LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY

STUDENT MANUAL

MECHANICS OF SOLIDS LAB

B.Tech -
Mechanical Engineering

Department of Mechanical Engineering

INSTITUTE

VISION

- Producing globally competent and quality technocrats with human values for the holistic needs of industry and society.

MISSION

- Creating an outstanding infrastructure and platform for enhancement of skills, knowledge and behavior of students towards employment and higher studies.

- Providing a healthy environment for research, development and entrepreneurship, to meet the expectations of industry and society.

- Transforming the graduates to contribute to the socio-economic development and welfare of the society through value based education.

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

- Envisions Mechanical Engineers of globally competent and skilled professionals to meet the needs of Industry and society.

MISSION

- Providing state of art facilities with inspiring learning environment to develop skill and ethical values of students towards higher studies and employment.
- Creating a conducive environment for technological development, research and entrepreneurship to fulfil the evolving needs of Industry and Society.
- Transforming the graduates to contribute towards wellbeing of society and sustainable development goals turn value based and sustainable engineering education.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Graduates will have strong knowledge, skills and attitudes towards employment, higher studies and research.

PEO2: Graduates shall comprehend latest tools and techniques to analyze, design and develop novel systems and products for real life problems.

PEO2: Graduates shall have multidisciplinary approach, professional attitude, ethics, good communication, teamwork and engage in life-long learning to adapt the rapidly changing technologies.

PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to:

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

P07: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

P09: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Capable of design, develop and implement sustainable mechanical and environmental systems.

PSO2: Qualify in national and international competitive examinations for successful higher studies and employment.

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE DATA SHEET

Academic Year: 2024-25

PROGRAM: Mechanical Engineering	**DEGREE**: B.Tech.
COURSE: Mechanics of Solids and Materials Science Lab	**SEMESTER**: III-II **CREDITS**: 1.5
COURSE CODE: R23MEC-PC2103 **REGULATION**: R23	**COURSE TYPE**: Professional Core
COURSE AREA/DOMAIN: Engineering Design & Production	**CONTACT HOURS:** 3 hours/Week.
CORRESPONDING LAB COURSE CODE (IF ANY): NA	**LAB COURSE NAME** (IF ANY): NA

SYLLABUS:

S.No.	DETAILS
SECTION-A MECHANICS OF SOLIDS LAB	
1	Tensile test
2	Bending test on a. Simply supported beam b. Cantilever beam
3	Torsion test
4	Hardness test a. Brinells hardness test b. Rockwell hardness test c. Vickers hardness test
5	Test on springs
6	Impact test a. Charpy test b. Izod test
7	Punch shear test
8	Brick compression test
SECTION-B MATERIAL SCIENCE LAB	
1	Preparation and study of the Microstructure of pure metals.
2	Preparation and study of the Microstructure of Mild steel, medium carbon steels, and High carbon steels.
3	Study of the Microstructures of Cast Irons.
4	Study of the Microstructures of Non-Ferrous alloys.
5	Study of the Microstructures of Heat-treated steels.

6	Hardenability of steels by Jominy End Quench Test

NOTE: Any 6 experiments from each section A and B.

Exp. No.	NAME OF THE EXPERIMENT
1	Tensile Strength of Materials Using a Universal Testing Machine.
2	Compressive Strength of Materials Using a Universal Testing Machine.
3	Compressive Strength of Bricks Using a Compression Testing Machine.
4	Torsional Strength of Materials Using a Torsion Testing Machine.
5	Hardness of a Materials by conducting Hardness Test on Brinell Hardness and Rockwell Hardness equipment.
6	Stiffness and Modulus of Rigidity of springs by Conducting Spring Test.
7	Impact Strength of Material by conducting Impact Test by using Charpy and Izod test methods.
8	Determination of Hardenability of Steels by Jominy End Quench Test.
9	Preparation and Study of the Microstructure of Pure Metals.
10	Preparation and study of the Microstructure of Mild Steel, Medium Carbon Steels, and High Carbon Steels.
11	Study of the Microstructures of Cast Irons.
12	Study of the Microstructures of Non-Ferrous alloys.
13	Study of the Microstructures of Heat-Treated Steels.

