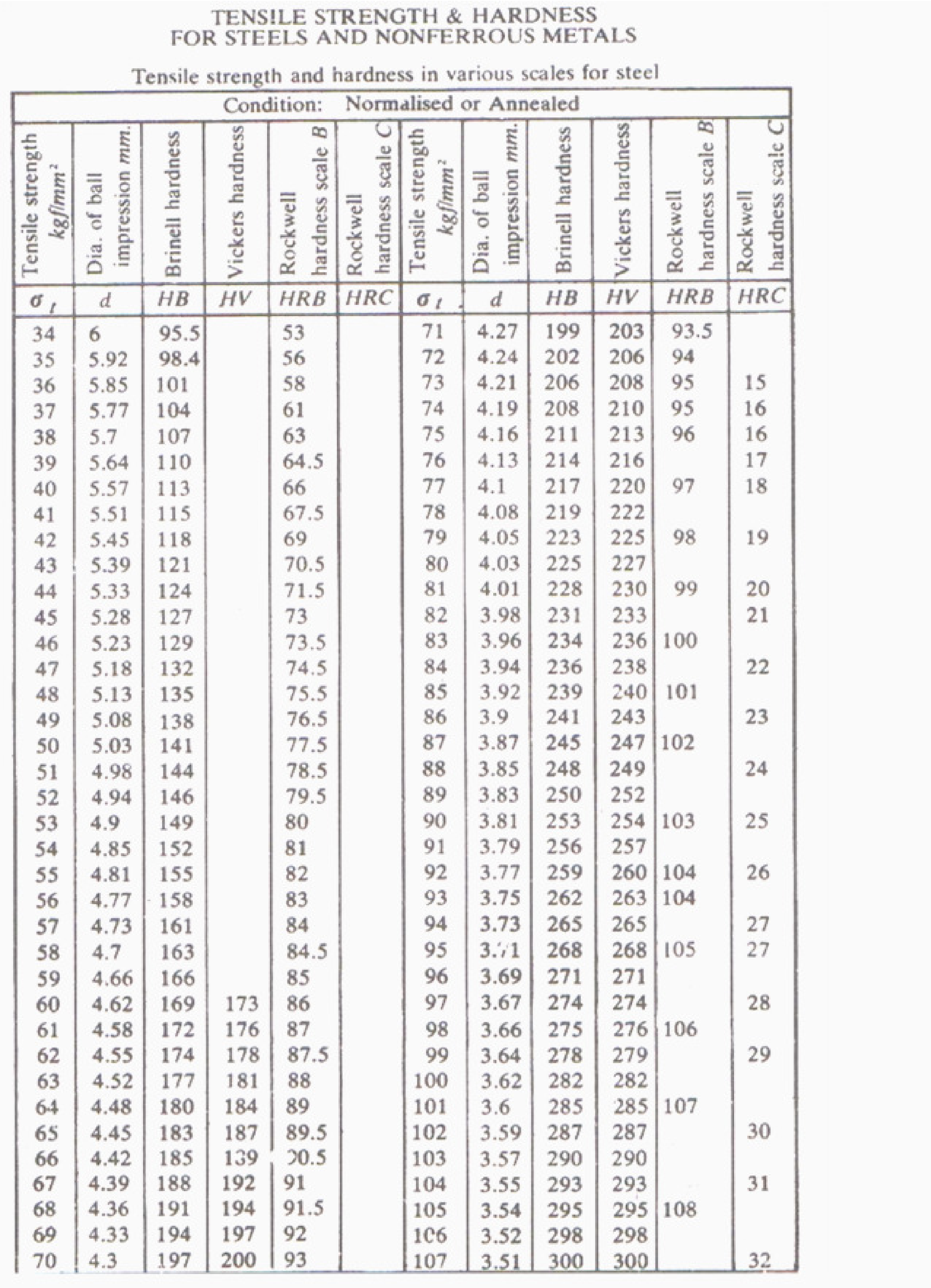
3B.12. PRECAUTIONS:

1. For testing cylindrical test specimens use V-type platform.
2. Calibrate the machine occasionally by using standard test blocks.
3. For thin metal prices place another sufficiently thick metal piece between the test specimen and the platform to avoid any damage, which may likely occur to the platform.
4. After applying major load wait for some time to allow the needle to come to rest. The waiting time may vary from 2 t0 8 seconds.
5. The surface of the test piece should be smooth and even and free from oxide scale and foreign matter.
6. Test specimen should not be subjected to any heating of cold working.
7. The distance between the canters of two adjacent indentation should be at least 4 times the diameter of the indentation and the distance from the center of any indentation to the edge of the test piece should be at least 2.5 times the diameter of the indentation.

3B.13. Viva Questions:

1. Define Hardness.
2. How the hardness will vary from hardened to unhardened steels.
3. What are the various methods of finding the hardness number of materials.

Reference Tables:



