Techno India NJR Institute of Technology

Material Testing Lab (4CE4-21)

2022-23

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SYLLABUS

II Year-IV Semester: B.Tech. (Civil Engineering)

4CE21: MATERIAL TESTING LAB

Credit: 01 **Max. Marks: 50 (IA:30, ETE:20)**

0L+0T+2P

1. Tests on Mild steel and HYSD Bar –To determine compressive and tensile strength, yield strength, percentage elongation etc.
2. Tests on Cement and concrete cubes/ core to establish their strength
3. Hardness Test – Rockwell Hardness and Brinell Hardness
4. Impact Test – Izod and Charpy
5. Modulus of Rupture of Wooden Beam
6. Fatigue Test
7. Spring Test
8. Torsion Test

Course Overview:

The mechanical response of materials to different external loadings is of great importance to many fields of science, engineering, and industry. Structural failure is realized when the functionality of engineering components has been depleted. In general, there are three main reasons for a component to become dysfunctional—excessive (elastic or inelastic) deformation, fracture, and wear. Excessive elastic deformation is controlled by the elastic properties of the material, such as elastic modulus, and may occur under loading conditions of stable equilibrium (e.g., excessive deflection of a beam), unstable equilibrium (e.g., buckling of a column), and brittle fracture. Excessive inelastic deformation depends on plastic material properties, such as ultimate tensile strength, strain hardening, and hardness, and may occur under loading conditions conducive to fatigue (a process involving alternating stresses (or strain) that induce crack initiation from stress raisers or defects in the material followed by crack growth), ductile fracture due to excessive accumulation of plastic deformation, and creep (a time-dependent deformation process encountered with viscoelastic materials and elastic-plastic materials at elevated temperatures subjected to a constant stress). Material degradation may also occur as a result of mechanical wear arising at contact interfaces of load-bearing components when the transmitted contact stresses are comparable of the material hardness. It is therefore important to not only know how the mechanical properties control the material response to a certain external force, but also have knowledge of standard mechanical testing methods for measuring different material properties.

Course Outcomes:

CO.NO.	Cognitive Level	Course Outcome
1	Knowledge	Determine the compressive and tensile strength of steel and HYSD bar.
2	Application	Determine the strength of cement and concrete cubes.
3	Comprehension	Determine the hardness and impact of distinct materials.
4	Application	Explain basic material's properties like fatigue, torsion, modulus of rupture etc.
5	Synthesis	Explain the characteristics involved in finalizing the selection of material for a specific work.

Prerequisites:

1. Fundamentals Knowledge of Different types of Properties of Materials

Course Outcome Mapping with Program Outcome:

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO247.1	2	2	2	2	0	1	1	0	0	0	0	1	1	1	1
CO247.2	2	2	2	2	1	1	0	0	0	1	0	0	1	1	1
CO247.3	2	2	2	1	2	2	2	2	1	1	2	1	1	1	1
CO247.4	3	3	3	3	2	1	2	1	1	1	1	2	2	2	1
CO247.5	3	2	3	2	2	1	2	2	1	2	1	2	2	2	1
CO247 (AVG)	2.4	2.2	2.4	2	1.4	1.2	1.4	1	0.6	1	0.8	1.2	1.4	1.4	1

Course Coverage Module Wise:

Lab No.	Experiments List According to RTU Syllabus
1	Tests on Mild steel and HYSD Bar –To determine compressive and tensile strength, yield strength, percentage elongation etc.
2	Tests on Cement and concrete cubes/ core to establish their strength
3	Hardness Test – Rockwell Hardness and Brinell Hardness
4	Impact Test – Izod and Charpy
5	Modulus of Rupture of Wooden Beam
6	Fatigue Test
7	Spring Test
8	Torsion Test

Viva QUIZ Link
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Assessment Methodology:

1. Practical exam Based on Experiments.
2. Internal exams and Viva Conduct.
3. Final Exam (practical paper) at the end of the semester

LIST OF EXPERIMENTS

EXPERIMENT NO.1

OBJECTIVE:-To conduct tensile test on the specimen and determine its properties

EQUIPMENT:-TFUC Universal Testing Machine

MACHINE DISCRIPTION:- The machine comprises of three main parts,

1. Machine frame i.e. loading unit
2. Hydraulic system
3. Electronic control panel

The machine frame consists of two cross head which can be adjusted by means of geared motor. Compression test carried out between centre and lower table, and tension test is carried between centre and upper crosshead. Sensing of load is by means of precision pressure transducer of strain gauge type.

For measurement of ram stroke ,rotary encoder is fitted in the bottom of the machine, also adjustable limit switch is provide for safety limiting of ram stroke. Hydraulic system consists of motor pump unit with cylinder and piston. Safety relief valve is provided for additional safety.

SAFETY PRECAUTION:-

1. Remove the jaw – lock handle before starting the tensile test.
2. The jaws should be released slowly.
3. Ensure proper locking of test specimen.