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
T1	Mechanics of Materials by B.C. Punmia; Laxmi Publication.
T2	Strength of Materials by S S Rattan; McGraw Hill Education.
T3	Materials Science and Engineering by V Raghavan; Prentice Hall India Learning Private Limited.
T4	Material Science and Metallurgy for Engineers by Dr. V.D Kodgire and S.V Kodgire; Everest Publishing House.
R1	Mechanics of Material by R. C. Hibbeler; Pearson Publication.
R2	Mechanics of Materials by Gere and Timoshenko; CBS Publishers & Distributors.
R3	Mechanical Metallurgy by George E. Dieter; McGraw Hill Education.
R4	Materials Science and Engineering by Jr. Callister, William D & David G. Rethwisch; John Wiley & Sons Inc

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
R23MEC-ES1202	Basic Civil & Mechanical Engineering	Fundamentals of Engineering Materials - Ferrous Metals and Ferrous Metals	I-II
R23MEC-PC1201	Engineering Mechanics	Fundamentals of Mechanics are useful for calculation of reaction forces in beams	I-II

COURSE OBJECTIVES:

1	To evaluate the values of yield stress, ultimate stress and bending stress of the given specimen under tension test and bending test
2	To Conduct the torsion test to determine the modulus of rigidity of given specimen
3	To Justify the Rockwell hardness test over with Brinell hardness and measure the hardness of the given specimen
4	To Examine the stiffness of the open coil and closed coil spring and grade them.
5	To Analyze the microstructure and characteristics of ferrous and non-ferrous alloy specimens.

COURSE OUTCOMES: student should able

S. No.	DESCRIPTION	PO MAPPING	PSO MAPPING
CO1	**Find** the Mechanical properties of materials through tension, compression, torsion, and hardness tests **(RBT Level: Apply)**	PO1, PO2, PO5, PO6, PO8, PO9, P10, PO12	PSO1, PSO2
CO2	**Compare** the impact strength, hardness, and torsional strength of materials with various equipment. **(RBT Level: Analyze)**	PO1, PO2, PO6, PO8, PO9, P10, PO12	PSO1, PSO2
CO3	**Analyze** the mechanical behaviour of springs, bricks by tension, compression tests. **(RBT Level: Analyze)**	PO1, PO2, PO6, PO8, PO9, P10, PO12	PSO1, PSO2
CO4	**Examine** the microstructure of steels, cast irons, and non-ferrous alloys with Microscope**. (RBT Level: Apply)**	PO1, PO2, PO6, PO8, PO9, P10, PO12	PSO1, PSO2
CO5	**Compare** the Hardenability of Materials by conducting the Heat Treatment Processes. **(RBT Level: Analyze)**	PO1, PO2, PO6, PO8, PO9, P10, PO12	PSO1, PSO2
COURSE OVERALL PO/PSO MAPPING		PO1, PO2, PO5, PO6, PO8, PO9, PO10, PO12	PSO1, PSO2

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH:3; MEDIUM:2; LOW:1**):**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	1	2	-	1	2	2	-	2	2	2
CO2	3	3	-	-	-	2	-	1	3	2	-	2	2	2
CO3	3	3	-	-	-	2	-	1	3	2	-	2	2	2
CO4	3	2	-	-	-	1	-	1	3	2	-	2	2	2
CO5	3	3	-	-	-	1	-	1	3	2	-	2	2	2
CO*	**3**	**3**	**-**	**-**	**1**	**2**	**-**	**1**	**3**	**2**	**-**	**2**	**2**	**2**

** For Entire Course, PO & PSO Mapping*

POs & PSO REFERENCE:

PO1	Engineering Knowledge	PO7	Environment & Sustainability	PSO1	Capable of design, develop and implement sustainable mechanical and environmental systems
PO2	Problem Analysis	PO8	Ethics	PSO2	Qualify in national and international competitive examinations for successful higher studies and employment
PO3	Design & Development	PO9	Individual & Teamwork		
PO4	Investigations	PO10	Communication Skills		
PO5	Modern Tools	PO11	Project Mgt. & Finance		
PO6	Engineer & Society	PO12	Lifelong Learning		

COs VS POs MAPPING JUSTIFICATION:

CO	PO/PSO MAPPED	LEVEL OF MAPPING	JUSTIFICATION
CO1	PO1	3	Understanding material properties requires applying fundamental engineering concepts from tensile, compression, torsion, and hardness tests.
	PO2	2	Interpreting test results and analyzing material behavior involves problem-solving skills in material science.
	PO5	1	Performing tensile tests are performed by UTM involves modern testing tools.
	PO6	2	Understanding material strength contributes to safety and

			reliability in engineering applications.
	PO8	1	Ethical considerations in material testing and reporting ensure accuracy and integrity in engineering practice.
	PO9	2	Conducting material tests requires teamwork in a laboratory environment.
	PO10	2	Documentation of test results and observations improves technical reporting and presentation skills.
	PO12	2	Understanding and testing materials is crucial for continuous learning in material science advancements.
	PSO1	3	Mechanical property evaluation helps in designing and implementing sustainable mechanical systems.
	PSO2	2	Knowledge of mechanical properties is essential for higher studies and competitive exams in mechanical/materials engineering.
CO2	PO1	3	Understanding impact resistance, hardness, and torsional strength through Charpy, Izod, Brinell, Rockwell, and torsion tests requires applying fundamental engineering principles.
	PO2	3	Students analyze and compare test results to determine material performance under different conditions.
	PO6	2	Understanding the mechanical properties of materials helps engineers ensure safety and reliability in real-world applications.
	PO8	1	Following standardized test procedures ensures ethical testing and reporting practices.
	PO9	3	Performing laboratory experiments requires collaboration in a team-based environment.
	PO10	2	Recording and presenting test results improve technical communication skills.
	PO12	2	Understanding different mechanical properties fosters continuous learning and adaptation to new material testing techniques.
	PSO1	2	Material property analysis is essential for designing and implementing sustainable mechanical systems.
	PSO2	2	Knowledge of impact, hardness, and torsional strength testing is crucial for higher studies and competitive exams in mechanical/materials engineering
CO3	PO1	3	Understanding the mechanical behavior of springs and bricks through tension and compression tests requires applying fundamental engineering principles.
	PO2	3	Students analyze load-bearing capacity and deformation characteristics of materials under mechanical stress.
	PO6	2	Conducting mechanical behavior tests requires handling modern testing equipment and interpreting data.
	PO8	1	Evaluating material behavior contributes to sustainable and eco-friendly engineering solutions.

	PO9	3	Standardized test procedures ensure ethical engineering and testing practices.
	PO10	2	Performing tension and compression tests requires collaborative teamwork in a lab environment.
	PO12	2	Selecting materials with appropriate mechanical properties ensures cost-effective solutions in engineering projects.
	PSO1	2	Understanding different mechanical behaviors fosters continuous learning and adaptation to advanced material testing methods.
	PSO2	2	Knowledge of spring and brick mechanics aids in designing sustainable mechanical and structural components.
CO4	PO1	3	Calculating material strength, deformation, and structural integrity involves applying fundamental engineering principles from mechanics of solids.
	PO2	2	Understanding deformation and strength helps in evaluating material behavior under different loading conditions.
	PO6	1	Using experimental setups for measuring deformation and material strength involves modern testing tools.
	PO8	1	Strength and deformation analysis contribute to sustainable and durable engineering solutions.
	PO9	3	Following standardized calculation and testing procedures ensures ethical engineering practices.
	PO10	2	Conducting material strength calculations requires team collaboration and coordination.
	PO12	2	Selecting materials based on strength calculations supports cost-effective engineering solutions.
	PSO1	2	Understanding strength and deformation fosters continuous learning and adaptation to new material analysis techniques.
	PSO2	2	Knowledge of material strength and structural integrity is essential for designing sustainable mechanical systems.
CO5	PO1	3	Examining microstructures of steels, cast irons, and non-ferrous alloys requires knowledge of materials science, phase diagrams, and metallurgical properties.
	PO2	3	Analyzing microstructures helps in understanding phase transformations, grain structure, and material properties, which is crucial for material selection and failure analysis.
	PO6	1	Using microscopes and metallurgical tools for examining microstructures enhances practical skills in material characterization.
	PO8	1	Examining microstructures allows engineers to choose eco-friendly and sustainable materials for different applications.
	PO9	3	Ethical considerations are essential in material testing, reporting accurate results, and avoiding misinterpretations.
	PO10	2	Conducting microstructural analysis requires collaborative teamwork in material science labs.

