Solid Mechanics Laboratory

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CERTIFICATE

This is to certify that this is a bonafide record of practical work done by

Mr/Ms________________________ __Reg.No.__________________________

of II B.Tech ____________ Semester in the of Solid Mechanics Laboratory

during the academic year_________________

Faculty In charge External Examiner

Solid Mechanics Laboratory

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EXPERIMENT NO:
DATE:

BRINNELL'S HARDNESS TEST

AIM: To find the Brinnel's hardness number of the given metals using Brinell's hardness testing machine.

APPARATUS: Brinell's hardness tester, Optical microscope.

THEORY: Hardness of a material is generally defined as Resistance to Permanent indentation under static or dynamic loads. However it also refers to stiffness or to resistance to scratching, abrasion or cutting. Indentation hardness maybe measured by various hardness tests, such as Rockwell, Vickers, Brinnells hardness etc. In brinnel's hardness test, a hard steel ball, under specified conditions of load and time, is forced into the surface of the material under test and the diameter of the impression is measured. Hardness number is defined as the load in kilograms per square millimeters of the surface area of indentation. This number depends on the magnitude of the load applied, material and geometry of the indentor.

For the Brinnels hardness number, the diameter of the indentor and load shall be taken from the following table:

Ball dia (D)	Load kilograms		
	Ferrous metals	Non-ferrous metals	
	Steel& iron 30 D^2	Brass 10 D^2	Aluminum 5 D^2
10 mm	3000	1000	500
5 mm	750	250	______

Brinnels hardness number (HB) is given by

$$HB = \frac{\text{Load on ball in kg}}{\text{Surface area of indentation in mm}^2}$$

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

Where: P=load in kg

D=diameter of indenter in 10 mm

d=average diameter of impression in mm

PROCEDURE:

- Select the proper diameter of the indentor and load.
- Start the machine by pushing the green button of starter and allow oil to circulate for few minutes.
- Keep the hand lever in position A.
- Place the specimen securely on the testing table. Turn the hand wheel in clockwise direction, so that the specimen will push the indentor and will show a reading on dial gauge. The movement will continue until the long pointer will stop at '0' and small pointer at red dot when the initial load of 250kg is applied. If little error exists the same can be adjusted by rotating the outer ring dial gauge.
- Turn the handle from position 'A' to 'B' so that the total system is brought into action.
- When the long pointer of dial gauge reaches a steady position, the load may be released by taking back the lever to position 'A'.
- Turn back the hand wheel and remove the specimen.
- The diameter of the impression can be found by using optical microscope.
- Read the hardness number from the tables.

OBSERVATIONS:

Table: 1.1

S.No	Material	Load kgf	Diameter of impression(mm)	BHN(kg/mm^2)
1				
2				
3				
4				

Model Table

S.No	Material	Load kgf	Diameter of impression(mm)	BHN(kg/mm^2)
1.	EN-8	3000	5	144.6
2.	EN-24	3000	4.4	142.6
3.	Stainless steel(SS)	3000	4.8	155.2
4.	Aluminum(Al)	500	3	69.15

Important Viva Questions:

1. What is the relation between Brinnel’s hardness number and Rockwell’s hardness number?

PRECAUTIONS:

1. Operate the hand lever from A to B several times to raise and lower the weights in order to eliminate air from the hydraulic system.
2. Operate it slowly for accurate results.

RESULT:

The Brinnel's hardness number of EN-8 ________________

The Brinnel's hardness number of EN-24 _______________

The Brinnel's hardness number of Stain less Steel __________

The Brinnel's hardness number of Aluminum ____________

BRINNELL'S HARDNESS TESTING MACHINE

EXPERIMENT NO:
DATE:

ROCKWELL'S HARDNESS TEST

AIM: To determine Rockwell hardness number for a given specimen.

APPARATUS: Rockwell hardness testing machine.

THEORY:

The Rockwell test is similar to Brinnel's test. In that the hardness number found is a function of degree of indentation of test piece and the action of an indenter under a given static load. Various loads and indentor are used depending on the condition of given static load. It differs from the Brinnel's test in that the loads are smaller and hence resulting indentation is smaller and shallower. It is applicable in testing of materials beyond the scope of Brinnel's test. It is faster because it gives arbitrary direct readings. It is widely used in industrial works. The test is conducted in a specially designed machine that applies load through a system of lever and weights. The indentor is a steel ball or a diamond with a somewhat rounded point. The hardness value as read from a specially graduated dial indentor, it is an arbitrary number that is related inversely to depth of indentation.

PROCEDURE:

(1) Adjust the weights on the plunger of dash pot according to Rockwell scale as shown in chart.
(2) Keep the lever in position A.
(3) Place the specimen on testing table.
(4) Turn the hand wheel clockwise, on that specimen will push the indentor and the small pointer moves to the red spot (Do not turn the wheel in a way to cross the red spot). The long pointer automatically stops at zero on black scare. If there is any resistance, unload and check the weights, indenter and the gap between inner faces of hanger and jaws.

(5) Turn the lever from position A to B slowly so that the total load into brought in to action without any jerks.

(6) The long pointer of dial gauge reaches a study position when indentation is complete. Take back the lever to position A slowly.

(7) Read the figure against the long pointer. That is direct reading of the hardness of specimen.

(8) Turn back the hand wheel and remove the specimen.

(9) Repeat the procedure 3 to 4 times.

Choice of Loads and Indentor for various hardness tests:

Total load	588.4N	980.7N	1471N	1839N	2452N
Indentor	Diamond 120^0	Ball 1.558mm dia.	Diamond 120^0	Ball 2.5mm dia	Ball 5mm dia
Scale	A	B	C	Brinnel 30 D^2	Brinnel $10D^2$
Dial to be read	Black	Red	black	………..	…………..
Typical applications	Thin steel & shallow case Hardened steel	Soft steel, malleable, copper& Aluminum alloys.	Steel, hard, cast steel, deep case hardened steel, other metals, harder than HRB-100	Steel and cast iron	Copper and aluminum alloys

OBSERVATIONS:

Table 2.1

S.NO	MATERIAL	ROCKWELL SCALE OF WEIGHTS PLACED			ROCK WELL NUMBER
		SCALE	WEIGHT	INDENTOR	
1					
2					
3					
4					

Model Observations:

S.NO	MATERIAL	ROCKWELL SCALE OF WEIGHTS PLACED			ROCK WELL NUMBER
		SCALE	WEIGHT	INDENTOR	
1	EN-36	B	100	1/16”	B98
2	EN-24	B	100	1/16”	B95
3	SS	B	100	1/16”	B87
4	BRASS	B	100	1/16”	B61
5	ALLUMINIUM	B	100	1/16”	B40

PRECAUTIONS:

1. Select the proper indentor and load to suit the material under the Test.
2. Surface to be tested must be sufficiently smooth and free from any defects.
3. The surface under the test must be at right angle to the axis of the indentor.
4. Diamond indentor has highly polished surface and is Susceptible to damage if not handled properly.

RESULT:

The rock well hardness number for Mild Steel is _______________

The rock well hardness number for Copper is ___________________

The rock well hardness number for Aluminum ________________

The rock well hardness number for Brass is ____________________

ROCKWELL'S HARDNESS TESTING MACHINE

EXPERIMENT NO:
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VICKERS HARDNESS TEST

AIM: To find the hardness of the given material using Vickers hardness testing machine.

APPARTAUS: Vickers hardness testing machine

PROCEDURE:

1. Select the weights according to the expected hardness of specimen to be tested by turning the “weight selection knob”. The respective figure of weight is visible on one side of knob itself.
2. Turn the hand-wheel clockwise slowly so that specimen will get focused on front screen sharply. At this stage a gap of about 0.2 to 0.25 mm expected between tip of diamond indentor and top face of specimen.
3. Adjust the “dwell” timer for required duration of load on specimen.
4. Press start push button, the loading cycle starts gradually through a geared motor provided with a drive cam. The loading/ dwell / unloading cycle is fully automatic.
5. Index indentor head to next position so that objective of optical system will be exactly over the indentation.
6. The indentation is now predicted on front focusing screen. Measure diagonal of impression in both axes.
7. To have next test, change the position of specimen where hardness is to be checked. Verify from front focusing screen that there is no earlier indentation near about expected new indentation. Index the head to original position and bring back indentor on specimen.
8. The vicker hardness value is always mentioned with reference to load applied. Standard Tables for different loads supplied by the manufacturer are used for reference.