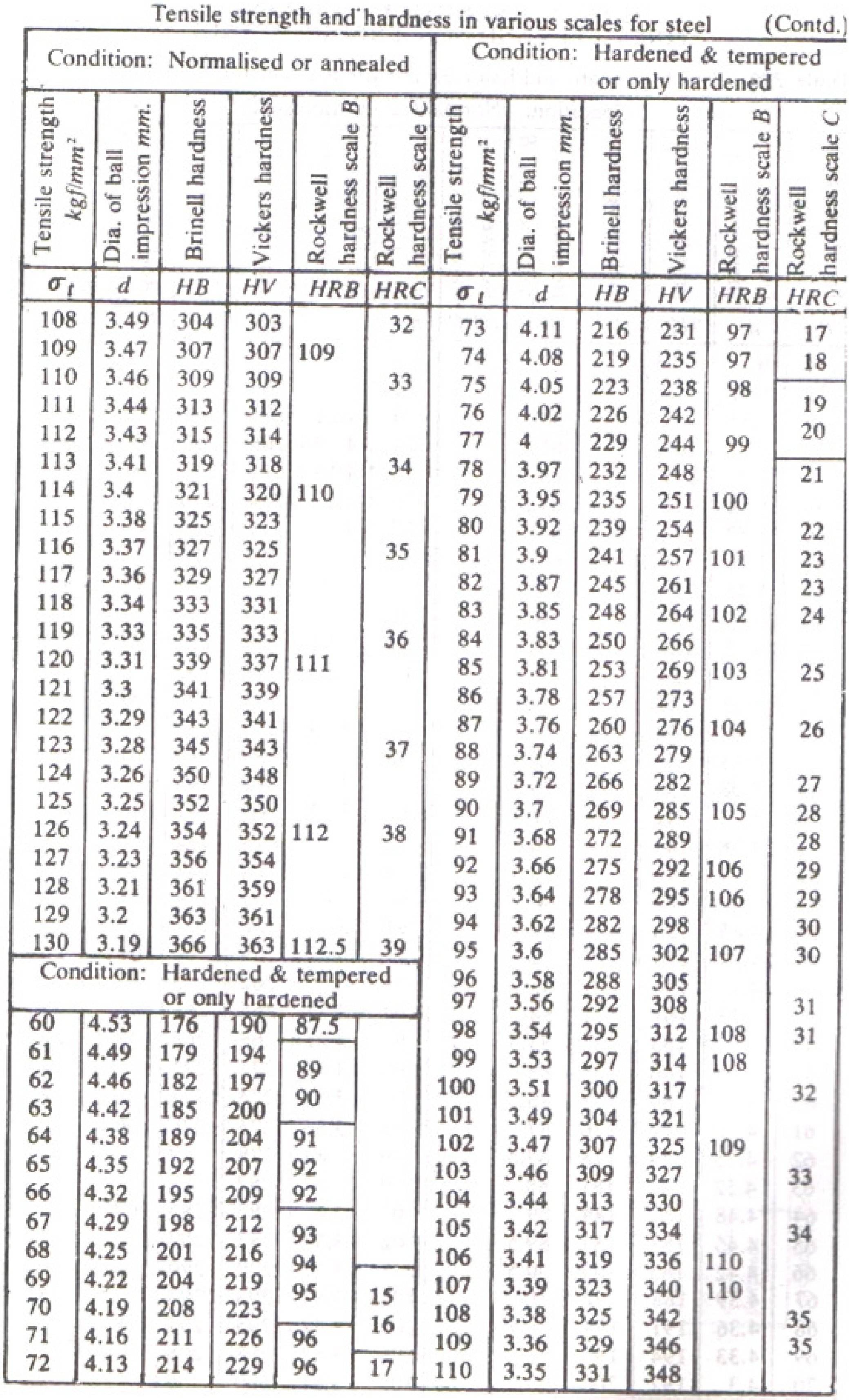
TENSILE STRENGTH & HARDNESS
FOR STEELS AND NONFERROUS METALS

Tensile strength and hardness in various scales for steel

Condition: Normalised or Annealed

Tensile strength *kgf/mm²*	Dia. of ball impression *mm.*	Brinell hardness	Vickers hardness	Rockwell hardness scale *B*	Rockwell hardness scale *C*	Tensile strength *kgf/mm²*	Dia. of ball impression *mm.*	Brinell hardness	Vickers hardness	Rockwell hardness scale *B*	Rockwell hardness scale *C*
σ_t	*d*	*HB*	*HV*	*HRB*	*HRC*	σ_t	*d*	*HB*	*HV*	*HRB*	*HRC*
34	6	95.5		53		71	4.27	199	203	93.5	
35	5.92	98.4		56		72	4.24	202	206	94	
36	5.85	101		58		73	4.21	206	208	95	15
37	5.77	104		61		74	4.19	208	210	95	16
38	5.7	107		63		75	4.16	211	213	96	16
39	5.64	110		64.5		76	4.13	214	216		17
40	5.57	113		66		77	4.1	217	220	97	18
41	5.51	115		67.5		78	4.08	219	222		
42	5.45	118		69		79	4.05	223	225	98	19
43	5.39	121		70.5		80	4.03	225	227		
44	5.33	124		71.5		81	4.01	228	230	99	20
45	5.28	127		73		82	3.98	231	233		21
46	5.23	129		73.5		83	3.96	234	236	100	
47	5.18	132		74.5		84	3.94	236	238		22
48	5.13	135		75.5		85	3.92	239	240	101	
49	5.08	138		76.5		86	3.9	241	243		23
50	5.03	141		77.5		87	3.87	245	247	102	
51	4.98	144		78.5		88	3.85	248	249		24
52	4.94	146		79.5		89	3.83	250	252		
53	4.9	149		80		90	3.81	253	254	103	25
54	4.85	152		81		91	3.79	256	257		
55	4.81	155		82		92	3.77	259	260	104	26
56	4.77	158		83		93	3.75	262	263	104	
57	4.73	161		84		94	3.73	265	265		27
58	4.7	163		84.5		95	3.71	268	268	105	27
59	4.66	166		85		96	3.69	271	271		
60	4.62	169	173	86		97	3.67	274	274		28
61	4.58	172	176	87		98	3.66	275	276	106	
62	4.55	174	178	87.5		99	3.64	278	279		29
63	4.52	177	181	88		100	3.62	282	282		
64	4.48	180	184	89		101	3.6	285	285	107	
65	4.45	183	187	89.5		102	3.59	287	287		30
66	4.42	185	139	90.5		103	3.57	290	290		
67	4.39	188	192	91		104	3.55	293	293		31
68	4.36	191	194	91.5		105	3.54	295	295	108	
69	4.33	194	197	92		106	3.52	298	298		
70	4.3	197	200	93		107	3.51	300	300		32