THEORY:-

In this test the load is applied along one axis, and rate of loading is constant. The test is done on the universal mechanical testing machine which is typically screw – driven or hydraucally powered. In some cases the machine may be computer controlled. The primary data generated are load vs elongation which converts into stress vs strain data.

Typical device for measuring strain are mechanical dial indicator, electrically-resistive strain gauge attached to specimen, or extensometer that employ either an optical device, a strain gauge or an inductive or capacitive transducer.

There are different types of specimen depending on the type of the grips and in the form of the available material (sheet, rod, etc.). A good surface finish is required so that surface flows do not provide stress concentrations to cause premature failure.

Stress = load / A_0

Strain= $\Delta l / l$

PROCEDURE:-

(A) TENSION TEST :-

1. Select the proper jaw and complete the upper and lower chuck assemblies .
2. Apply some graphite grease to the tapered surface of the grip for the smooth motion. Then operate the upper cross –head grip operation handle and grip fully the upper end of the test piece.
3. Keep the left valve in fully closed position and the right valve in normal position .Open the right valve and close it after the lower table is slightly lifted.
4. Now adjust the load to zero by TARE push button.
5. Operate the lower grip handle and lift the lower cross head up and grip fully the lower part of the specimen. Then lock the jaws in this position by operating the jaw locking handle. Then, slowly turn the right control valve to open the position (i.e.anticlockwise) until you get the desired loading rate.
6. Then keep on increasing the load. When the test specimen is broken, close the right control valve, take out the broken test pieces.

(B) COPMRESSION TEST

1. Fix the lower pressure plate on the lower crosshead and lower table respectively.
2. Place the specimen on lower compression plate.
3. Then adjust the ZERO by lifting the lower table and perform the test in the same way as the tension test.

OBSERVATIONS :-

Original dimensions:

Length= Diameter=

Final dimensions:

Length= Diameter=

Stress (at any three points in elastic limit): From Stress Strain Curve

Strain (at any three points in elastic limit): From Stress Strain Curve

CALCULATIONS:-

i. Original Area
ii. Final Area
iii. Final percentage reduction in area
iv. Load (at three points selected on stress strain curve)
v. Modulus of Elasticity
vi. Possion’s ratio

<u>TABULAR REPRESENTATION OF CALCULATED DATA FROM TEST</u>

<table>
<tr><th>S.No.</th><th>Load</th><th>Stress</th><th>Strain</th><th colspan="2">Yield points</th><th>UTS</th></tr>
<tr><td>1.</td><td></td><td></td><td></td><td>UYP</td><td>LYP</td><td rowspan="3"></td></tr>
<tr><td>2.</td><td></td><td></td><td></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>3.</td><td></td><td></td><td></td></tr>
</table>

UYP: Upper yield point

LYP: Lower yield point

RESULT:- The given material has:

- Modulus of Elasticity =
- Poisson Ratio=
- Tensile Strength=

DISCUSSION:-

- When the initial area of the specimen is used in the calculation, the stress is called the nominal stress.
- A more exact value of the axial stress, called the true stress, can be calculated by using the actual area of the bar at the cross section where failure occurs.
- The slope of the straight line in graph is called the modulus of elasticity.
- Considerable elongation of the test specimen occurs with little increase in the tensile force called yielding.
- During strain hardening, the material undergoes changes in its crystalline structure.
- The load eventually reaches its maximum value, and the corresponding stress is called the ultimate stress

EXPERIMENT NO.2

OBJECTIVE:-To conduct torsion test on a round specimen.

EQUIPMENT:- Torsion testing machine

SAFETY PRECAUTION:-

1. Be carefull to avoid pinching fingers in grips during installation of parts.

2. Care should be taken to avoid damage to strain gauges mounted on specimen.

THEORY:-

Torsion is the twisting of an object due to an applied torque, therefore is expressed in Nm. In sections perpendicular to the torque axis, the resultant shear stress in this section is perpendicular to the radius.

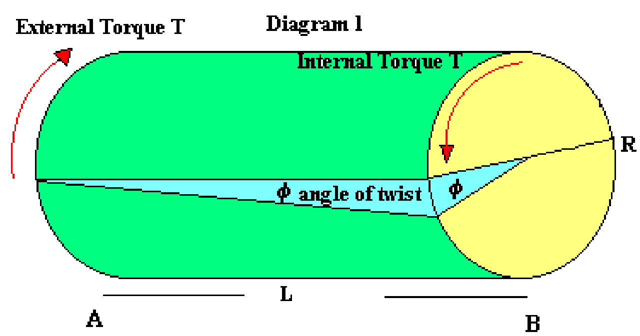


Figure 1

The applied torque (*T*) as shown in **Figure 1**, to the specimen and resulting deformation (angle of twist,ϕ) are measured during the torsion test. These results are converted to shear stress (τ) and shear strain (γ) by the following respective equations (1-3):

- $T=\frac{\pi}{2}\tau_{max}R^3$ (1)
- $\frac{\tau_{max}}{R}=\frac{C\phi}{L}$ (2)
- $\tau_{max}=C\,\Upsilon$ (3)

C is the shear modulus or more commonly the modulus of rigidity

PROCEDURE

1. Place specimen in grip by tightening the collet chuck.
2. Set the main pointer at “0”by turning the rack.
3. Set the “0” by on angle measuring discs by rotating it.
4. Reset the counter.
5. Fit the recorder pen into pen holder mounted on rack and set its starting position over graph paper.
6. Pull out the locking pin provided to lock the jaw head of measuring panel.
7. Start the geared motor with the help of forward switch.
8. Now the torque will be applied to the specimen and the pointer will start indicating the torque until the specimen fails.