OBSERVATIONS:

S.No	Material	Load (kgf)	Diagonal $d1$(mm)	Diagonal d_2(mm)	Average Diagonal $(d_1+d_2)/2$

PRECAUTIONS:

1. Select the proper indentor and load to suit the material under the Test.
2. Surface to be tested must be sufficiently smooth and free from any defects.
3. The surface under the test must be at right angle to the axis of the indentor.
4. Diamond indentor has highly polished surface and is Susceptible to damage if not handled properly.

Result:

The hardness of the given material tested in Vickers apparatus is _______

VICKERS HARDNESS TESTING MACHINE

TABLE FOR VICKER HARDNESS (Load = 10kgf)

(All Dimensions in mm)

Mean Diagonal	0	1	2	3	4	5	6	7	8	9
0,11*	1533	1505	1478	1452	1427	1402	1378	1354	1332	1310
0,12*	1288	1267	1246	1226	1206	1187	1168	1150	1132	1115
0,13*	1097	1081	1064	1048	1033	1018	1003	988	974	960
0,14*	946	933	920	907	894	882	870	858	847	835
0,15*	824	813	803	792	782	772	762	752	743	734
0,16*	724	715	707	698	690	681	673	665	657	649
0,17*	642	634	627	620	613	606	599	592	585	579
0,18*	572	566	560	554	548	542	536	530	525	519
0,19*	514	508	503	498	493	488	483	478	473	468
0,20	464	459	455	450	446	442	437	433	429	425
0,21	421	417	413	409	405	401	397	394	390	307
0,22	383	380	376	373	370	366	363	360	357	354
0,23	351	348	345	342	339	336	333	330	327	325
0,24	322	319	317	314	312	309	306	304	302	299
0,25	297	294	292	289	287	285	283	281	279	276
0,26	274	272	270	268	266	264	262	260	258	256
0,27	254	253	251	249	247	245	243	242	240	238
0,28	236	235	233	232	230	228	227	225	224	222
0,29	221	219	218	216	215	213	212	210	209	207
0,30	206	205	203	202	201	199	198	197	196	194
0,31	193	192	191	189	188	187	186	185	183	182
0,32	181	180	179	178	177	176	175	173	172	171
0,33	170	169	168	167	166	165	164	163	162	161
0,34	160	160	159	158	157	156	155	154	153	152
0,35	151	151	150	149	148	147	146	146	145	144
0,36	143	142	142	141	140	139	138	138	137	136
0,37	136	135	134	133	133	132	131	131	130	129
0,38	128	128	127	126	126	125	125	124	123	123
0,39	122	121	121	120	120	119	118	118	117	117
0,40	116	115	115	114	114	113	113	112	111	111
0,41	110	110	109	109	108	108	107	107	106	106
0,42	105	105	104	104	103	103	102	102	101	101
0,43	100	99,8	99,4	98,9	98,5	98,0	97,6	97,1	96,7	96,2
0,44	95,8	95,3	94,9	94,5	94,1	93,6	93,2	92,8	92,4	92,0
0,45	91,6	91,2	90,8	90,4	90,0	89,6	89,6	88,8	88,4	88,0
0,46	87,6	87,3	86,9	86,5	86,1	85,8	85,4	85,0	84,7	84,3
0,47	84,0	83,6	83,2	82,9	82,5	82,2	81,8	81,5	81,2	80,8
0,48	80,5	80,2	79,8	79,5	79,2	78,8	78,5	78,2	77,9	77,6
0,49	77,2	76,9	76,6	76,3	76,0	75,7	75,4	75,1	74,8	74,5
0,50	74,2	73,9	73,6	73,3	73,0	72,7	72,4	72,1	71,9	71,6
0,51	71,3	71,0	70,7	70,5	70,2	69,9	69,6	69,4	69,1	58,8
0,52	68,6	68,3	68,1	67,8	67,5	67,3	67,0	66,8	66,5	66,3
0,53	66,0	65,8	65,5	65,3	65,0	64,8	64,5	64,3	64,1	63,3
0,54	63,6	63,4	63,1	62,9	62,7	62,4	62,2	62,0	61,7	61,5
0,55	61,3	61,1	60,9	60,6	60,4	60,2	60,0	59,8	59,6	59,3
0,56	59,1	58,9	58,7	58,5	58,3	58,1	57,9	57,7	57,5	57,3
0,57	57,1	56,9	56,7	56,5	56,3	56,1	55,9	55,7	55,5	55,3
0,58	55,1	54,9	54,7	54,6	54,4	54,2	54,0	53,8	53,6	53,4
0,59	53,3	53,1	52,9	52,7	52,6	52,4	52,2	52,0	51,9	51,7
0,60	51,5	51,3	51,2	51,0	50,8	50,7	50,5	50,3	50,2	50,0

* These values are beyond normal range and are given for information only.

TABLE FOR VICKER HARDNESS (Load = 5kgf)

(All Dimensions in mm)

Mean Diagonal	0	1	2	3	4	5	6	7	8	9
0,08*	1449	1413	1379	1346	1314	1283	1253	1225	1197	1171
0,09*	1145	1120	1095	1072	1049	1027	1006	986	966	946
0,10*	927	908	891	874	857	841	825	810	795	781
0,11*	766	752	739	726	713	701	689	677	666	655
0,12*	644	633	623	613	603	593	584	575	566	558
0,13*	549	540	532	524	516	509	502	494	487	480
0,14*	473	466	460	454	447	441	435	429	423	418
0,15*	412	407	401	396	391	386	381	376	371	367
0,16*	362	358	353	349	345	341	336	332	329	325
0,17*	321	317	313	310	306	303	299	296	293	289
0,18*	286	283	280	277	274	271	268	265	262	260
0,19*	257	254	251	249	246	244	241	239	236	234
0,20	232	229	227	225	223	221	219	216	214	212
0,21	210	208	206	204	203	201	199	197	195	193
0,22	192	190	188	187	185	183	182	180	178	177
0,23	175	175	172	171	169	168	167	165	164	162
0,24	161	160	158	157	156	155	153	152	151	150
0,25	148	147	146	145	144	143	142	140	139	138
0,26	137	136	135	134	133	132	131	130	129	128
0,27	127	126	125	124	124	123	122	121	120	119
0,28	118	117	117	116	115	114	113	113	112	111
0,29	110	110	109	108	107	107	106	105	104	104
0,30	103	102	102	101	100	99,7	99,0	98,4	97,8	97,1
0,31	96,5	95,9	95,3	94,6	94,0	93,4	92,9	92,3	91,7	91,1
0,32	90,6	90,0	89,4	88,9	88,3	87,8	87,2	86,7	86,2	85,7
0,33	85,2	84,6	84,1	83,6	83,1	82,6	82,1	81,6	81,2	80,7
0,34	80,2	79,7	79,3	78,8	78,4	77,9	77,5	77,0	76,6	76,1
0,35	75,7	75,3	74,9	74,4	74,0	73,6	73,2	72,8	72,4	72,0
0,36	71,6	71,2	70,8	70,4	70,0	69,6	69,2	68,8	68,5	68,1
0,37	67,7	67,4	67,0	66,6	66,3	66,0	65,6	65,2	64,9	64,6
0,38	64,2	63,9	63,6	63,2	62,9	62,6	62,3	61,9	61,6	61,3
0,39	61,0	60,7	60,3	60,0	59,7	59,4	59,1	58,8	58,5	58,3
0,40	58,0	57,7	57,4	57,1	56,8	56,5	56,3	56,0	55,7	55,4
0,41	55,2	54,9	54,6	54,4	54,1	53,9	53,6	53,3	53,1	52,8
0,42	52,6	52,3	52,1	51,8	51,6	51,3	51,1	50,9	50,6	50,4
0,43	50,2	49,9	49,7	49,5	49,2	49,0	48,8	48,6	48,3	48,1
0,44	47,9	47,7	47,5	47,3	47,0	46,8	46,6	46,4	46,2	46,0
0,45	45,8	45,6	45,4	45,2	45,0	44,8	44,6	44,4	44,2	44,0
0,46	43,8	43,6	43,4	43,3	43,1	42,9	42,7	42,5	42,3	42,2
0,47	42,0	41,8	41,6	41,4	41,3	41,1	40,9	40,8	40,6	40,4
0,48	40,2	40,1	39,9	39,7	39,6	39,4	39,3	39,1	38,9	38,8
0,49	38,6	38,5	38,3	38,2	38,0	37,8	37,7	37,5	37,4	37,3
0,50	37,1	37,0	36,8	36,7	36,5	36,4	36,2	36,1	35,9	35,8
0,51	35,6	35,5	35,3	35,2	35,1	35,0	34,8	34,7	34,6	34,4
0,52	34,3	34,2	34,0	33,9	33,8	33,6	33,5	33,4	33,3	33,1
0,53	33,0	32,9	32,8	32,6	32,5	32,4	32,3	32,2	32,0	31,9
0,54	31,8	31,7	31,6	31,5	31,3	31,2	31,1	31,0	30,9	30,8

* These values are beyond normal range and are given for information only.