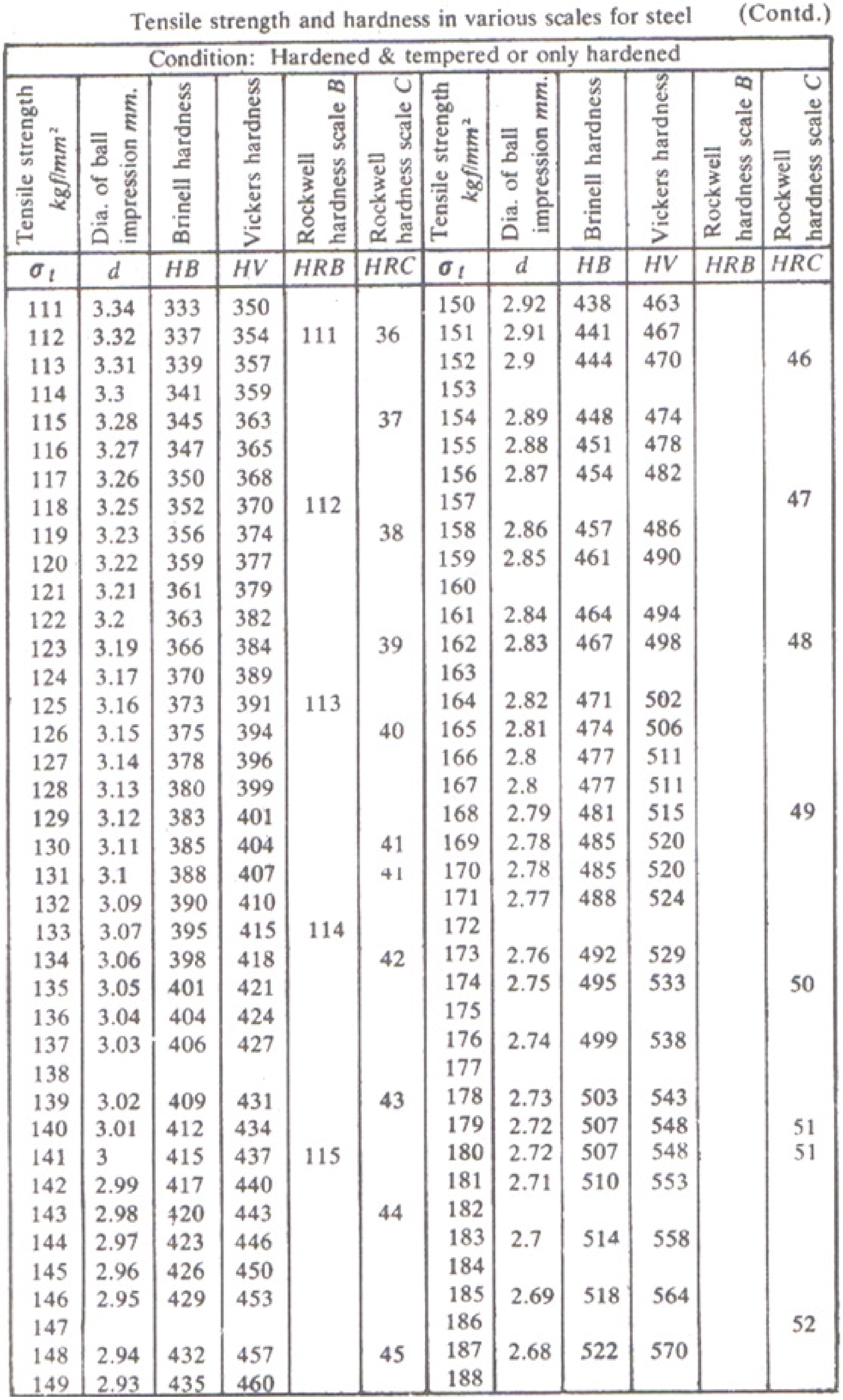
Table 3.0



Tensile strength and hardness in various scales for steel (Contd.)

Tensile strength kgf/mm^2	Dia. of ball impression *mm.*	Brinell hardness	Vickers hardness	Rockwell hardness scale *B*	Rockwell hardness scale *C*
σ_t	*d*	*HB*	*HV*	*HRB*	*HRC*
Condition: Normalised or annealed					
108	3.49	304	303		32
109	3.47	307	307	109	
110	3.46	309	309		33
111	3.44	313	312		
112	3.43	315	314		
113	3.41	319	318		34
114	3.4	321	320	110	
115	3.38	325	323		
116	3.37	327	325		35
117	3.36	329	327		
118	3.34	333	331		
119	3.33	335	333		36
120	3.31	339	337	111	
121	3.3	341	339		
122	3.29	343	341		
123	3.28	345	343		37
124	3.26	350	348		
125	3.25	352	350		
126	3.24	354	352	112	38
127	3.23	356	354		
128	3.21	361	359		
129	3.2	363	361		
130	3.19	366	363	112.5	39
Condition: Hardened & tempered or only hardened					
60	4.53	176	190	87.5	
61	4.49	179	194		
62	4.46	182	197	89	
63	4.42	185	200	90	
64	4.38	189	204	91	
65	4.35	192	207	92	
66	4.32	195	209	92	
67	4.29	198	212	93	
68	4.25	201	216	94	
69	4.22	204	219	95	
70	4.19	208	223		15
71	4.16	211	226	96	16
72	4.13	214	229	96	17
73	4.11	216	231	97	17
74	4.08	219	235	97	18
75	4.05	223	238	98	
76	4.02	226	242		19
77	4	229	244	99	20
78	3.97	232	248		21
79	3.95	235	251	100	
80	3.92	239	254		22
81	3.9	241	257	101	23
82	3.87	245	261		23
83	3.85	248	264	102	24
84	3.83	250	266		
85	3.81	253	269	103	25
86	3.78	257	273		
87	3.76	260	276	104	26
88	3.74	263	279		
89	3.72	266	282		27
90	3.7	269	285	105	28
91	3.68	272	289		28
92	3.66	275	292	106	29
93	3.64	278	295	106	29
94	3.62	282	298		30
95	3.6	285	302	107	30
96	3.58	288	305		
97	3.56	292	308		31
98	3.54	295	312	108	31
99	3.53	297	314	108	
100	3.51	300	317		32
101	3.49	304	321		
102	3.47	307	325	109	
103	3.46	309	327		33
104	3.44	313	330		
105	3.42	317	334		34
106	3.41	319	336	110	
107	3.39	323	340	110	
108	3.38	325	342		35
109	3.36	329	346		35
110	3.35	331	348		

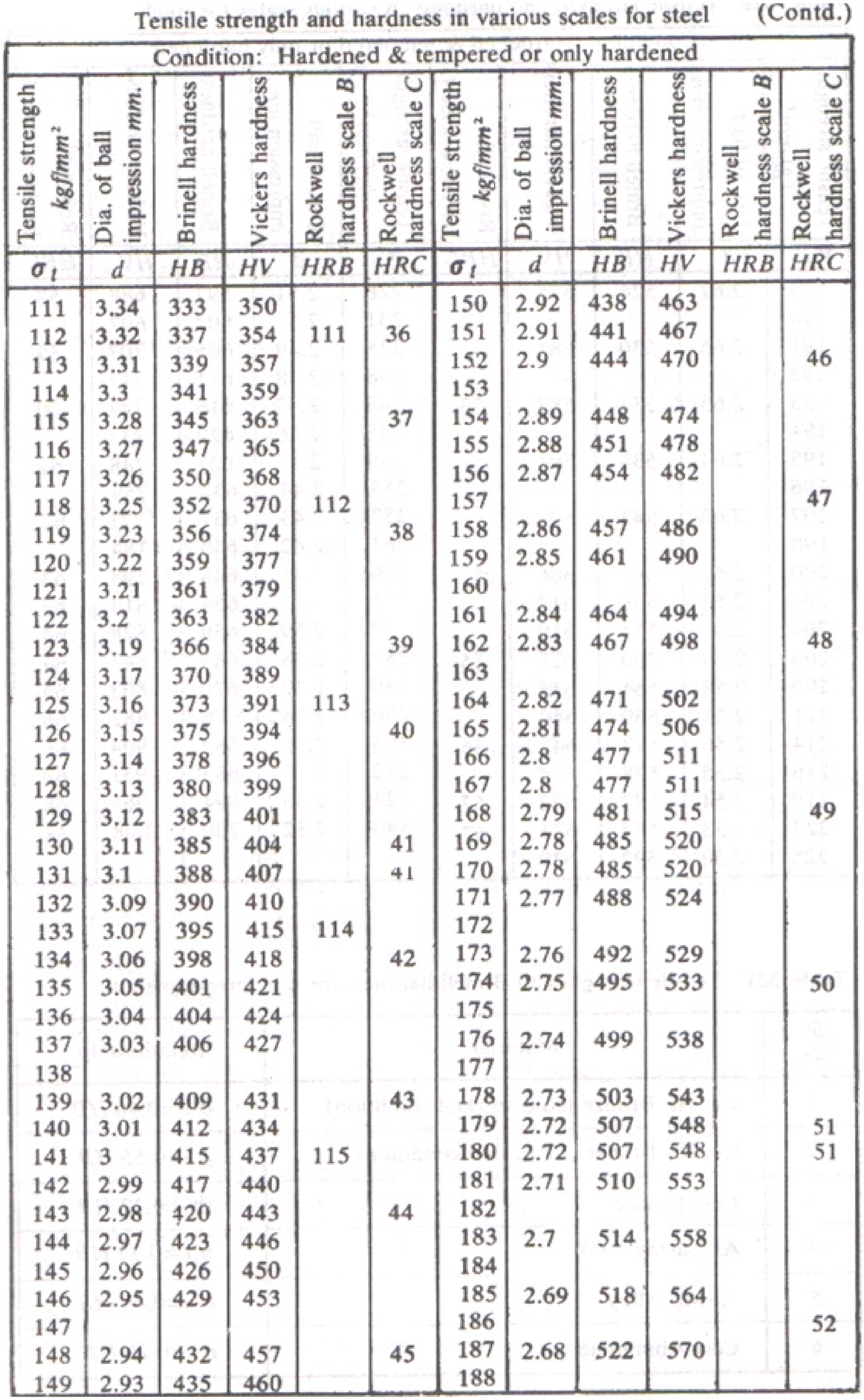
Table 3.1



Tensile strength and hardness in various scales for steel (Contd.)