OBESERVATION TABLE:

S.No.	Torque (Nm)	Total number of specimen revolution	Specimen revolution in degree	Angle on disc1in degree	Angle on disc 2 in degree	Actual angle of twist in degree	Actual angle of twist in radian
1.							
2.							
3.							

Length of Specimen:

Diameter of specimen:

CALCULATIONS:-

1. Maximum Shear stress in test specimen:
2. Modulus of Rigidity:

3. Shear Strain:

RESULT:-

1. Torsional strength of test specimen is……
2. Modulus of rigidity of test specimen…………..

DISCUSSION:-

- Could the same procedure can be applied on hollow shaft? Justify
- What are the assumptions upon which the elastic torsion formula is based ?

Assumptions:

1. Material is homogenous.
2. Circular section remains circular and do not warp.
3. A plane section of a material perpendicular to its longitudinal axis remain plane and do not warp after the torque is applied.
4. Shaft is loaded by a couple or torque in a plane perpendicular to the longitudinal axis of the plane.
5. Shear stress is proportional to shear strain, it means that Hook's Law is applicable.
6. In circular shafts subjected to torque shearing strain varies linearly.

EXPERIMENT NO. 3

OBJECTIVE:-To conduct hardness test on test specimen.

EQUIPMENT:- TRB-250 Hardness testing machine

***DISCRIPTION*:-**The material of hardness tester is cast iron. The enclosed design protects the internal operating parts from the dust effect. The elevating screw is also protected by a rubber bellow. One end of main loading lever is located internally by two bearing and other end is free. The weights under hydraulic dashpot system control are applied on this free end, which transmits the pressure on diamond holder and thereby on the test piece for determination of hardness value.

The diamond holder of this machine is guided with linear motion. Bearings facilitate measurement of hardness of pin of very small diameters.

SAFETY PRECAUTION:-

1. Adjust the test specimen on anvil at almost central position.
2. Use the micrometer precisely.

THEORY :-

Hardness is the property of material to resists surface indentations or abrasion. Factors influencing hardness include microstructure, grain size, strain hardening etc. Generally as hardness increase, yield strength and ultimate tensile strength decrease, thus, specification often require of hardness test rather than tensile tests.

Different materials have different performance, but the test result also depends on what kind of indenter is used (size/shape/material) and how much force is used to push it into the sheet metal.

In standard brinells test 10 mm diameter hardened steel ball is forced to penetrate the material by 3000 kgf for steel and cast iron. The Brinell hardness number is calculated by dividing the load applied by the hemispherical surface area of the indentation. Brinell hardness number of a material is given by:

$BHN = 2P/\{\Pi D[D-(D^2-d^2)]\}$

where:

P = applied force (kgf)

D = diameter of indenter (mm)

d = diameter of indentation (mm)

BHN is designated by the most commonly used test standards as *HBW* (*H* from hardness, *B* from brinell and *W* from the material of the indenter, tungsten carbide).

HBW is calculated in both standards using the SI units as

$$\mathrm{HBW} = 0.102 \frac{2F}{\pi D \left(D - \sqrt{D^2 - d^2}\right)}$$

Where, *F* is applied force (N)

PROCEDURE:-

(A) BRINELL TEST

1. Place the specimen on anvil.
2. Bring the surface of specimen up by rotating handle of elevating screw just to touch the indenter.
3. Now apply the minor load of 10 kgf by revolving handle up to the small dial indicator come to rest position.
4. Select load as per the dia. of ball indenter.
5. First load and then unload the specimen.

Note: the dia .of indent in the test piece using brinell microscope.

Calculate brinell hardness.

The Brinell hardness test involves applying a specified load using a hardened steel or tungsten carbide spherical indenter of a specified diameter (typically 1mm to 10mm). Due to the challenges of measuring a curved surface area, Brinell testing is typically not used for sheet metal.

Like Brinell testing, the Vickers hardness number is calculated by dividing the applied load by the surface area of the indentation. However, a Vickers microhardness test is typically done with significantly less force than a Brinell test, using a diamond indenter having a square cross-section. Built into the Vickers microhardness test machine is a microscope that allows for more precise measurement of the diagonal cross-sectional lengths. By magnifying the surface, it becomes possible to target specific microstructural constituents (like martensite or bainite in Advanced High Strength Steels) or to assess the quality of heat treating or surface hardening operations.