EXPERIMENT NO:
DATE:

COMPRESSION TEST ON SPRING

AIM: To find the rigidity modulus of a material of a given spring by conducting compression test under axial load.

APPARATUS: Vernier calipers, loading frame with proving ring.

THEORY: When an axial compression load w is applied on spring, every section of the spring wire is subjected to twisting moment WR, where R is the mean radius of the coil. For a close called the helical spring

$$\delta = \frac{64WR^3n}{Nd^4}$$

Where,

δ = deflection of spring

W = load applied

R = mean radius of the coil

N = rigidity modulus

d = diameter of the wire of the coil

n = no of turns in the spring

From the above expression for a given spring Rigidity modulus (N) can be calculate by measuring deflection of the spring δ under the particular load w.

PROCEDURE:

For Machine 1

1. Fix the load discs to the pendulum according to the requirement.
2. Adjust the pointer to read zero under no load conditions
3. Place the spring between the jaws and allow the jaws to close so that both the jaws should touch the spring.
4. Read the distance between the jaws as l_1 with the help of Vernier calipers.

5. Apply load by pressing the switch for reverse direction.
6. Read the distance between the jaws again as compressed length I_1 with the help of Vernier calipers.
7. Repeat the procedure for different loads and tabulate the readings.

For machine 2

1. Place the spring between the jaws/tables and allow the jaws/table to close so that both the jaws/table should touch the spring.
2. If any load is applied on the spring then that is displayed on the digital meter. Now use Tare button to show the load as Zero.
3. Turn the handle so that the spring is compressed. Note down the load required for compressing the spring for 1 mm or 2 mm lengths. The amount of load and the amount of compressed length is displayed on the digital screen.

OBSERVATIONS:

Spring 1

Diameter of the spring wire d in mm =

Mean radius of the coil R in mm =

Number of effective turns of the spring, n =

Original length of the spring, l in mm =

TABULAR FORM: For machine 1

S.No	Load W in N	Compressed length l_1 in mm	Deflection, $\delta = l - l_1$ mm	$N = \dfrac{64WR^3n}{\delta d^4}$ N/mm^2

OBSERVATIONS:

Spring 2

Diameter of the spring wire d in mm =

Mean radius of the coil R in mm =

Number of effective turns of the spring n =

Original length of the spring l in mm =

TABULAR FORM: For machine 2

S.No	Load W in N	Compressed length/Deflection δ in mm	$N = \frac{64WR^3n}{\delta d^4}$ N/mm^2

CALCULATIONS:

Draw an average linear graph between load and deflection. Take two pointers on the graph and note down the load and deflection values corresponding to them. Find the ratio of (w/δ) of the difference between loads to the difference between deflection at these two points as shown in the figure. Calculate the rigidity modulus of the spring by substituting W/δ value in the formula.

$$N = \frac{64WR^3n}{\delta d^4}$$

STIFFNESS: The stiffness, k, of a body is a measure of the resistance offered by an elastic body to deformation. For an elastic body with a single degree of freedom (DOF) (for example, stretching or compression of a rod), the stiffness is defined as

$$k = W/\delta$$

where,

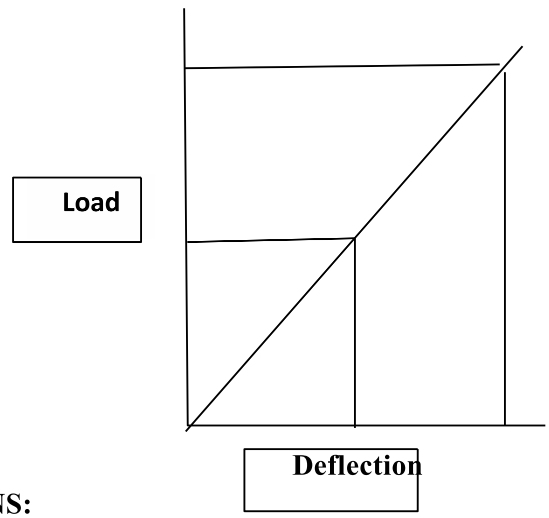
W is the force applied on the body
δ is the displacement produced by the force along the same degree of freedom (for instance, the change in length of a stretched spring)

RESULT:

Rigidity modulus for spring 1 from graph =

Rigidity modulus for spring 2 from graph =

Graph:



PRECAUTIONS:

1. For initial reading, the jaws should just touch the top and bottom surfaces of the spring.
2. Switch off the power, after the required load is attained.
3. No one should stand in front of the spring while it is loaded.

Important viva questions:

1. What is spring constant?
2. Classification of springs.
3. Differentiate between springs.
4. What is spring stiffness?

Spring Testing Machine 1

Spring Testing Machine 2

Graph Sheet:

EXPERIMENT NO:
DATE:

TENSION TEST

AIM: To find the modulus of elasticity of the material of the given specimen by conducting a tension test. Also to find (i) yield stress (ii) ultimate stress (iii) Breaking Stress (iv)Percentage elongation and (v) Percentage reduction in cross sectional area.

APPARATUS: 40T U.T.M/100T U.T.M, Callipers, scale and standard mild steel rod specimen.

THEORY:

Universal Testing machine (U.T.M) is a machine designed to test the specimen in tension, compression, flexure and shear. The machine comprises of three main parts

(1) Machine frame i.e. loading unit

(2) Hydraulic Machine

(3) Electronic Control Panel

The machine frame consists of two cross heads and lower table. Centre crosshead is adjustable by means of geared motor. Compression test is carried out between centre and lower table and tension test is carried out between centre and upper crosshead. Sensing of load is by means of precision pressure transducer of strain gauge type. Hydraulic system consists of motor pump unit with cylinder and piston. Safety relief valve is provided for additional safety.

Two valves on the control panel, one at the right side and the other at the left side. The right side valve is a pressure compensated flow control valve is adjusted and locked. The left side valve is a return valve. This valve allows the oil from the cylinder to go back to the tank, thereby reducing the pressure in the cylinder and then the working piston comes down. The rate of oil returns and so the speed of the piston return can be adjusted by this valve. If the return valve is closed, oil delivered by this pump passes through the flow control valve (if in open condition) to the cylinder and the piston goes up. If it comes across any resistance (i.e. resistance of test piece) pressure starts developing until either the specimen brakes or load reaches the maximum value of the range adjusted.

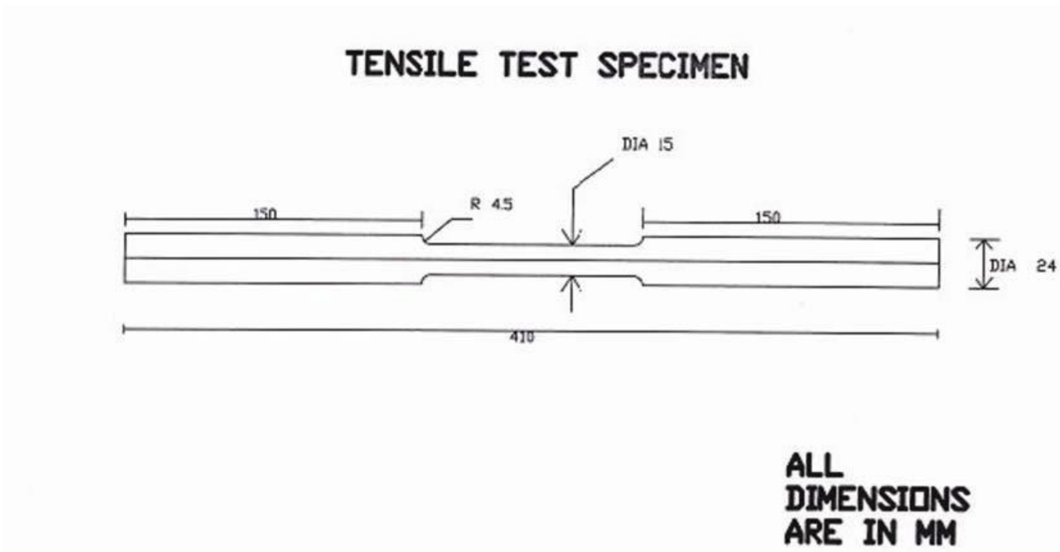
PROCEDURE:

Measure the diameter of the given mild steel rod at three sections with the help of the gauge marker. Now sub-divide the length between the grips where A_0 is original area of cross section of the rod for calculation of percentage elongation

Fix the specimen in the machine using appropriate grips maintaining the grip length accurately.