Condition: Hardened & tempered or only hardened											
Tensile strength kgf/mm^2	Dia. of ball impression *mm.*	Brinell hardness	Vickers hardness	Rockwell hardness scale *B*	Rockwell hardness scale *C*	Tensile strength kgf/mm^2	Dia. of ball impression *mm.*	Brinell hardness	Vickers hardness	Rockwell hardness scale *B*	Rockwell hardness scale *C*
σ_t	*d*	*HB*	*HV*	*HRB*	*HRC*	σ_t	*d*	*HB*	*HV*	*HRB*	*HRC*
111	3.34	333	350			150	2.92	438	463		
112	3.32	337	354	111	36	151	2.91	441	467		
113	3.31	339	357			152	2.9	444	470		46
114	3.3	341	359			153					
115	3.28	345	363		37	154	2.89	448	474		
116	3.27	347	365			155	2.88	451	478		
117	3.26	350	368			156	2.87	454	482		
118	3.25	352	370	112		157					47
119	3.23	356	374		38	158	2.86	457	486		
120	3.22	359	377			159	2.85	461	490		
121	3.21	361	379			160					
122	3.2	363	382			161	2.84	464	494		
123	3.19	366	384		39	162	2.83	467	498		48
124	3.17	370	389			163					
125	3.16	373	391	113		164	2.82	471	502		
126	3.15	375	394		40	165	2.81	474	506		
127	3.14	378	396			166	2.8	477	511		
128	3.13	380	399			167	2.8	477	511		
129	3.12	383	401			168	2.79	481	515		49
130	3.11	385	404		41	169	2.78	485	520		
131	3.1	388	407		41	170	2.78	485	520		
132	3.09	390	410			171	2.77	488	524		
133	3.07	395	415	114		172					
134	3.06	398	418		42	173	2.76	492	529		
135	3.05	401	421			174	2.75	495	533		50
136	3.04	404	424			175					
137	3.03	406	427			176	2.74	499	538		
138						177					
139	3.02	409	431		43	178	2.73	503	543		
140	3.01	412	434			179	2.72	507	548		51
141	3	415	437	115		180	2.72	507	548		51
142	2.99	417	440			181	2.71	510	553		
143	2.98	420	443		44	182					
144	2.97	423	446			183	2.7	514	558		
145	2.96	426	450			184					
146	2.95	429	453			185	2.69	518	564		
147						186					52
148	2.94	432	457		45	187	2.68	522	570		
149	2.93	435	460			188					

Table 3.2



Tensile strength and hardness in various scales for steel (Contd.)

Condition: Hardened & tempered or only hardened											
Tensile strength kgf/mm^2	Dia. of ball impression *mm.*	Brinell hardness	Vickers hardness	Rockwell hardness scale *B*	Rockwell hardness scale *C*	Tensile strength kgf/mm^2	Dia. of ball impression *mm.*	Brinell hardness	Vickers hardness	Rockwell hardness scale *B*	Rockwell hardness scale *C*
σ_t	*d*	*HB*	*HV*	*HRB*	*HRC*	σ_t	*d*	*HB*	*HV*	*HRB*	*HRC*
111	3.34	333	350			150	2.92	438	463		
112	3.32	337	354	111	36	151	2.91	441	467		
113	3.31	339	357			152	2.9	444	470		46
114	3.3	341	359			153					
115	3.28	345	363		37	154	2.89	448	474		
116	3.27	347	365			155	2.88	451	478		
117	3.26	350	368			156	2.87	454	482		
118	3.25	352	370	112		157					47
119	3.23	356	374		38	158	2.86	457	486		
120	3.22	359	377			159	2.85	461	490		
121	3.21	361	379			160					
122	3.2	363	382			161	2.84	464	494		
123	3.19	366	384		39	162	2.83	467	498		48
124	3.17	370	389			163					
125	3.16	373	391	113		164	2.82	471	502		
126	3.15	375	394		40	165	2.81	474	506		
127	3.14	378	396			166	2.8	477	511		
128	3.13	380	399			167	2.8	477	511		
129	3.12	383	401			168	2.79	481	515		49
130	3.11	385	404		41	169	2.78	485	520		
131	3.1	388	407		41	170	2.78	485	520		
132	3.09	390	410			171	2.77	488	524		
133	3.07	395	415	114		172					
134	3.06	398	418		42	173	2.76	492	529		
135	3.05	401	421			174	2.75	495	533		50
136	3.04	404	424			175					
137	3.03	406	427			176	2.74	499	538		
138						177					
139	3.02	409	431		43	178	2.73	503	543		
140	3.01	412	434			179	2.72	507	548		51
141	3	415	437	115		180	2.72	507	548		51
142	2.99	417	440			181	2.71	510	553		
143	2.98	420	443		44	182					
144	2.97	423	446			183	2.7	514	558		
145	2.96	426	450			184					
146	2.95	429	453			185	2.69	518	564		
147						186					52
148	2.94	432	457		45	187	2.68	522	570		
149	2.93	435	460			188					

Table 3.3

EXPERIMENT 4

EXPERIMENT NO – 04: SPRING TEST

4.1 OBJECTIVE: To determine the stiffness and modulus of rigidity of the spring wire.

4.2 APPARATUS: -

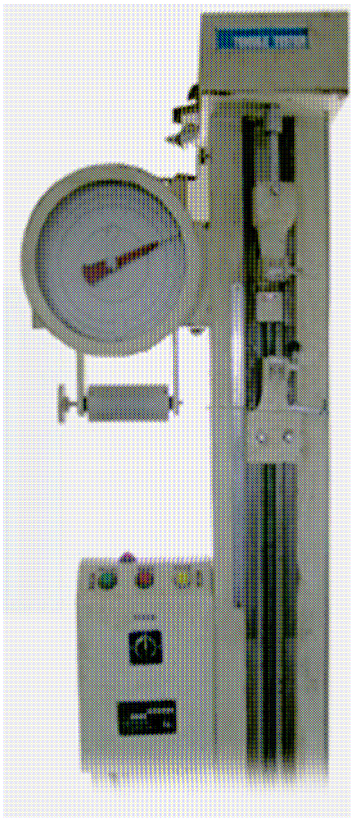
i) Spring testing machine.