	PO12	2	Proper material selection based on microstructural analysis contributes to cost-effective material usage in engineering applications.
	PSO1	2	Microstructure study fosters continuous learning in advanced material science, metallurgy, and nanotechnology.
	PSO2	2	Understanding microstructural changes in materials helps in designing sustainable and high-performance mechanical systems.

DELIVERY/INSTRUCTIONAL METHODOLOGIES/PEDAGOGICAL INITIATIVES:

☑CHALK & TALK	☑LABORATORY DEMONSTRATION	☐ADD-ON TOPIC	☑OBSERVATION AND RECORD WRITING
☐INDUSTRIAL VISITS	☐INTERNSHIPS	☑LABORATORY LEARNING	☐MODEL-BASED LEARNING
☐GUEST LECTURES/WORKSHOPS	☑COLLABORATIVE LEARNING	☐MINI/MAJOR PROJECTS	☐CASE STUDIES/REAL LIFE EXAMPLES

ASSESSMENT METHODOLOGIES-DIRECT:

☐ ASSIGNMENTS	☐ STUD. SEMINARS	☐ MID TERM EXAMINATIONS	☑ END SEMESTER EXAMINATION
☑ DAY TO DAY EVALUTION	☑ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS

ASSESSMENT METHODOLOGIES-INDIRECT:

☑ COURSE EXIT SURVEY		

Prepared by

Approved by

1. Dept. IQAC Coordinator **2. Head of the Department**

LIST OF EXPERIMENTS

1. Determination of Hardness of a Materials by conducting Rockwell Test.
2. Determination of Hardness of a Materials by conducting Brinell Hardness Test.
3. Determination of Compressive Strength of Bricks Using a Compression Testing Machine.
4. Determination of Impact Strength of Material by conducting Izod Impact Test.
5. Determination of Stiffness and Modulus of Rigidity of springs by Conducting Spring Test.
6. Determination of Tensile Strength of Materials Using a Universal Testing Machine.
7. Determination of Impact Strength of Material by conducting Charpy Impact Test.
8. Determination of Torsional Strength of Materials Using a Torsion Testing Machine.
9. Determination of Compressive Strength of Materials Using a Universal Testing Machine.