The left valve is kept in fully closed position and the right valve is in normal open position. Open the right side valve and close it after the lower table is slightly lifted. Now adjust the load to zero by tare push button. This is necessary to remove the dead weight of the lower table, upper cross head and other connecting parts from the load.

Operate the lower grip operation handle and lift the lower crosshead by pressing motor control buttons and grip lower part of the specimen. Then lock the jaws in this position by operating the jaw lock handle. Then turn the right control valve slowly to open position (anti clockwise) until desired loading rate is achieved. Now the specimen is under load. Unclamp the locking handle. Now the jaws will not slide down due to their own weight. Now press the start button on the electronic control panel. Now the electronic system is ready to absorb the date viz. load and elongation directly from the transducers. The load is to be increased until the specimen breaks. Collect the data of load, elongation and ultimate load from the digital display of the electronic system. Note the load and the corresponding elongation from the display of electronic system of machine. This procedure of noting the elongation for each increment of load is continued until the specimen yields. Note further, elongation readings and load from the electronic display. Now on further increase of load it reaches a maximum value called the ultimate load and then specimen breaks at some load called breaking load, which is to be noted on hearing the breaking sound of the specimen. Press plot button on electronic system to get the plot between load and extension. From this plot the upper yield point and lower yield point, ultimate point can be read.



OBSERVATIONS:

Average original diameter of a given specimen, d_0	=	mm
Original cross sectional area, A_0	=	mm^2
Gauge length, L_0 (minimum 5 d_0)	=	mm
Final length	=	mm

S.No.	Load (kN)	Elongation (mm)	Engineering Stress (kN/mm^2)	Engineering Strain	Young's Modulus (kN/mm^2)
1					
2					
.					
.					
74					
75					

Diameter of the specimen at necking d_u = mm

Final length of the specimen is measured by keeping the two broken pieces together.

CALCULATIONS:

- Calculate the nominal stress and the strain over the gauge length. Draw a graph between stress and strain diagram as the original cross sectional area of the specimen is taken to calculate the stress.
- In the graph the slope of straight portion gives young's modulus of the given specimen.
- Calculate the stress corresponding to the points A,C and D which are
  yield stress, ultimate stress and breaking stress respectively

$$\text{Percentage of elongation} = \frac{L_u - L_0}{L_0} * 100$$

$$\text{Percentage of reduction in cross sectional area} = \frac{A_u - A_0}{A_0} * 100$$

Where A_u is area of cross section at the peaking point and A_0 is original cross sectional area.

RESULT:

(i) Young's modulus of the given specimen ________________

(ii) Yield stress of the given specimen_____________________

(iii) Ultimate tensile stress of the given specimen_____________

(iv) Breaking stress of the given specimen__________________

(v) Percentage elongation of the given specimen______________

(vi) Percentage reduction in the cross sectional area of the given specimen________

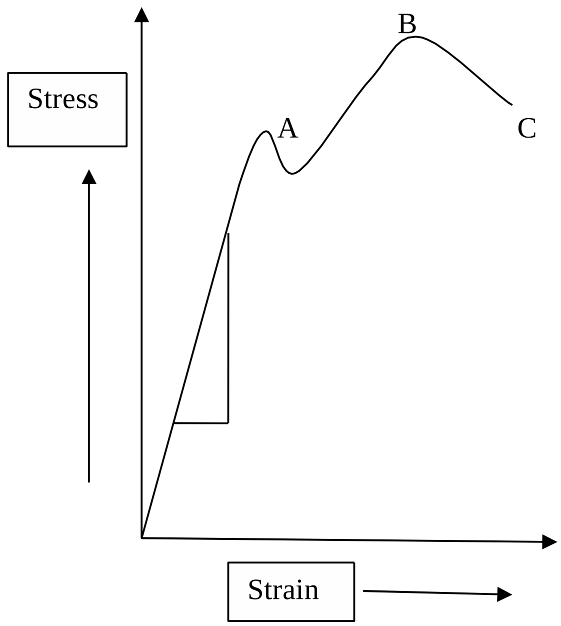
PRECAUTIONS:

1. The load due to lower and cross head must be released
2. Check for suitable grips for the given size of the specimen
3. After completion of test release the hydraulic load by opening the left side valve.

IMPORTANT VIVA QUESTIONS:

1. Explain about stress- strain diagram for mild steel (Ductile material) and cast iron (brittle material)
2. What tests you can do on UTM?
3. Why this machine is called a universal testing machine?
4. Differentiate between tensile stress, compressive stress, shear stress and bending stress.
5. What are the different mechanical properties of the material?
6. What are the different non-destructive testing methods?

Graph:



TENSION TESTING MACHINE

Graph Sheet:

EXPERIMENT NO:
DATE:

TORSION TEST

AIM: To find the rigidity modulus of given material by conducting torsion test by using torsion testing machine.

APPARATUS:

Torsion testing machine, vernier callipers, steel rule.

THEORY:

If a round shaft is subjected to axial twisting moment as shown, the relation between torque T and angle of twist ş is given by

$T/J = G ş /L$

Where T is torque applied

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

G=rigidity modulus

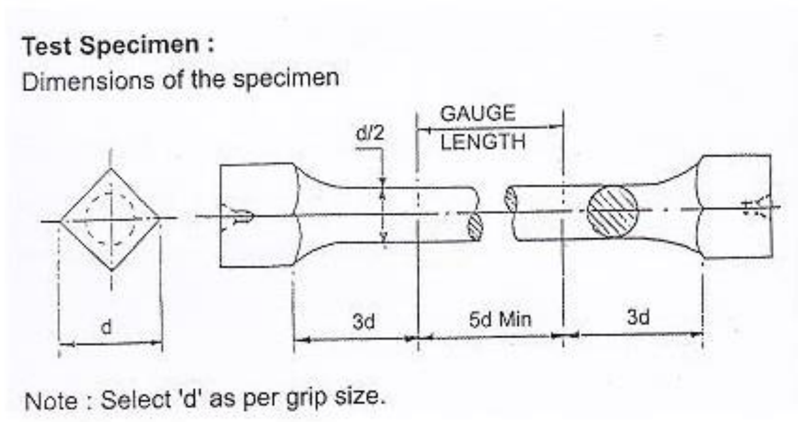
Ɵ =angle of twist in radians

L=gauge length

PROCEDURE:

Fix the gauge length on the shaft with punch marks. Measure the diameter of the shaft at three sections within the gauge length with the help of Vernier callipers and take the average value for calculating the polar moment of inertia J.

From the expression $T/J = f_s/R$, where f_s is shear stress and R is radius of shaft cross section, find the permissible torque that can be applied on the shaft for the assumed permissible shear stress. Now select the suitable range for the torsion testing machine. Fix the specimen. Apply the torque slowly by rotating the handle to the right side of the machine. Note the torque from torque meter and corresponding angle of twist from angle measuring disc. Repeat the experiment with suitable interval to get 6 or 7 readings, until the permissible torque value is reached and tabulate as follows.



OBSERVATIONS: Machine 1

Material : ___________________

Shape and size: ___________________

Gauge length : __________________

Diameter of the shaft: ______________

Polar moment of inertia J: _____________

TABLE:

S.No	Twisting moment T		Angle of twist, Θ		Modulus of rigidity G (N/mm^2)
	Kgf cm	N-mm	degree	radians	
1					
2					
3					
4					
5					
6					
7					

OBSERVATIONS: Machine 2

Material : ____________________

Shape and size: ____________________

Gauge length : ___________________

Diameter of the shaft: ______________

Polar moment of inertia J: _____________

TABLE:

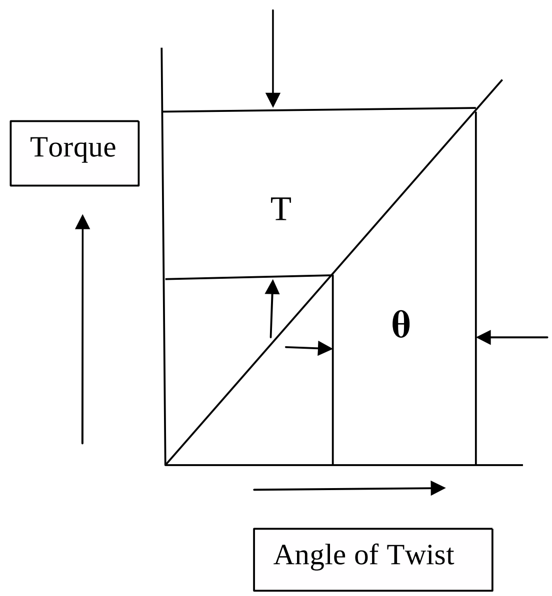
S.No	Twisting moment T		Angle of twist, ϴ		Modulus of rigidity G (N/mm^2)
	NM	N-mm	degree	radians	
1					
2					
3					
4					
5					
6					
7					

Calculations:

Plot a graph between the twisting moment (T) on y-axis and angle of twist on x-axis.