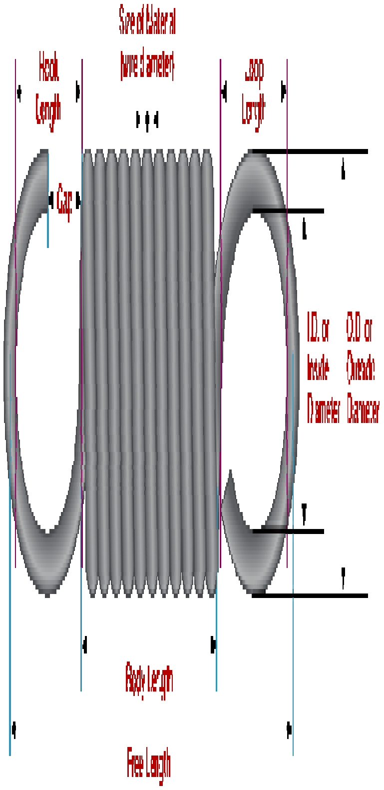
ii) A spring

iii) Vernier caliper, Scale.

iv) Micrometer.

4.3 DIAGRAM:-





4.4 M/C SPECIFICATIONS:

Capacity: 0-250 Kgf.

Model: MX-250

SR.No: 2001/1001.

Mfd. By: Macro Testing Machines, Ichalkaranji, M.H, India.

4.5 THEORY: -

Springs are elastic member which distort under load and regain their original shape when load is removed. They are used in railway carriages, motor cars, scooters, motorcycles, rickshaws, governors etc. According to their uses the springs perform the following Functions:

1) To absorb shock or impact loading as in carriage springs.
2) To store energy as in clock springs.
3) To apply forces to and to control motions as in brakes and clutches.
4) To measure forces as in spring balances.
5) To change the variations characteristic of a member as in flexible mounting of motors.

The spring is usually made of either high carbon steel (0.7 to 1.0%) or medium carbon alloy steels. Phosphor bronze, brass, 18/8 stainless steel and Monel and other metal alloys are used for corrosion resistance spring. Several types of spring are available for different application. Springs may classified as helical springs, leaf springs and flat spring depending upon their shape. They are fabricated of high shear strength materials such as high carbon alloy steels spring form elements of not only mechanical system but also structural system. In several cases it is essential to idealise complex structural systems by suitable spring.

4.6 PROCEDURE:

1) Measure the outer diameter (D) and diameter of the spring coil (d) for the given compression spring.
2) Count the number of turns i.e. coils (n) in the given compression specimen.
3) Place the compression spring at the centre of the bottom beam of the spring testing machine.
4) Insert the spring in the spring testing machine and load the spring by a suitable weight and note the corresponding axial deflection in tension or compression.
5) Note down the initial reading from the scale in the machine.
6) Increase the load and take the corresponding axial deflection readings.
7) Find the actual deflection of the spring for each load by deducting the initial scale reading from the corresponding scale reading.
8) Calculate the modulus of rigidity for each load applied.
9) Plot a curve between load and deflection. The shape of the curve gives the stiffness of the spring.

4.7 FORMULA:

Modulus of rigidity, $G = \dfrac{64WR^3 n}{\delta d^4}$

Where,

i. W = Load in N

ii. R = Mean radius of the spring in mm (D –(d /2))/2

iii. d = Diameter of the spring coil in mm

iv. δ = Deflection of the spring in mm

v. D = Outer diameter of the spring in mm.

4.8 OBESERVATIONS:

1) Material of the spring specimen =
2) Least count of micrometer = ……...mm
3) Diameter of the spring wire, d =………mm
   (Mean of three readings)
4) Least count of Vernier Caliper = ……...mm
5) Diameter of the spring coil, D = ……...mm
   (Mean of three readings)
6) Number of turns, n =
7) Initial scale reading = ……...mm

4.9 TABULATION: (Refer Tables)

S.No.	Applied Load		Scale Reading, mm	Actual Deflection, mm	Modulus of Rigidity, GPa	Stiffness, N/mm
	Kg	N				
1						
2						
3						
4						
5						

4.10 RESULT:

The modulus of rigidity of the given spring = ------------------- GPa

The stiffness of the given spring = -------------------N/mm^2

4.11 GRAPH:

1. **Load Vs Deflection**

4.12 PRECAUTIONS:-

1) Dimensions should be measure accurately with the help of Vernier Calipers.

2) Deflection from the scale should be noted carefully and accurately.

4.12 VIVA QUESTIONS:-

1. Define stiffness of a material.

2. Explain various types of springs.

3. How modulus of rigidity of a same material will vary with varying dimensions?

Properties of common spring materials (Adopted from ace wire spring and form company)