(B) ROCKWELL TEST

1. Place sample on anvil.
2. Move to red spot (inner scale) while applying minor load.
3. Select load according to the chart.
4. Apply load using lever when the pointer comes in stable position while unload.
5. Read Rockwell hardness no. directly from outer scale.

Rockwell hardness values are determined using a two-step process. First, the indenter (either ball- or cone-shaped) is pushed into the surface until the desired pre-load (also called "minor load") is reached (10kg for the B and C scales, 3kg for the N and T superficial scales). This small initial penetration seats the indenter and provides a reference depth. An additional "major load" is applied, which results in deeper penetration into the sheet metal surface. The major load is then removed and the minor load is re-applied. The difference between this depth reading and the reference depth is used in the Rockwell hardness calculation, and is "d" in the equation for the Rockwell B scale:

$HRB = 130 - (d / 0.002mm)$

OBSERVATION: -

(A) Brinell test

S.No.	Indenter Dia.	BHN
1.		
2.		
3.		

(B) Rockwell test

S.No.	Indenter area	RHN

CALCULATION:-

Calculate brinell hardness using formula.

RESULT:- BHN and HRB of given specimen is...

DISCUSSION:-

- What are the limitations on the thickness of specimen for hardness test?

Answer: Specimen thickness should be at least ten times the indentation depth; allowance should be made for at least three indentation diameters between the centre of one indentation and the specimen edge, or to the centre of a second indentation.

- What are advantages of vicker test against brinell test?

Answer: The Vickers test is reliable for measuring the hardness of metals, and also used on ceramic materials. The diamond material of the indenter has an advantage over other indenters because it does not deform over time and use. The impression left by the Vickers penetrator is a dark square on a light background. The Vickers impression is more easily "read" for area size than the circular impression of the Brinell method.

Just one type of indenter is used for all types of metals and surface treatments

- Why surface condition is necessary for Brinell, Rockwell, Vicker hardness test.

Answer: Another big source of error with some hardness testing is the surface quality on the test sample. This is where surface finish inspection starts to play a role. A minimum surface finish requirement is specified in order to assure proper hardness gage function. A surface finish of 80 microinches or better average roughness (Ra) is often required to assure proper hardness measurements.

Surface finish—also known as profile—is composed of two elements: waviness and roughness. Waviness, or longer wavelength variation, is caused by macro-type influences, such as worn spindle bearings or vibration from other equipment on the shop floor. Roughness is the short wavelength pattern caused by tool marks from grinding, milling or other machining processes and is influenced by the condition and quality of that tooling. As the indenter is apt to be small compared to the waviness component of the surface, it is the latter, short wavelength roughness pattern that influences hardness values the most.

EXPERIMENT NO. 4, 5

OBJECTIVE:- To conduct impact test on single notch square section specimen using

(a) **Izod Test** (b) **Charpy Test**

EQUIPMENT: - Universal pendulum impact testing machine

SPECIMEN Details

(a) A steel specimen 75 mm X 10mm X 10mm for Izod Test

(b) A steel specimen 55 mm X 10mm X 10mm for Charpy Test

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. During the impact test load is applied as an impact blow of weighted pendulum hammer released from a fixed height h. The specimen is positioned at the base. The pendulum released from height $h$strikes and fracture the specimen at the notch. The pendulum continue its swing due to inertia and rise up to maximum height h' which is lower than h.

The energy absorbed at the fracture E can be obtained by simply calculating the difference between the potential energy of pendulum before and after the test using formula.

$E=m.g.(h-h')$

where, m=mass of pendulum

g=gravitational acceleration

The notch impact strength (I) is calculated by:-

I=E/A

Where, I = impact strength in joules/cm^2

E = Impact energy absorbed by the specimen during rupture in joules

A=area of cross section of specimen below the notch before test in cm^2

In impact tests, the fracture may be either brittle or ductile. The brittle fracture is not accompanied by noticeable plastic deformation. On the other hand, considerable plastic deformation takes place in ductile fracture.

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

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 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.

SAFETY PRECAUTIONS :-

1. Confirm the tightness of all the fixing screws of charpy –izod block, stiker etc.
2. Do not stand in swinging area of pendulum.
3. Do not operate the machine if the release mechanism is found defective.
4. The support/striker should be removed when machine is idle. Confirm that the pendulum hammer is positively secured in horizontal position with the help of hook.
5. Do not operate the hammer by operating pendulum release mechanism when the hook is in suspended position.
6. Fixed the specimen in proper position for the betterment of test result.