INDEX

S. No.	NAME OF THE EXPERIMENT	COs-MAPPING	POs & PSOs - MAPPING
1	Tensile Strength of Materials Using a Universal Testing Machine.	CO1	PO1, PO2, PO5, PO6, PO8, PO9, P10, PO12, PSO1, PSO2
2	Compressive Strength of Materials Using a Universal Testing Machine.	CO1	PO1, PO2, PO3, PO4, PO5, PO6, PO7, PO8, PO9, P10, PO11, PO12, PSO1, PSO2
3	Compressive Strength of Bricks Using a Compression Testing Machine	CO2	PO1, PO2, PO6, PO8, PO9, P10, PO12, PSO1, PSO2
4	Torsional Strength of Materials Using a Torsion Testing Machine	CO2	PO1, PO2, PO6, PO8, PO9, P10, PO12, PSO1, PSO2
5	Hardness of a Materials by conducting Hardness Test on Brinell Hardness and Rockwell Hardness equipment.	CO1, CO2	PO1, PO2, PO6, PO8, PO9, P10, PO12, PSO1, PSO2
6	Stiffness and Modulus of Rigidity of springs by Conducting Spring Test.	CO3	PO1, PO2, PO6, PO8, PO9, P10, PO12, PSO1, PSO2
7	Impact Strength of Material by conducting Impact Test by using Charpy and Izod test methods	CO2	PO1, PO2, PO6, PO8, PO9, P10, PO12, PSO1, PSO2
8	Determination of Hardenability of Steels by Jominy End Quench Test.	CO1, CO2, CO5	PO1, PO2, PO6, PO8, PO9, P10, PO12, PSO1, PSO2
9	Preparation and Study of the Microstructure of Pure Metals.	CO4	PO1, PO2, PO6, PO8, PO9, P10, PO12, PSO1, PSO2
10	Preparation and study of the Microstructure of Mild Steel, Medium Carbon Steels, and High Carbon Steels.	CO4	PO1, PO2, PO6, PO8, PO9, P10, PO12, PSO1, PSO2
11	Study of the Microstructures of Cast Irons.	CO4	PO1, PO2, PO6, PO8, PO9, P10, PO12, PSO1, PSO2
12	Study of the Microstructures of Non-Ferrous alloys.	CO4	PO1, PO2, PO6, PO8, PO9, P10, PO12, PSO1, PSO2
13	Study of the Microstructures of Heat-Treated Steels.	CO4	PO1, PO2, PO6, PO8, PO9, P10, PO12, PSO1, PSO2

Course Outcomes:

At the end of the course, the student will be able to

CO1: Find the Mechanical properties of materials through tension, compression, torsion, and hardness tests.

CO2: Compare the impact strength, hardness, and torsional strength of materials with various equipment.

CO3: Analyse the mechanical behaviour of springs, bricks by tension, compression tests.

CO4: Examine the microstructure of steels, cast irons, and non-ferrous alloys with microscope.

CO5: Compare the Hardenability of Materials by conducting the Heat Treatment Processes.

EXPERIMENT NO: - 1

ROCKWELL HARDNESS TEST

OBJECTIVE:

The objective of the Rockwell Hardness Test is to measure the hardness of a material by determining the depth of penetration of an indenter under a specific load. This test provides a quick and accurate method for assessing the hardness of materials, which reflects their resistance to deformation and wear.

AIM:

To determine hardness of a material by conducting Rockwell's hardness test.

APPARATUS:

1. Rockwell hardness testing machine.
2. 1/16″ steel ball indenter.
3. 1/8″ steel ball indenter.
4. Diamond cone indenter.

THEORY:

The Rockwell hardness tester is essentially a machine that measures hardness by determining the depth of penetration of a penetrator into the specimen under certain fixed conditions of test. The penetrator may be either a steel ball or a diamond Sphero conical penetrator. The hardness number is related to the depth of the indentation and the higher the number, the harder the material.

The hardness of a material is the resistance offered by a material to indentation or penetration under a localized pressure or resistance to abrasion. Hardness tests provide an accurate, rapid and economical way of determining the resistance of materials to deformation. Hardness can be measured by the indentation made by a harder material. There are a number of indentation tests to measure the hardness of a material normally. The indenters usually a ball, a cone or a pyramid of a material much harder than that being used. Hardened steel, tungsten carbide or diamond indenters are generally used in indentation tests. A load is applied by pressing the indentor at right angles to the surface being tested. The hardness of the material depends on the resistance which it exerts during a small amount of yielding or plastic deformation.

In Rockwell Hardness Test a small steel ball or diamond cone (called a Brale) is pressed into the material. The depth of penetration under a minor and then major load is measured, and hardness is read directly from the machine. A steel ball or diamond cone indentor is used for indentation. The typical load varies from 15 kgf to 150 kgf, depending on the scale used.