	Material	Nominal Analysis	Tensile	Properties	Torsional	Properties	Max. Operating Temp. °F	Max. Operating Temp. °C	Rockwell hardness>	Method of Manufacture Chief uses Special Properties
			Minimum Tensile Strength	Modulus of Elasticity E	Design Stress % Min. Tensile	Modulus in Torsion G				
			psi x 10^3 (MPa)	psi x 10^6 (MPa x 10^3)		psi x 10^6 (MPa x 10^3)				
High Carbon Spring Wire	Music Wire ASTM A 228	C 0.70-1.00% Mn 0.20-0.60%	230-399 (1586-2751)	30 (207)	45	11.5 (79.3)	250	121	C41-60	Cold drawn high and uniform tensile. High quality springs and wire forms. Suitable for cyclic applications
	Hard Drawn ASTM A 227	C 0.45-0.85% Mn 0.60-1.30%	CLI 147-283 (1014-1951) CLII 171-324 (1179-2234)	30 (207)	40	11.5 (79.3)	250	121	C31-52	Cold drawn. Average stress applications. Lower cost springs and wire forms.
	High Tensile Hard Drawn ASTM A 679	C 0.65-1.00% Mn 0.20-1.30%	238-350 (1641-2413)	30 (207)	45	11.5 (79.3)	250	121	c31-52	Cold Drawn. Higher Quality springs and wire forms.
	Oil Tempered ASTM A 229	C 0.55-0.85% Mn 0.60-1.20%	CLI 165-293 (1138-2020) CLII 191-324 (1317-2234)	30 (207)	45	11.5 (79.3)	250	121	C42-55	Cold drawn and heat treated before fabrication. General purpose spring wire.
	Carbon Valve ASTM A 230	C 0.60-0.75% Mn 0.60-0.90	215-240 (1482-1655)	30 (207)	45	11.5 (79.3)	250	121	C45-49	Cold drawn and heat treated before fabrication. Good surface conditionand uniform tensile. Suitable for cyclic applications
Alloy Steel Wire	Chrome Vanadium ASTM A 231	C 0.48-0.53% Cr 0.80-1.10% V 0.15 min %	190-300 (1310-2069)	30 (207)	45	11.5 (79.3)	425	218.5	C41-55	Cold drawn and ehat treated before fabrication. Used for shock loads and moderately elevated temperature.
	Chrome Silicon ASTM A 401	C 0.51-0.59% Cr 0.60-0.80% Si 1.20-1.60%	235-300 (1620-2069)	30 (207)	45	11.5 (79.3)	475	246	C48-55	Cold drawn and heat treated before fabrication. Used for shock loads and moderately elevated temperature.
Stainless Steel Wire	AISI 302/304 ASTM A 313	Cr 17.-19.% Ni 8.-10.%	125-325 (862-2241)	28 (193)	35	10 (69.0)	550	288	C35-45	Cold drawn general purpose corrosion and heat resistant. Magnetic in spring tempor.
	AISI 316 ASTM A 313	Cr 16.-18% Ni 10.-14.% Mo 2.-3.%	110-245 (758-1689)	28 (193)	40	10 (69.0)	550	288	C35-45	Cold drawn. Heat resistant and better corrosion resistance than 302. Magnetic in spring tempor.
	17-7 PH ASTM A 313 (631)	Cr 16.-18.% Ni 10.-14.% Al 0.75-1.5%	Cond CH 235-335 (1620-2310)	29.5 (203)	45	11 (78.5)	650	343	C38-57	Cold drawn and precipitation hardened afeter fabrication. High strength and general purpose corrosion resistance. Slightly magnetic in spring tempor.
Non-Ferrous Alloy Wire	Phosphor Bronze Grade A ASTM B 159	Cu 94.-96.% Sn 4.-6.%	105-145 (724-1000)	15 (103)	40	6.25 (43.1)	200	93.3	B98-104	Cold drawn. Good corrosion resistance and electrical conductivity.
	Berylium Copper ASTM B 197	Cu 98% Be 2%	150-230 (1034-1586)	18.5 (128)	45	7.0 (48.3)	400	204	C35-42	Cold drawn and may be mill hardened before fabrication. Good corrosion resistance and electrical conductivit. High physicals.
	Monel 400 AMS 7233 Monel K 500 QQ-N-286^3	Ni 66% Cu 31.5% C/Fe Ni 65.0% Cu 29.5% C/Fe/Al/Ti	145-180 (1000-1241) 160-200 (1103-1379)	26 (179) 26 (179)	40 40	9.5 (65.5) 9.5 (65.5)	450 550	232 28	C23-32 C23-35	Cold drawn. Good corrosion resistance at moderately elevated termperature. Excellent corrosion resistance at moderately elevated temperature.
High temperature Alloy Wire	A 286 Alloy	Ni 26.% Cr 15.% Fe 53.%	160-200 (1103-1379)	29 (200)	35	10.4 (71.7)	950	510	C35-42	Cold drawn and precipitation hardened after fabrication. Good corrosion resistance at elevated temperature.
	Inconel 600 QQ-W-390^3	Ni 76.% Cr 15.8% Fe 7.2%	170-230 (1172-1586)	31 (214)	40	11.0 (75.8)	700	371	C35-45	Cold drawn. Good corrosion resistance at elevated temperature.
	Inconel 718	Ni 52.5% Cr 18.6% Fe 18.5%	210-250 (1448-1724)	29 (200)	40	11.2 (77.2)	1100	593	C45-50	Cold drawn and precipitation hardened after fabrication. Good corrosion resistance at elevated temperature.
	Inconel x 750 AMS 5698, 5699	Ni 73.% Cr 15.% Fe 6.75%	No. IT 155 Min. 1069 Spg T 190-230 (1310-1586)	31 (214)	40	12 (82.7)	750-1100	399-593	C34-39 C42-48	Cold drawn and precipitation hardened after fabrication. Good corrosion resistance at elevated temperature.

EXPERIMENT 5

EXPERIMENT NO – 05: COMPRESSION TEST ON CUBE

5.1 OBJECTIVE:- To perform compression test on UTM.

5.2 APPARATUS:-

1. UTM or A compression testing m/c,
2. Cylindrical or cube shaped specimen,
3. Vernier caliper,
4. Liner scale.

5.3 DIAGRAM:-

5.4 THEORY:-

Bricks are used in construction of either load bearing walls or in portion walls incase of frame structure. In bad bearing walls total weight from slab and upper floor comes directly through brick and then it is transversed to the foundation. In case the bricks are loaded with compressive nature of force on other hand in case of frame structure bricks are used only for construction of portion walls, layers comes directly on the lower layers or wall. In this case bricks are loaded with compressive nature of force. Hence for safely measures before using the bricks in actual practice they have to be tested in laboratory for their compressive strength.

5.5 PROCEDURE: -

1. Select some brick with uniform shape and size.
2. Measure its all dimensions. (LxBxH)
3. Now fill the frog of the brick with fine sand. And
4. Place the brick on the lower platform of compression testing machine and lower the spindle till the upper motion of ram is offered by a specimen the oil pressure start increasing the pointer start returning to zero leaving the drug pointer that is maximum reading which can be noted down.

5.6 TABULATION:- (Refer Tables)

S. No.	L x B x H, Cm^3	Area, L x B, Cm^2	Load (P), N	Compressive Strength (P/A), KPa	Avg. Compressive Strength (P/A), KPa
1					
2					
3					
4					
5					

5.7 CALCULATION:-

$$\text{Compressive Strength} = \frac{\text{Max. Load at failure}}{\text{Loaded Area of brick}}\ \textbf{KPa}$$

5.8 RESULT:- The average compressive strength of new brick sample is found to be ………. **KPa**

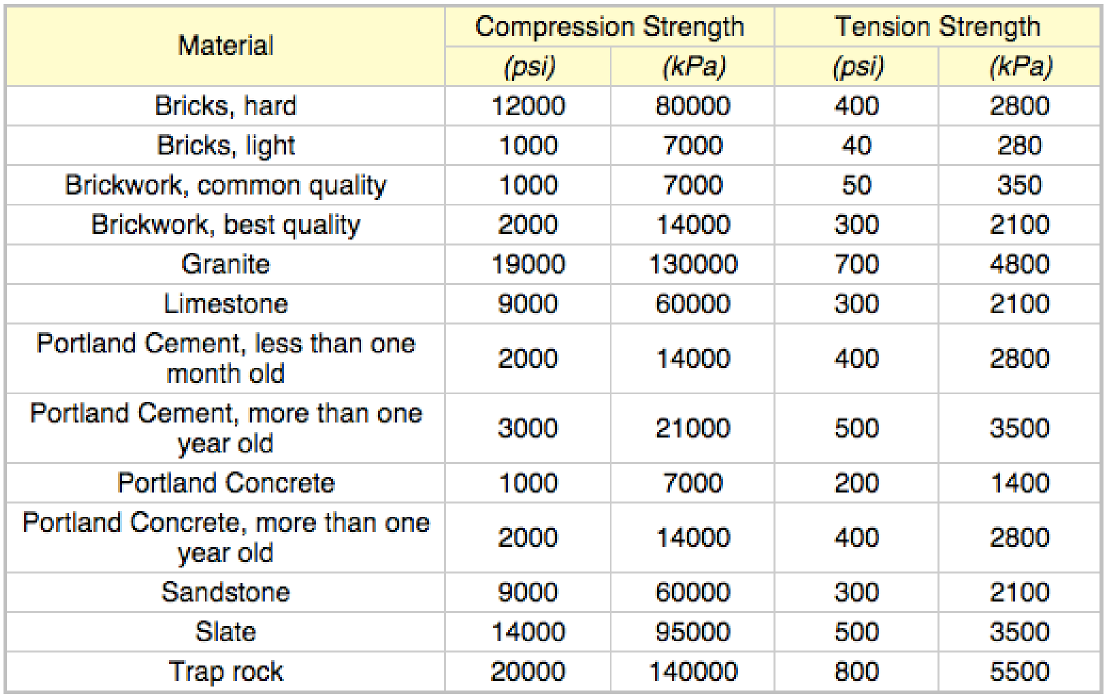
5.9 PRECAUTIONS:-

1) Measure the dimensions of Brick accurately.