OBSERVATION:-

(a) Izod test

S.No.	Mass of pendulum (kg)	Test specimen (Area in cm^2)	h (m)	h' (m)
1				
2				
3				

(a Charpy test

S.No.	Mass of pendulum (kg)	Test specimen (Area in cm^2)	h (m)	h' (m)
1				
2				
3				

CALCULATION:-

Average Energy absorb at fracture

Average Notch Impact strength

RESULT:-

(A) Energy absorbed by test specimen and its notch impact strength determined by Izod test are:

(B) Energy absorbed by test specimen and its notch impact strength determined by Charpy test are:

DISCUSSION:-

- Difference between Izod and Charpy Test (test material position, notch position, test specimen dimension, angle of impact)

EXPERIMENT NO. 6

OBJECTIVE:- To conduct fatigue test and interpret the results.

EQUIPMENT:- FTG-8(D) fatigue testing machine

'MACHINE DISCRIPTION':Two swivelling bodies LH and RH are mounted in their brackets and fixed over the base. These bodies contain the hollow shaft assemblies within them. The hollow shaft assembly consists of hollow shaft, collet, clamping cum loosening ring, lock nut and bearings. These RH and LH assemblies hold and grip the specimen .The clamping cum loosening ring tightens the specimen .The rotation preventing assembly consisting of locking ring, locking rod and spring which help in preventing the rotation of hollow shaft assembly while clamping/loosening of the specimen. The motor inside the base drives the RH hollow shaft assembly through belt and flexible shaft. The pulleys are selected such that the specimen rotates at 4200 rpm.

SAFETY PRECAUTION:-

1. The flexible shaft shall never be rotated in direction opposite to the direction indicated by arrow.

2. The specimen shall never be run without tightening it in both side collets.

3. Never allow the locking rod to enter into slots of clamping ring when machine is in running condition.

THEORY:-

When a material is subjected to repeated stresses, it fails at a stress below the yield point stress. Such type of failure of material is known as **fatigue.** The fatigue of material is effected by the size of the component, relative magnitude of static and fluctuating load and the number of load reversals.

Fatigue limit (σ_e) is defined as the maximum value of the completely reversed bending stress which is polished standard specimen can withstand without failure.

The stress v/s time diagram for fluctuating stress having values σ_{min} and $\sigma_{max.}$ The variable stress, in general, may be considered as a combination of steady stress and completely reversed stress component $\sigma_{v.}$

1. Mean or average stress (σ_m) = $(\sigma_{max+}\ \sigma_{min})/2$
2. Reversed or alternating or variable stress (σ_v) = $(\sigma_{max\ -}\ \sigma_{min})/2$
3 .Stress ratio (R) = σ_{max} / σ_{min}

The specimen loading arrangement results in a constant bending moment PL/2 kg-cm over the length of specimen.

Bending stress can be calculated using the equation:

$$\frac{\sigma_b}{y} = \frac{M}{I}$$

Where, σ_b is bending stress, I is moment of inertia, M is bending moment, and y is the radius of rod.

PROCEDURE:-

1. Fix the specimen in the fatigue testing machine.
2. Start the machine allow the specimen for cyclic loading. The specimen is rotate at constant speed. Revolution counter is used to record the number of cycle to which the specimen fails.
3. Construct the S-N curve for the specimen.
4. Investigate fracture surface of broken specimen and sketch the result.

OBSERVATION:-

Details	Specimen 1	Specimen2	Specimen3	Specimen4	Specimen5
Specimen dia. (cm)					
Length (cm)					
Weight(kg)					
No. of cycle to failure (N)					

CALCULATION:-

(i) Bending Moments

Specimen 1	Specimen2	Specimen3	Specimen4	Specimen5

(ii) Moment of Inertia=

(iii) Bending stress(S)

Specimen 1	Specimen2	Specimen3	Specimen4	Specimen5

RESULT:- Plotting of S-N curve

DISCUSSION :-

- What are the stages in a fatigue facture?
- Where do most fatigue cracks start?
- What information can be obtained observing the fracture?
- What are the mean stress and R-ratio?

EXPERIMENT NO. 7

OBJECTIVE:-To determine the stiffness of the spring and modulus of rigidity ofthe spring wire

EQUIPMENT:-

i) Spring testing machine. ii) A spring iii) Vernier calliper, Scale. iv) Micrometre.

THEORY:-

Springs are elastic member which distort under load and regain theiroriginal 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 metal and other metal alloys are used for corrosion resistance spring.

Several types of spring are available for different application. Springs may classify 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 idealize complex structural systems by suitable spring.

Expression (1) to (5) are used for identifying stiffness and modulus of rigidity of spring coil

$$J=\frac{\pi}{32}d^3 \quad (1)$$

$$T=W\text{x}\frac{d}{2} \quad (2)$$

$$\frac{T}{J}=\frac{C\phi}{L} \quad (3)$$

$$\phi=\frac{\delta}{R} \quad (4)$$

$$W=-K\delta \quad (5)$$

- J : Polar Moment of Inertia
- T: Torque
- W: Weight or Load applied on spring
- C: Modulus of rigidity
- Ø : Angle of twist
- K: Stiffness of spring

PROCEDURE

1. Measure the diameter of the wire of the spring by using the micrometer.
2. Measure the diameter of spring coils by using the Vernier caliper
3. Count the number of turns.
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. Increase the load and take the corresponding axial deflection readings.
6. Plot a curve between load and deflection. The shape of the curve gives the stiffness of the spring.