35

Graph:



RESULT:

Modulus of rigidity of the given material = ___________________

TORSION TESTING MACHINE

Graph Sheet:

EXPERIMENT NO:
DATE:

COMPRESSION TEST

AIM: To find the compressive strength of Wood parallel and perpendicular to grains (or) Concrete Cube.

APPARATUS: 200T C.T.M, Vernier calliperse, Wooden (or) Concrete Cube.

THEORY: Compression testing machine, C.T.M is a machine designed to test the specimen in compression. The machine is operated hydralically and its driving is performed by the electric motor .Load verification of the testing machine meets the requirement of BS: 1610-1964 and IS: 1828-2000 .The machine consists of loading unit and the control panel.

PROCEDURE:

1. Measure the dimensions of the Concrete Cube (or) Cement Cube (or) Wooden Cube.
2. Keep the cube on the lower table of the loading unit. See that the gap between the swiveling attachment and the top surface of the cube should not be more than 50mm.
3. To achieve this use height adjusting solid discs.
4. Close the right control valve and left control valve of the control panel to make the unit ready for loading.
5. Switch on the green button to start the hydraulic pump. Then open slightly the right control valve.
6. Operate TARE button on the electronic display unit until the load is zero.
7. Operate the start button on the electronic display unit twice, so that the red light glows.
8. The lower table moves up and the cube subjected to compression load and it fractures. Now the red light and the Hydraulic pump stops.
9. Operate the result button to view the maximum load on the electronic display unit.

Repeat the procedure for another specimen placed across the grains for wood.

OBSERVATIONS:

1. Crushing load of Cement or Concrete cube: kN
2. Crushing load of wooden specimen

a) Along the grain direction: kN

b) Across the grain direction: kN

Compressive strength = Crushing load /Cross-sectional Area ____________N/mm^2

PRECAUTIONS:

1. The load due to lower table and cross head must be released.
2. Release the hydraulic load after the completion of the test by opening the left side valve.
3. Take care while removing the broken cube from the loading unit.

Important viva questions:

1. What tests you can do on UTM/CTM?
2. Why this test is called a universal testing machine?
3. Differentiate between tensile stress, compressive stress, shear stress and bending stress
4. Why compressive strength is important for wood/concrete/ cement cubes?

COMPRESSION TESTING MACHINE

IMPACT TEST

EXPERIMENT NO:
DATE:

AIM: To find impact energy of the given specimen.

THEORY:

BRITTLENESS:

A tendency to fracture without appreciable deformation generally indicated in impact tests by low values or by very low percentage reduction of area in tensile test.

IMPACT TEST:

In impact test is specially prepared notched specimen is fractured by a single blow from a heavy hammer and energy required being a measure of resistance to impact.

CHARPY IMPACT TEST:

A pendulum type single blow impact test, in which the specimen (usually notched) is supported at both ends, as a simple beam, and broken by a falling pendulum. The energy absorbed, as determined by the subsequent rise of pendulum is a measure of impact strength. The impact strength is expressed as N-m

IZOD IMPACT TEST:

A pendulum type single blow impact test, in which the specimen (usually notched) is fixed at one end, as a cantilever, and broken by a falling pendulum. The energy absorbed, as determined by the subsequent rise of the pendulum is a measure of impact strength. The impact strength is expressed as N-m.

DESCRIPTION OF MACHINE:

The pendulum impact testing machine consists of the robust frame, the pendulum, the specimen support and the measuring dial. The pendulum shaft is fitted in anti friction bearings. The pendulum is clamped to the pendulum shaft. The pendulum consists of the pendulum pipe and the pendulum hammer of u-shape design. Into this the striker is mounted for conducting charpy impact test. The range, within which the pendulum is swinging, partially protected by the guard. A latch is provided which keeps the pendulum in elevated position. A lever is provided for operating the latch and releasing the pendulum. There is a dial attached concentrically with the pendulum shaft. The scale is designed such that the impact energy absorbed in breaking the specimen can be read directly in joules. A separate striker for Izod test is provided.

PREPARATION OF TEST SPECIMEN:

Impact test specimens for charpy and Izod tests must be prepared according to IS 1499-1959 and 1598-1960. The notch is produced either by milling or grinding. The plane of symmetry of notch shall be perpendicular to the horizontal axis of test piece.

TECHNICAL DATA FOR CHARPY TEST:

Maximum impact energy of pendulum	: 300J
Minimum value of scale graduation	: 2J
Distance between supports	: 40mm ± 0.2mm
Angle of test piece supports	: 78˚ to 80˚
Angle of inclination of supports	: 0^0
Radius of supports	: 1 to 1.5 mm
Maximum width of striker	: 10 to 18mm
Angle of striking edge	: 30 ± 1^0
Radius of curvature of striking edge	: 2 to 2.5 mm

PROCEDURE OF CARRYING OUT CHARPY TEST:

For conducting Charpy test, Charpy striker is to be firmly secured to the bottom of the hammer with the help of clamping piece. The latching tube for charpy test is to be firmly clamped to the bearing housing on the inclined face. Before proceeding to the actual test, the test for determining the frictional loss in the machine is to be conducted. Adjust the reading pointer with pointer carrier to 300J dial reading, when the pendulum is ganging free vertical. For this, use socket head screw of carrier. Now raise the hammer by hands and latch in. release the hammer by operating lever. The pointer will then indicate the energy loss due to friction. From this reading, confirm that the frictional loss is not exceeding 0.5 & of the initial potential energy.

Now raise the hammer on the specimen support touching end stop. The specimen should be placed in such a way that the notch is opposite to the direction of impact of the pendulum. For correct centering of the specimen, the end stop is provided. Operate the lever so that the pendulum is reversing it's direction of motion and begins to swing slow.

Thereafter, bring the pendulum carefully to stand still position by applying the pendulum brake.

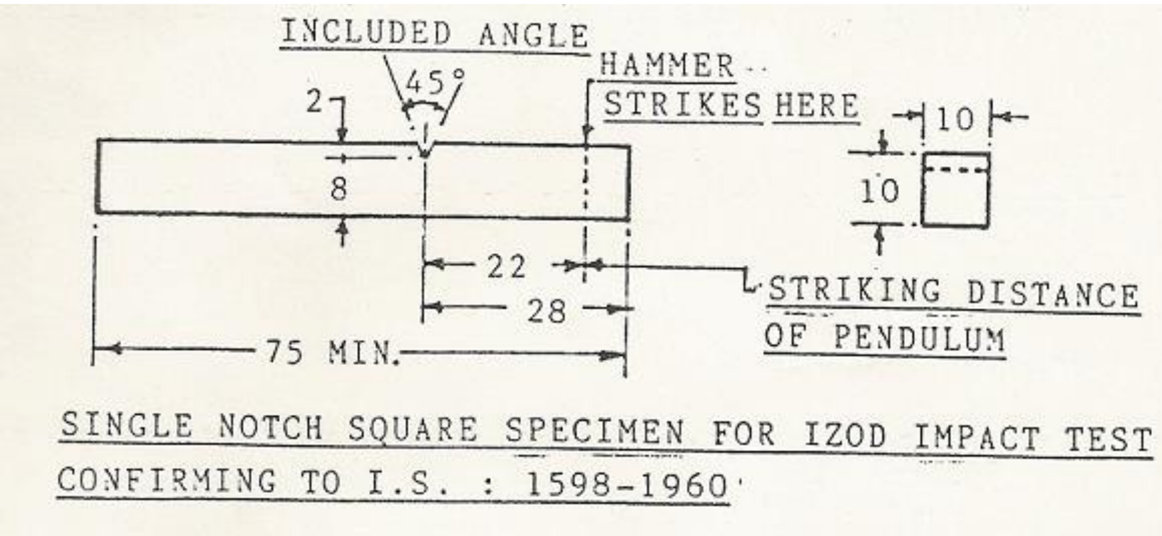
Note down the impact energy.