2) Specimen should be placed as for as possible in the of lower plate.

3) The range of the gauge fitted on the machine should not be more than double the breaking load of specimen for reliable results.

5.10 Compressive and tensile strength of some common materials:



Material	Compression Strength		Tension Strength	
	(psi)	*(kPa)*	*(psi)*	*(kPa)*
Bricks, hard	12000	80000	400	2800
Bricks, light	1000	7000	40	280
Brickwork, common quality	1000	7000	50	350
Brickwork, best quality	2000	14000	300	2100
Granite	19000	130000	700	4800
Limestone	9000	60000	300	2100
Portland Cement, less than one month old	2000	14000	400	2800
Portland Cement, more than one year old	3000	21000	500	3500
Portland Concrete	1000	7000	200	1400
Portland Concrete, more than one year old	2000	14000	400	2800
Sandstone	9000	60000	300	2100
Slate	14000	95000	500	3500
Trap rock	20000	140000	800	5500

Image credit: http://www.engineeringtoolbox.com/compression-tension-strength-d_1352.html

EXPERIMENT 6

6a) IMPACT TEST (IZOD)

6A.1 AIM: - To Determine the impact strength of steel by Izod impact test

6A.2 APPARATUS: - 1.Impact testing machine

2. A steel specimen 75 mm X 10mm X 10mm

6A.3 DIAGRAM:-

6A.4 M/C SPECIFICATIONS:

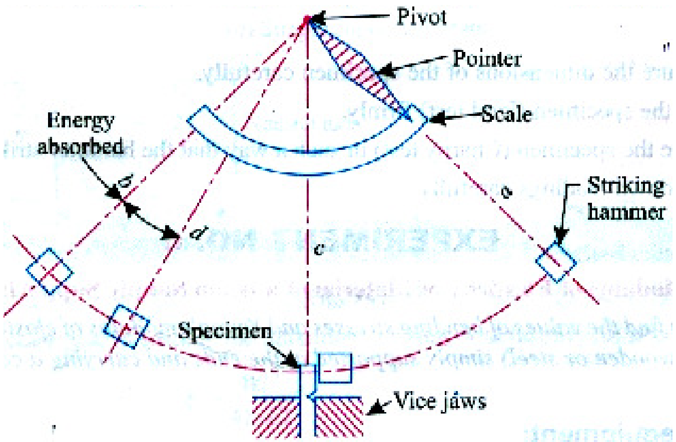
Capacity: Energy range: i. Charpy: 0-300 J.

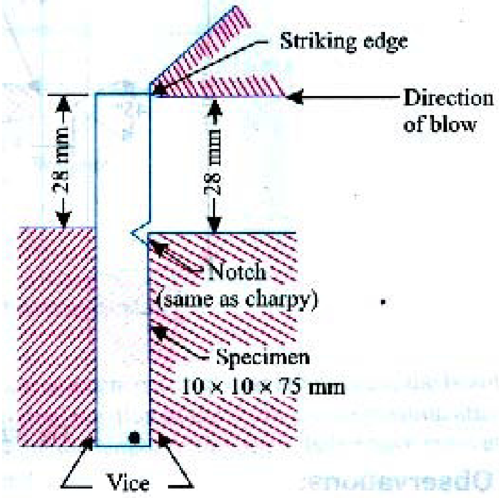
ii. Izod: 0-168 J.

Model: ITM-300

SR.No: 2001/1016.

Mfd. By: Macro Testing Machines, Ichalkaranji, M.H, India.





6A.5 THEORY:-

An impact test signifies toughness of material that is ability of material to absorb energy during plastic deformation. Static tension tests of unnotched specimens do not always reveal the susceptibility of a metal to brittle fracture. This important factor is determined by impact test. Toughness takes into account both the strength and ductility of the material. Several engineering materials have to withstand impact or suddenly applied 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 notch bar tests are most extensively used. Therefore, the impact test measures the energy necessary to fracture a standard notch bar by applying an impulse load. The test measures the notch toughness of material under shock 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 the same material under different condition. This test can also be used to assess the ductile brittle transition temperature of the material occurring due to lowering of temperature.

6A.6 PROCEDURE:-

(a) lzod test

1. With the striking hammer (pendulum) in safe test position, firmly hold the steel specimen in impact testing machine's vice in such a way that the notch face the hammer and is half inside and half above the top surface of the vice.

2. Bring the striking hammer to its top most striking position unless it is already there, and lock it at that position.

3. Bring indicator of the machine to zero, or follow the instructions of the operating manual supplied with the machine.

4. Release the hammer. It will fall due to gravity and break the specimen through its momentum, the total energy is not absorbed by the specimen. Then it continues to swing. At its topmost height after breaking the specimen, the indicator stops moving, while the pendulum falls back. Note the indicator at that topmost final position.

5. Again bring back the hammer to its idle position and back

6A.7 OBESERVATIONS:-

Izod Test.

1. Impact value of - Mild Steel ------------N-m

2. Impact value of - Brass ------------N-m

3. Impact value of - Aluminum ------------N-m

6A.8 RESULT:-

i. The energy absorbed for Mild Steel is found out to be (K) ----------------Joules.

ii. The energy absorbed for Brass is found out to be (K) ------------------- Joules.

iii. The energy absorbed for Aluminium is found out to be (K) ------------------ Joules

iv. Impact strength of the specimen, (K/A) = -------------------J/mm^2

6A.9 PRECAUTIONS:-

1. Measure the dimensions of the specimen carefully.

2. Hold the specimen (lzod test) firmly.

3. Note down readings carefully.

EXPERIMENT NO – 06: b) IMPACT TEST (CHARPY)

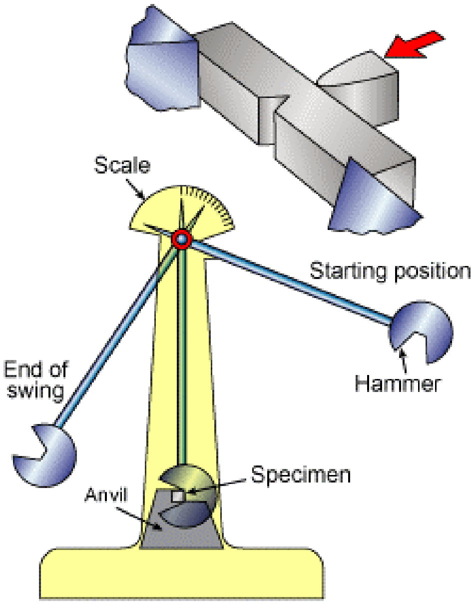
6B.1 AIM: -To determined impact strength of steel**.**