OBESERVATION:

Least count of micrometer = ……mm

Diameter of the spring wire, d =………mm (Mean of three readings)

Least count of Vernier caliper   = ……mm

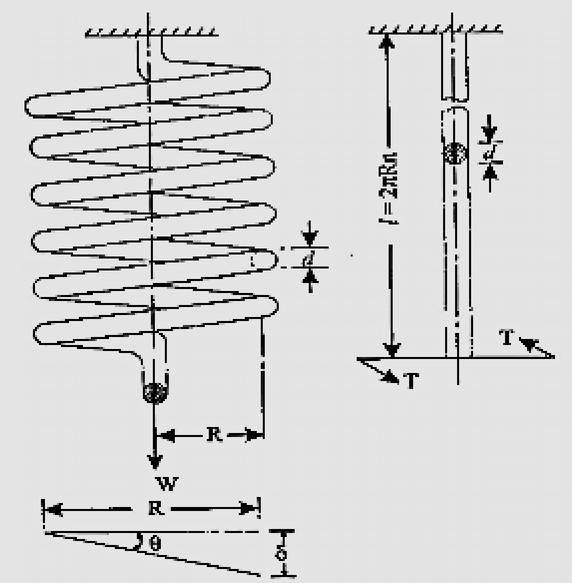
Diameter of the spring coil, D_n = ……mm (mean of three readings)

Mean coil diameter, D:

Number of turns, *n*:

Length of Spring coil, l :

DIAGRAM:-



OBSERVATION TABLE:

S.No.	1	2	3	4	5	6	7	8	9	10
Compressive Load, W (N)										
Deflection, δ(mm)										
Stiffness, K (N/mm)										

CALCULATION:-

1. Average Stiffness

2. Modulus of Rigidity (mean of three calculations)

RESULT:-

1. The value of spring constant k of closely coiled helical spring isfound to be------------ **N / mm**

2. Modulus of rigidity of given spring is specimen………….. **N / mm^2**

DISCUSSION:-

- Spring Definitions:

A spring may be defined as an elastic member whose primary function is to deflect or distort under the action of applied load; it recovers its original shape when load is released.

or

Springs are energy absorbing units whose function is to store energy and to restore it slowly or rapidly depending on the particular application

- Uses of springs:

(a) To apply forces and to control motions as in brakes and clutches.
(b) To measure forces as in spring balance.
(c) To store energy as in clock springs.
(d) To reduce the effect of shock or impact loading as in carriage springs.
(e) To change the vibrating characteristics of a member as inflexible mounting of motors.

EXPERIMENT NO. 8

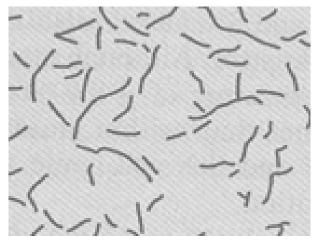
OBJECTIVE: Comparative study of microstructures of different types of Cast Iron and steel.

EQUIPMENTS:-

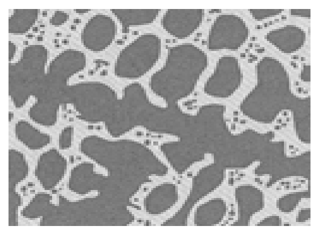
N/A

THEORY: Microstructure of different types of Cast Iron:

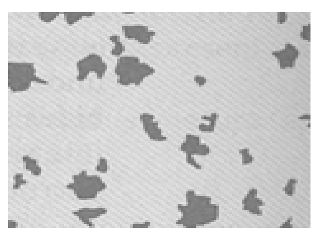
1. Gray Cast Iron



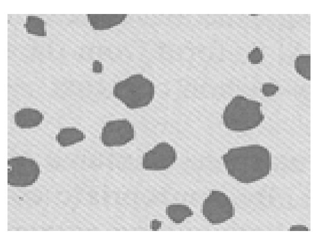
2. White Cast Iron



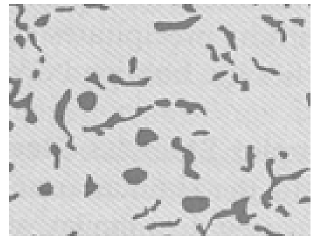
3. Malleable Cast Iron



4. Ductile Cast Iron

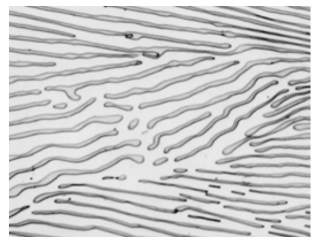


5. Compacted Graphite Cast Iron

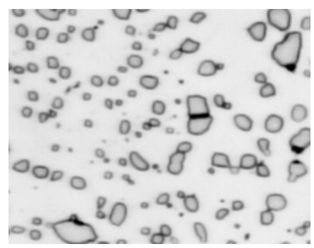


Microstructure of different types of Steel:

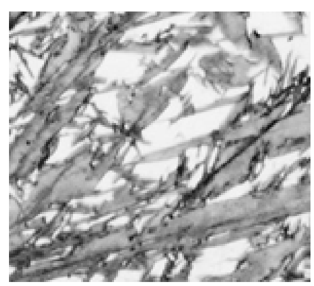
1. Microstructure of Steel Formed from Eutectoid Composition



2. Eutectoid Steel

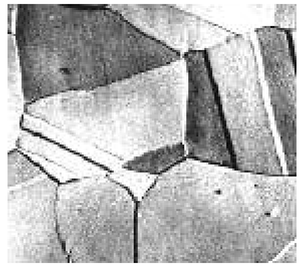


3. Martensite



4. Ferrite

5. Austenite



DISSCUSSION:

Investigate the following factors:

- The use of different types of cooling media (air and oil) to investigate the effect of the cooling fluid on the formed structure.
- The variation of carbon content and the impact on the microstructure.
- The effect of tempering temperature on the formed structure.
- The effect of the tempering time on the microstructure.
- The Martensitic structure and its types.

EXPERIMENT NO. 9

OBJECTIVE: Specimen preparation for metallographic examination /micro structural examination.

EQUIPMENTS:- Grinding papers, Grinder, Etching agent, Metallurgical Microscope

THEORY: The preparation of a metallurgical specimen generally can be divided into a series of stages: sectioning, mounting, grinding and polishing, and etching.

(i)Sectioning: Sectioning is the removal of a small representative volume of material from the parent piece. The microstructure of the material must not be altered in the process. Cold work and heat are the two most likely conditions that can quickly bring about structure changes. Quite obviously operations such as sawing that generates heat or shearing that introduces cold work are not preferable for sectioning. Cutting using a bonded abrasive wheel with coolant offers the best solution to minimize or eliminate heat and deformation.

(ii)Mounting: Metallurgical specimens are mounted primarily for (1) convenience in handling and (2) protection and preservation during subsequent grinding and polishing.

(iii) Grinding and Polish: Grinding and polish are accomplished by sequential coarse grinding, medium grinding, and rough and final polishing. The specimen should be carefully rinsed before proceeding from one operation to the next.

Coarse grinding is done on a wet-belt grinder with 120 and 240 grit belts. The purpose of coarse grinding is to obtain a flat surface free from previous cutting tool marks.

Medium grinding is accomplished using successively finer grits of metallographic grinding paper. The paper is supported on a hard, flat surface such as glass or steel. The specimen is moved along the length of grinding paper without rotation or a rocking motion. When grinding is completed on one grit the scratches should all run in the same direction. Before proceeding to the next finer grit the specimen should be washed to avoid brining large particles to the finer grit. The specimen is rotated 90 degrees between grits so that scratches from each successively finer grit run at right angles to those from the previous one. The polishing on a grit is complete when coarser scratches from previous grit have been totally removed.

Rough and final polishing is accomplished on cloth-covered wheels charged with fine abrasive alumina particles suspended in water.

(iv) Etching: The specimen surface is fairly smooth immediately after the final polish. A smooth surface deflects lights from the illuminator in the metallurgical microscope along the same direction showing no contrast and cannot reveal surface characteristics. Surface characteristics such as different phases, inclusions, porosity, cracks, intergranular corrosion can be revealed by etching. Etching is defined as the process to reveal structural details by preferential attack of a metal surface with an acid or other chemical solutions.

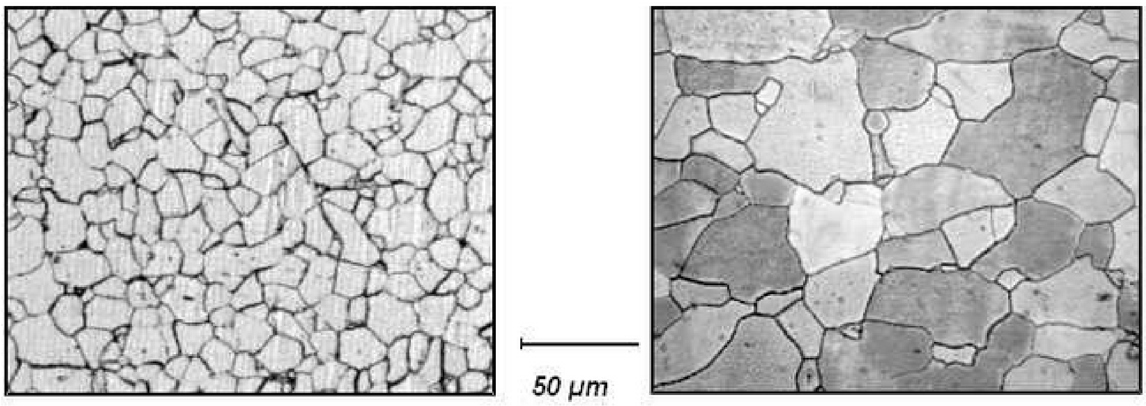
PROCEDURE:

1. Obtain a steel specimen from the instructor and remove as much surface scale as possible
2. Mount the specimen in a phenolic cylinder using a compression mounting press.
3. Prepare the specimen by coarse grinding on a wet-belt grinder, hand polishing on four successively finer grits of polishing paper, and fine polishing on two polishing wheels with 1.0- mm and 0.05-mm alumina powders.
4. Etch the steel specimen by immersing it in a nital solution (5% concentrated nitric acid in alcohol). Start with 5 seconds of immersion. Rinse the specimen with water, dry with paper towel, immerse briefly in alcohol, and blow dry the specimen with a blow dryer.
5. Examine the specimen under microscope for identifying the surface features.
6. Make the power supply ON to microscope. Select an appropriate lens for vision. Focus the microscope by using the general knob and then fine tuning knob. See the surface of specimen through eyepiece lens. Depending upon whether the microscope is binocular or trinocular, use each objective lens to study the microstructure.

PRECAUTIONS:

The specimen must be completely dry, otherwise the microstructure will not be clearly visible.

MICROSTRUCTURE OF STEEL WHEN VIEWED THROUGH MICROSCOPE:



DISCUSSION:

- Microstructure of metals are different from each other-why?
- How microstructure is related to mechanical properties?
- What are the methods of finding out the grain size.

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Viva Questions

1. Why surface condition is necessary for Brinell, Rockwell, Vicker hardness test
2. What are advantages of vicker test against brinell test?
3. What are the limitations on the thickness of specimen for hardness test?
4. Difference between Izod and Charpy Test (test material position, notch position, test specimen dimension, angle of impact)
5. What are the stages in a fatigue facture?
6. Where do most fatigue cracks start?
7. What information can be obtained observing the fracture?
8. What are the mean stress and R-ratio?
9. Spring Definitions:
10. Uses of springs:
11. The use of different types of cooling media (air and oil) to investigate the effect of the cooling fluid on the formed structure.
12. The variation of carbon content and the impact on the microstructure.
13. The effect of tempering temperature on the formed structure.
14. The effect of the tempering time on the microstructure.
15. The Martensitic structure and its types.
16. Microstructure of metals are different from each other-why?
17. How microstructure is related to mechanical properties?
18. What are the methods of finding out the grain size?

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Quiz

1. Which of the following machine is used to measure compressive strength?

a) Universal testing machine

b) Impact testing machine

c) Fatigue testing machine

d) Erichsen machine

Answer:(A)

2. Which of the following instrument is used to measure formability?

a) Universal testing machine

b) Impact testing machine

c) Fatigue testing machine

d) Erichsen machine

Answer:(D)

3. Which of the following device is used to measure hardness in Mohs?

a) Rockwell tester

b) Sclerometer

c) Universal testing machine

d) Gyro meter

Answer:(B)

4. What is the cross-section of standard specimen for impact testing?

a) 10mm × 10mm

b) 20mm × 60mm

c) 10mm × 40mm

d) 45mm × 60mm

Answer:(A)

5. Which of the following test is more preferred for testing hardness of electroplated surface?

a) Microhardness test

b) Dynamic hardness test

c) Macro hardness test

d) Scratch hardness test

Answer:(A)

6. Which of the following is a drawback of ultrasonic testing?

a) Shape restriction

b) Low depth

c) Higher errors

d) High sensitivity

Answer:(D)

7. Is ultrasonic testing is destructive testing?

a) False

b) True

Answer:(A)

8. Which of the following factor affects ductile-brittle transition behavior the most?

a) Triaxiality

b) Notching

c) Temperature

d) Strain rate

Answer:(C)

9. Which of the following material shows a gradual rising R-curve with failure governed by R-curve behaviour?

a) Low toughness and strength

b) High toughness and strength

c) Low toughness / strength

d) High toughness / low strength

Answer:(D)

10. With an increase in strain rate, ductility ______ and tensile strength _____

a) Decreases, decreases

b) Decreases, increases

c) Increases, increases

d) Increases, decreases

Answer:(B)

11. Largest size flaw can be determined using which of the following test?

a) Shore test

b) Brinell test

c) Leeb test

d) NDT

Answer:(D)

12. Yield and flow strength at lower plastic strain is more dependent on _____ than ______

a) Strain rate, temperature

b) Temperature, tensile strength

c) Tensile strength, strain rate

d) Strain rate, tensile strength

Answer:(D)

13. R-curve behaviour is a material related property.

a) False

b) True

Answer:(A)

14. The slope of the stress-strain curve in the plastic range is _____

a) Bauschinger effect

b) Resolved shear stress

c) True strain

d) Rate of strain hardening

Answer:(D)

15. At strain rates _____ behaviour of the material is characterized by creep.

a) High, 104 per second

b) High, 10-4 per second

c) Low, 104 per second

d) Low, 10-4 per second

Answer:(D)