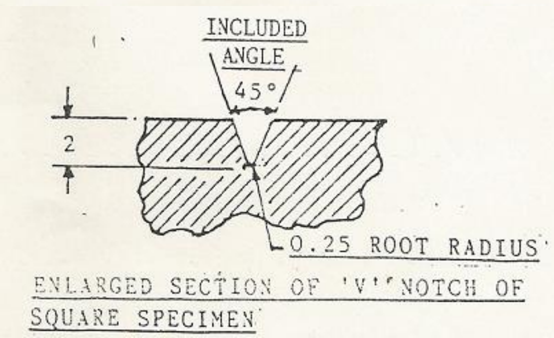
Before proceeding to the next test, remove the broken specimen from the machine and bring reading pointer on 300J dial marking and then repeat the procedure.

Technical data (Izod test):

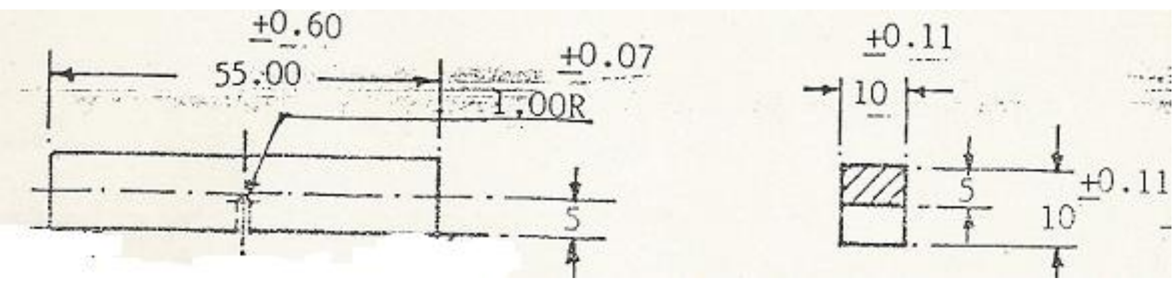
Maximum impact energy of pendulum	: 168 joules
Minimum value scale graduation	: 2 joules
Distance between base of specimen notch (or top of grips) and the point of specimen hit by the hammer	: 22mm ± 0.5
Angle of striking edge	: $75^0 \pm 1^0$
Radius of curvature of striking	: 0.5mm to 1mm
Angle between the normal to the specimen and the underside face of the striker at striking point	:$10^0 \pm 1^0$

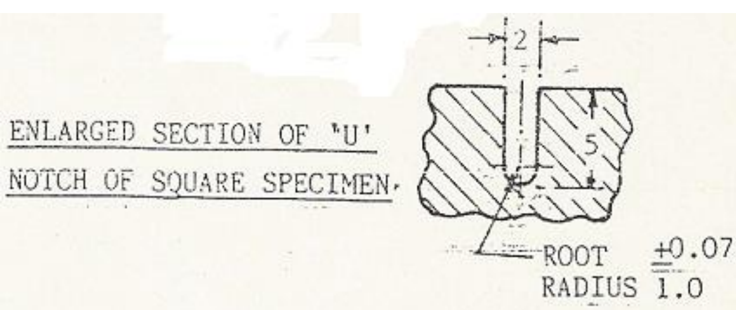
IZOD Test Specimen:





Charpy Test Specimen:





NOTE: ALL DIMENSIONS ARE IN mm, **Scale 1:1**

Procedure of carrying out Izod test:

For conducting Izod test, a proper striker is to be secured firmly to the bottom of the hammer with the help of clamping piece. The latching tube for Izod test is to be firmly clamped to the bearing housing at the side. The frictional loss of the machine can be determined in the same fashion, as it was determined in case of charpy test except the angle of fall in this case being 90^0

Adjust the pointer along with the pointer carrier on 168J reading on the dial when the pendulum is hanging free vertically.

Now simply raise the pendulum manually and latch in.

The specimen for Izod Test is firmly clamped in the specimen support with the help of clamping screw and setting gauge. Care is to be taken that the notch on the specimen should face the pendulum striker. Operate the lever so that the pendulum is released and specimen is hit. Wait till the pendulum reverses its swing and carefully retard the swinging pendulum by operating the pendulum brake.

Note down the impact energy.

Remove the broken specimen by losing the clamping screw and thus the machine will be ready for carrying out next test.

The notch impact strength depends largely on the shape of the specimen, therefore may not be compared with each other.

Observations:

S. No	Material	Charpy test			Izod test		
		K N-m or Joule	Area (A) mm^2	I = K/A	K N-m or Joule	Area(A) mm^2	I = K/A

Note: 1 Joule = 1 N-m = 1 N-mm * 10^3

Impact Value of Specimen = (Impact energy /Cross sectional area excluding notch area) = ________ N/mm

Toughness of Specimen = (Energy absorbed /Volume of Specimen ignoring notch) = ___________ N/mm^2

PRECAUTIONS:

1. Extreme care must be taken to see that correct striker and correct support/ clamping are chosen for a particular test.
2. Nobody should stand in front of the pendulum as the broken piece may fly off.

Result: Impact value of

Material	Charpy Test	Izod Test

Toughness of

Material	Charpy Test	Izod Test

IMPACT TESTING MACHINE

EXPERIMENT NO:
DATE:

DEFLECTION TEST ON CANTILEVER BEAM

AIM: To find the young's modulus of the given structural material (mild steel) by measuring deflection of cantilever beams.

APPARATUS: Beam supports, loading yoke, Slotted weight hanger, Slotted

Weights, Dial gauge, Dial gauge stand, Calipers and Scale

FORMULAE: For a cantilever beam with concentrated load at end-span the formulae of deflection are as follows.

Span deflection at point of deflection meter (δ_c) = ($WL^3/3EI$)

Where δ = Deflection

W = Load.

L = Span Length of Beam

E =Young's Modulus and

I = Moment of Inertia of the beam = $(1/12)*(bd^3)$

PROCEDURE: End span deflection

A beam of known cross-section (rectangular shape with width "b" and depth "d") and length "L" is supported at one end and free at the other end. A known load W is applied as shown in the following figure. The deflection at B is correlated graphically to the load applied and the young's modulus is determined.

Figure: End span deflection.

OBSERVATIONS:

S No	Parameters for set-up	Value
1	Width of the beam (rectangle) cross-section- b mm	
2	Depth of the beam (rectangle) cross-section- d mm	
3	Length of the beam - L mm	
4	Location of the load W from left support - L mm	

CALCULATION OF CONSTANTS:

Moment of inertia (I) = _______________ mm^4

Young's Modulus $E = (W/\delta_c) * (L^3/3I)$

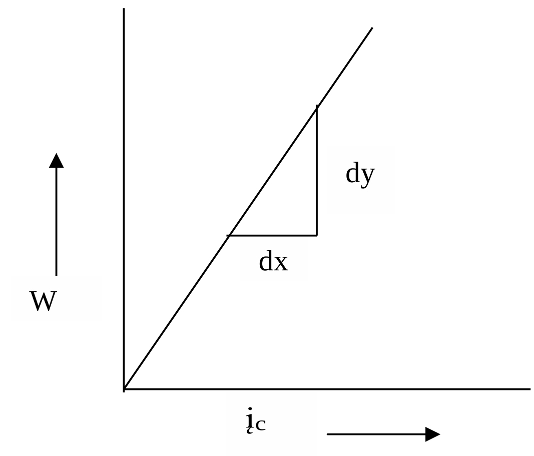
TABULAR COLUMN:

S No	Load applied(W)		Deflection in mm		Average	Deflection LC x Avg.	Young's Modulus (E)
	Kg	N	loading	unloading			N/mm^2

RESULT: Young's Modulus of steel = ________________ N/mm^2

GRAPH :

Deflection (įc) vs. Load (W):



CANTILEVER BEAM SETUP:

Graph Sheet:

Graph Sheet:

EXPERIMENT NO:
DATE:

DEFLECTION TEST ON SIMPLY SUPPORTED BEAM

AIM: To find the young's modulus of the given structural material (mild steel or wood) by measuring deflection of simply supported beams.

APPARATUS: Beam supports, Loading yoke, Slotted weight hanger, Slotted weights, Dial gauge, Dial gauge stand, Scale & Vernier callipers

THEORY:

į = $\frac{Wbx}{6EIL}(L^2 - b^2 - x^2)$

For a simply supported beam, AB of span L carrying a load W at a distance "a" from A and "b" from B , so that L= a+b , then the deflection "į" at a distance "x" from A is given above.