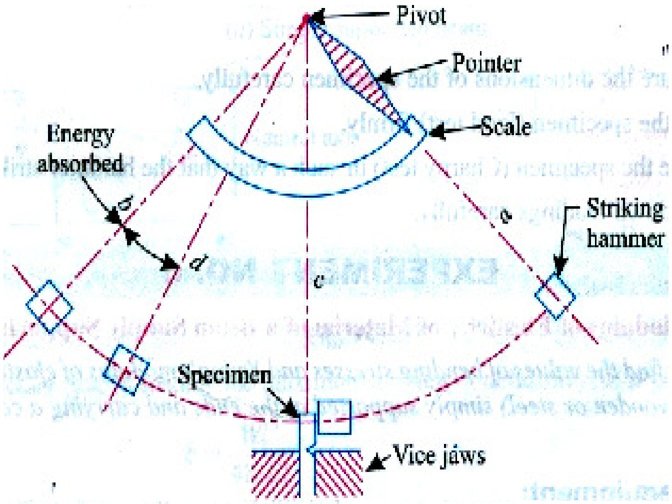
6B.2 OBJECT: -To Determine the impact strength of steel by (Charpy test)

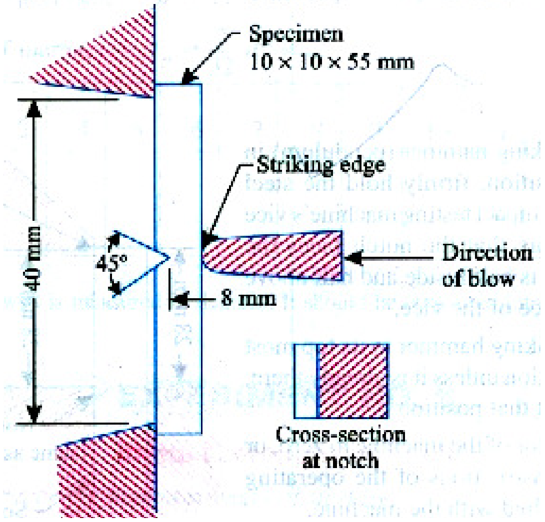
6B.3 APPARATUS: -1. Impact testing machine

2. A steel specimen 10 mm x 10 mm X 55mm

6B.4 DIAGRAM:-







6B.5 THEORY:-

An impact test signifies toughness of material that is ability of material to absorb energy during plastic deformation. Static tension tests of unmatched specimens do not always reveal the susceptibility of a metal to brittle fracture. This important factor is determined by impact test. Toughness takes into account both the strength and ductility of the material. Several engineering materials have to withstand impact or suddenly applied 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 notch bar tests are most extensively used. Therefore, the impact test measures the energy necessary to fracture a standard notch bar by applying an impulse load. The test measures the notch toughness of material under shock 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 the same material under different condition. This test can also be used to assess the ductile brittle transition temperature of the material occurring due to lowering of temperature.

6B.6 PROCEDURE :-

(b) Charpy Test

1. With the striking hammer (pendulum) in safe test position, firmly hold the steel specimen in impact testing machines vice in such a way that the notch faces s the hammer and is half inside and half above the top surface of the vice.

2. Bring the striking hammer to its top most striking position unless it is already there, and lock it at that position.

3. Bring indicator of the machine to zero, or follow the instructions of the operating manual supplied with the machine.

4. Release the hammer. It will fall due to gravity and break the specimen through its momentum, the total energy is not absorbed by the specimen. Then it continues to swing. At its topmost height after breaking the specimen, the indicator stops moving, while the pendulum falls back. Note the indicator at that topmost final position.

5. The specimen is placed on supports or anvil so that the blow of hammer is opposite to the notch.

6B.7 OBESERVATIONS:-

Charpy test

1. Impact value of - Mild Steel ------------N-m
2. Impact value of - Brass ------------N-m
3. Impact value of - Aluminum ------------N-m

6B.8 RESULT:-

i.The energy absorbed for Mild Steel is found out to be (K)-------------Joules.

ii. The energy absorbed for Brass is found out to be (K)------------ Joules.

iii. . The energy absorbed for Aluminum is found out to be (K) -------------Joules

iv. Impact strength of the specimen, (K/A) = -------------------J/mm^2

6B.9 PRECAUTIONS:-

1. Measure the dimensions of the specimen carefully.
2. Locate the specimen (Charpy test) in such a way that the hammer, strikes it at the middle.
3. Note down readings carefully.

6B.10 VIVA QUESTIONS:

1. Define toughness.

2. What is the difference between notched and unnotched specimens?

3. What will be the possible oscillations of a pendulum after hitting the specimen?

EXPERIMENT 7

7.1 AIM: -To find the shear strength of given specimen

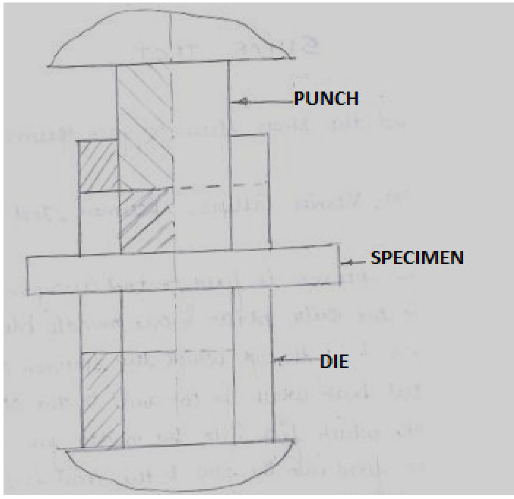
7.2 APPARATUS: -

i) Universal testing machine.

ii) Shear test attachment.

iii) Specimens.

7.3 DIAGRAM:-



7.4 THEORY:-

Place the shear test attachment on the lower table, this attachment consists of cutter. The specimen is inserted in shear test attachment & lift the lower table so that the zero is adjusted, then apply the load such that the specimen breaks in two or three pieces. If the specimen breaks in two pieces then it will be in single shear & if it breaks in three pieces then it will be in double shear.

7.5 PROCEDURE:

1. Insert the specimen in position and grip one end of the attachment in the upper portion and one end in the lower portion.
2. Switch on the main switch of universal testing machine machine.
3. The drag indicator in contact with the main indicator.
4. Select the suitable range of loads and space the corresponding weight in the pendulum and balance it if necessary with the help of small balancing weights.
5. Operate (push) buttons for driving the motor to drive the pump.
6. Gradually move the head control level in left-hand direction till the specimen shears.
7. Down the load at which the specimen shears.
8. Stop the machine and remove the specimen

Repeat the experiment with other specimens.

7.6 OBESERVATIONS:-

Diameter of the Rod, D = ….. mm

Cross-section area of the Rod (in double shear) = 2x $\pi/4$x d^2 =.. mm^2

Load taken by the Specimen at the time of failure , W =   N

Strength of rod against Shearing = fx2x $\pi/4$x d^2

f = **W / 2.π/4.d^2** N/mm^2

7.7 RESULT:

The Shear strength of mild steel specimen is found to be = ……………… N/mm2

7.8 PRECAUTIONS:-

1. The measuring range should not be changed at any stage during the test.

2. The inner diameter of the hole in the shear stress attachment should be slightly greater than that of the specimen.

3. Measure the diameter of the specimen accurately.

7.9 VIVA QUESTIONS:

1. Define shear stress.
2. Give the classification of stress.
3. What is the relationship between G and E.