FORMULAE:

For a simply supported beam with concentrated load at mid-span the formulae for deflection are as follows:

Quarter -span deflection (į) = $(11/768) * (WL^3/EI)$

Half-span deflection (į) = $(1/48) * (WL^3/EI)$

Where į = Deflection

W= Load.

L= span

E= Young's Modulus

I = Moment of inertia of the beam = $(1/12)*(bd^3)$

PROCEDURE:

1. Quarter span deflection:

A beam of known cross-section (rectangular shape with width “b” and depth “d”) and length “L” is simply supported between the ends. A known load W is applied as shown in the figure(1). The deflection at C is correlated graphically to the load applied and the Young’s Modulus is determined.

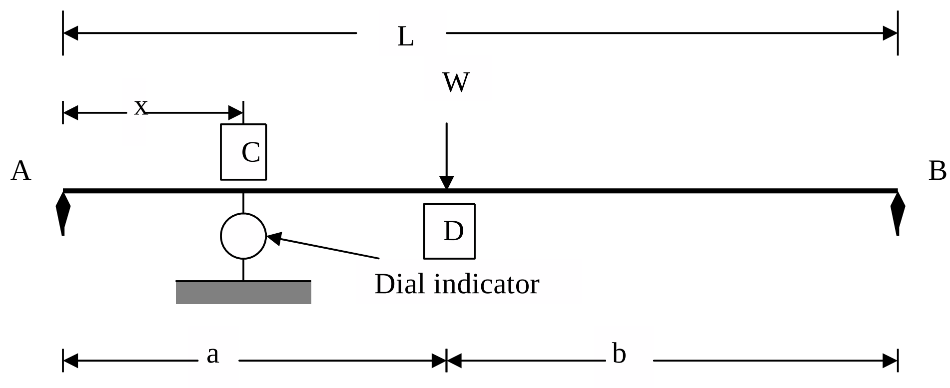


Figure 1. Quarter span deflection.

2. Half span deflection:

A beam of known cross-section (rectangular shape with width “b” and depth “d”) and length “L” is simply supported between the ends. A known load W is applied as shown in the following figure(2). The deflection at D is correlated graphically to the load applied and the Young’s Modulus is determined.

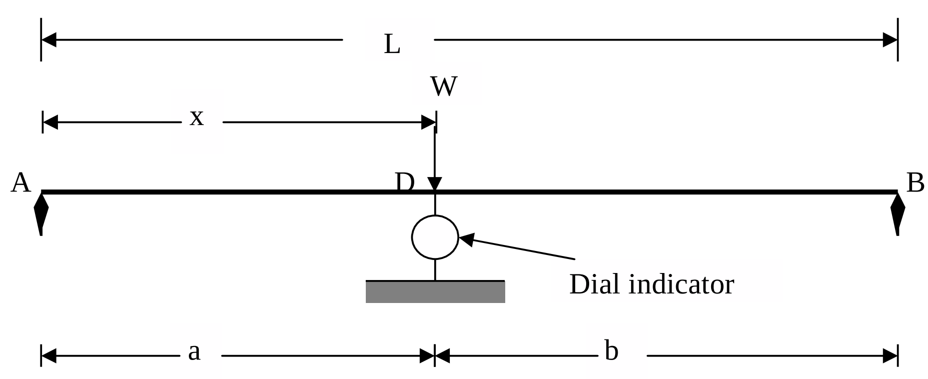


Figure 2. Mid-span deflection.

OBSERVATIONS:

(a) Quarter span deflection

S No	**Parameters for set-up-1**	**Steel**	**Wood**
1	Width of the beam (rectangular) cross-section, b mm		
2	Depth of the beam (rectangular) cross-section, d mm		
3	Length of the beam between supports , L, mm		
4	Location of the load W from left support , a, (L/2) mm		
5	Location of the deflection point from left support , C, (L/4) mm		

(b) Half span deflection

S No	**Parameters for set-up-2**	**Steel**	**Wood**
1	Width of the beam (rectangular) cross-section, b mm		
2	Depth of the beam (rectangular) cross-section, d mm		
3	Length of the beam between supports , L, mm		
4	Location of the load W from left support , a, (L/2) mm		
5	Location of the deflection point from left support , D, (L/2) mm		

TABULAR COLUMN:

S No	Load applied (W)		Deflection in mm		Average	Deflection LC x Avg.	Young's Modulus (E)
	Kg	N	loading	unloading			N/mm^2
Quarter span(Steel Specimen)							
Mid-span (Steel Specimen)							

S No	Load applied (W)		Deflection in mm		Average	Deflection LC x Avg.	Young's Modulus (E)
	Kg	N	loading	unloading			N/mm^2
Quarter span(Wood Specimen)							
Mid-span (Wood Specimen)							

CALCULATION OF CONSTANTS:

Moment of inertia (I) = __________ mm^4

Young's Modulus (E): (a) for quarter span: (11/768) * (W/į) * (L^3/I)

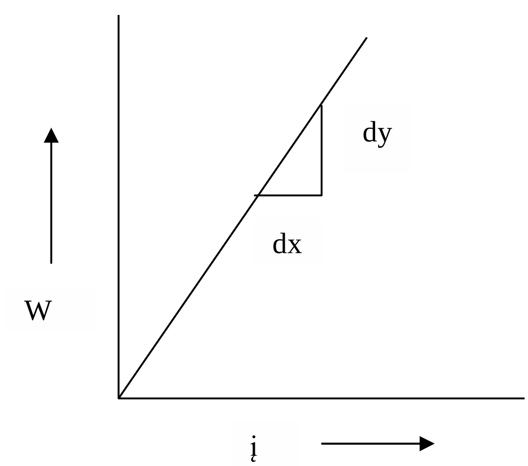
(b) For mid-span: (1/48) * (W/į) * (L^3/I)

RESULT:

1. Young's Modulus of STEEL from the deflections at quarter span:
2. Young's Modulus of WOOD from the deflections at quarter span:
3. Young's Modulus of STEEL from the deflections at half span:
4. Young's Modulus of WOOD from the deflections at half span:

GRAPHS TO BE DRAWN:

Deflection (į) vs. Load (W)



SIMPLY SUPPORTED BEAM SETUP

Graph sheets: 2 Sheets

Graph Sheet:

EXPERIMENT NO:
DATE:

VERIFICATION OF MAXWELL'S RECIPROCAL THEOREM ON BEAMS

AIM: To find young's modulus of the material of the given beam by conducting bending test on simply supported beam using Maxwell's law of reciprocal deflections.

APPARATUS: Beam supports, Loading yoke, Slotted weight hanger, Slotted weights, Dial gauge, Dial gauge stand, Scale & Vernier callipers

FORMULA: For a simply supported beam with concentrated load at mid-span the formulae of deflection is as follows:

$$ỉ = \frac{11\,WL^3}{768\,EI}$$

PROCEDURE:

1. The breadth and depth of the beam along the span is measured and average values are taken.
2. The load is applied in increments and the corresponding deflections with the help of dial gauge are measured.
3. Precautions are to be taken to keep the dial gauge in correct position to measure the desired deflection.
4. The deflections corresponding to various loads for each case are tabulated.
5. The beam is placed horizontally and in the first case, the loads are acted in the middle and dial gauge is placed at $1/4^{th}$ of the beam and loads are added slowly and according to the load, the readings are noted. Similarly note down the deflections while unloading.
6. In the second case load is placed at $1/4^{th}$ of the beam and dial gauge at the centre and the readings are noted similar to the first case.

Table 1:

S No	**Parameters of set-up**	**Value**
1	Width of the beam (rectangle) cross-section, b mm	
2	Depth of the beam (rectangle) cross-section, d mm	
3	Moment of inertia , $bd^3/12$	

OBSERVATIONS:

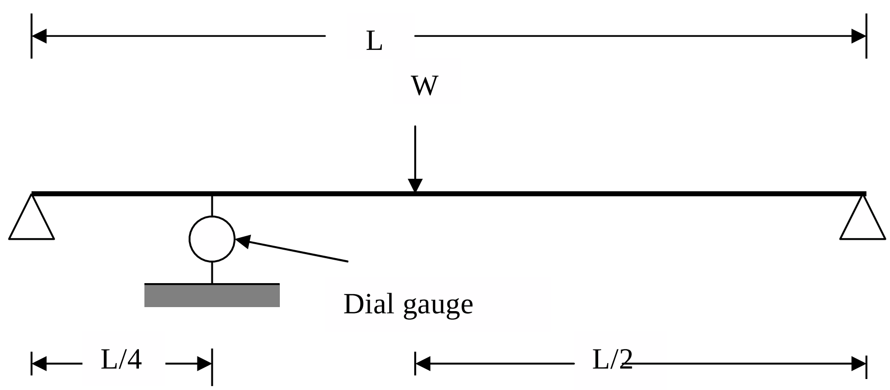
Table 2:

S No	Load applied(W)		Deflection in mm		Average	LC x Avg.	Young's Modulus (E) N/mm^2
	Kg	N	Loading	Unloading			
Case (i)							
1							
2							
3							
4							
5							
6							
7							
Case (ii)							
1							
2							
3							
4							
5							
6							
7							

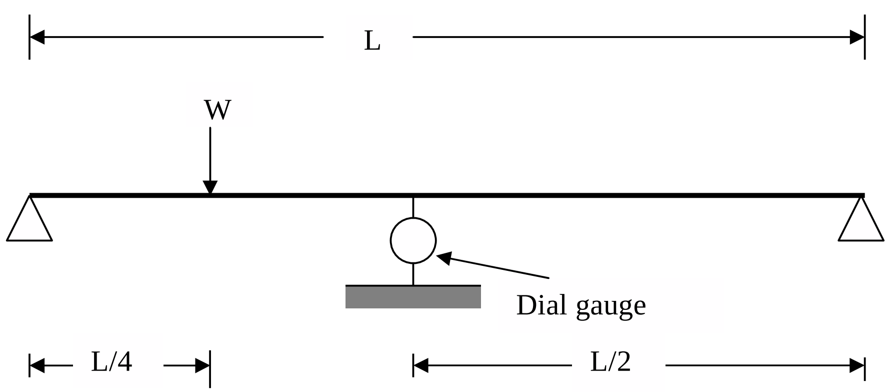
Table 3:

S.No	Load(W) N	Avg.1 (x)	Avg.2 (y)	Average of 1&2(z)	Young's Modulus (E)	% Error (z-(x or y))/z
1						
2						
3						
4						
5						
6						

Case (i):



Case (ii):



CALCULATIONS:

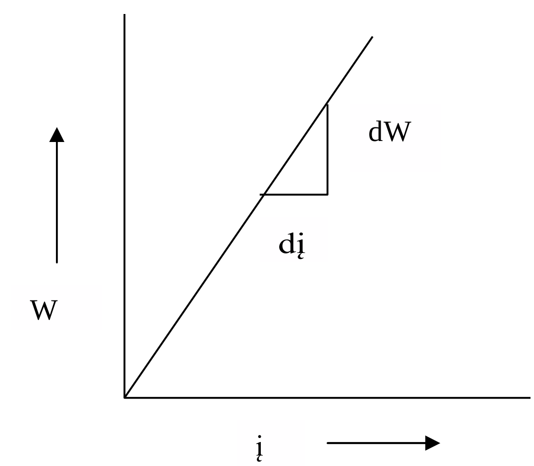
Moment of inertia (I) = __________ mm^4

Young's Modulus (E) = (11/768) * (W/į) * (L^3/I)

RESULT: The Young's modulus of steel by Maxwell's reciprocal theorem is:

The percentage error is:

GRAPHS TO BE DRAWN:



Graph Sheet:

EXPERIMENT NO:
DATE:

DEFLECTION TEST ON CONTINUOUS BEAM

AIM: To find the young's modulus of the given structural material (mild steel or wood) by measuring deflection of Continuous beam.

APPARATUS: Beam supports, loading yoke, Slotted weight hanger, Slotted weights, Dial gauge, Dial gauge stand, Scale & Vernier callipers.

THEORY: Consider the following loading case as a two span continuos beam of Uniform flexural rigidity EI. It is loaded at half of each span from end supports and deflection is measured at 1/4th of span from right end support.

Deflection (į) at F= (43/6144)* (WL^3/EI)

Where į = Deflection
W= Load.
L= span
E= Young's Modulus
I = Moment of inertia of the beam = (1/12)*(bd^3)

PROCEDURE:

A beam of known cross-section (rectangular shape with width "b" and depth "d") and length "L" is simply supported at two ends and at the centre(at A,C &B). Equal loads W are applied at half of each span (at D & E) as shown in the figure (1) in six increments. The deflection at F is correlated graphically to the load applied and the Young's Modulus is determined.

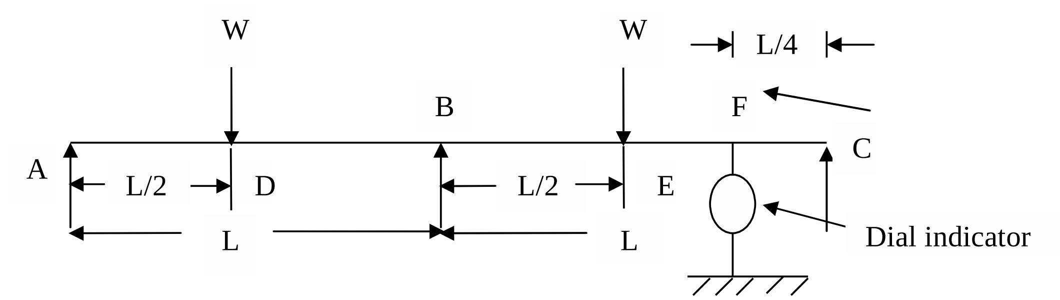


Figure.1: Continuous Beam Deflection.

OBSERVATIONS:

S No	Parameters for set-up-1	Value
1	Width of the beam (rectangular) cross-section, b mm	
2	Depth of the beam (rectangular) cross-section, d mm	
3	Length of the beam between supports , L, mm	
4	Location of the load W from left support (L/2) mm	
5	Location of the deflection point from right support (L/4) mm	

CALCULATION OF CONSTANTS:

Moment of inertia (I) = ___________mm^4

Young's Modulus (E) =

(43/6144) * (W/ị) * (L^3/I)

TABULAR COLUMN:

S No	Load applied (W)		Deflection in mm		Average	Deflection LC x Avg.	Young's Modulus (E)
	Kg	N	loading	unloading			N/mm^2
Quarter span(Steel Specimen)							

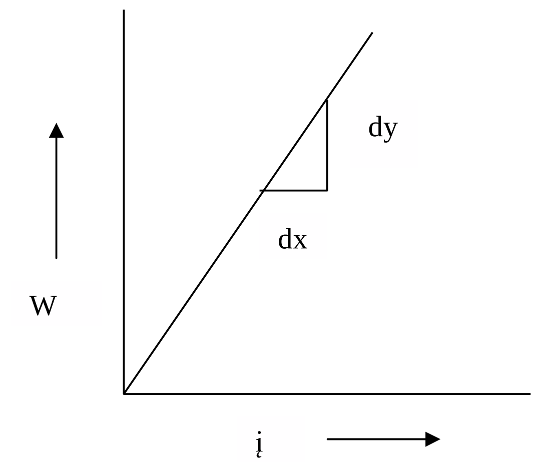
RESULT:

Young's Modulus of STEEL from the deflections on a two span continuous beam is:

______________________ **N/mm^2**

GRAPHS TO BE DRAWN:

Deflection (ị) vs. Load (W)



CONTINUOUS BEAM SETUP

Graph Sheet:

EXPERIMENT NO:
DATE:

DIRECT SHEAR TEST

AIM: To find the ultimate shear strength of the material of the given specimen by conducting the direct shear test using Universal testing machine

APPARATUS: Universal Testing Machine, Vernier calipers, shear test attachment.

THEORY: I**n** the direct shear test, the specimen is supported in the shear shackle, so that the bending stresses are avoided across the plane along which the shearing force is applied. The punching shear test is also a form of the shear test.

PROCEDURE:

1) The diameter of the specimen was measured in two dimensions at three sections and mean of the values was taken.
2) The specimen was placed in the shear shackle in such a way that the specimen over hangs equally on both sides.
3) The test piece was fit such that it is neither tight nor loose.
4) The shear specimen attachment was placed between compression plates of the machine.
5) The test piece being in double shear was broken into 3 pieces on application of load, failing along two cross sections.

CALCULATIONS:

Shear Stress (G) = W / 2A

Where W = Load at which specimen fails

A = Cross sectional area of the rod

RESULT:

The ultimate shear strength of the material in direct shear =__________N/mm^2

UNIVERSAL TESTING MACHINE (UTM)