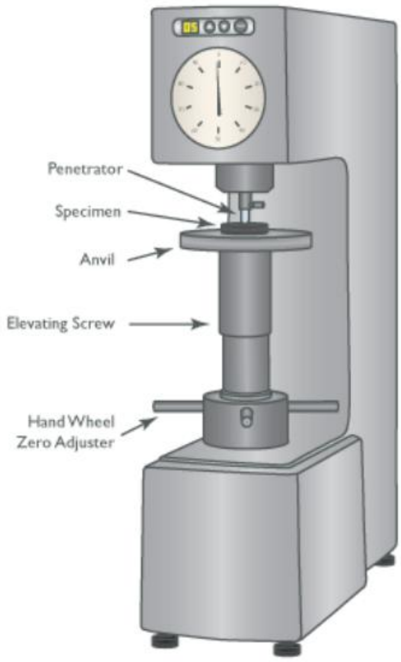


Fig-1. Schematic of Rockwell Hardness Testing Machine

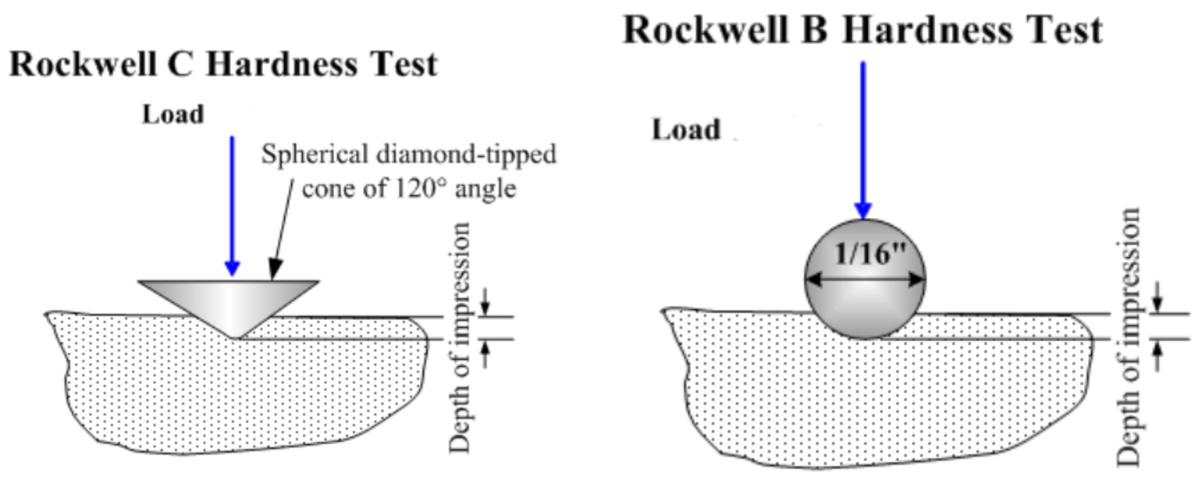


Fig-2. Schematic of Indentaions.

PROCEDURE:

1. Keep the lever at position A.
2. Select the suitable indenter according to the scale.
3. Select the weights according to the scale.

4. Adjust initial load for hardness testing by turning the external knob, provided at upper right side of the machine.
5. Place the specimen on testing table.
6. Turn the hand wheel to raise specimen, making contact with penetrator and continue turning until the long pointer of the dial gauge has made two and half turns. Then it stops at ‘0’. Continue turning further till the small pointer reaches red spot.
7. Turn the lever from position ‘A’ to ‘B’. So the total load will act.
8. When the long pointer of dial gauge reaches a steady position, take back the lever to position ‘A’ slowly.
9. Turn back the hand wheel and remove the job.

OBSERVATIONS:

S. No.	Material	Scale	Indenter	Reading (HRB/HRC)			Mean
				1	2	3	

RESULT:

Average Hardness of the given specimens are

EXPERIMENT NO: - 2

BRINELL HARDNESS TEST

OBJECTIVE:

The objective of the Brinell Hardness Test is to determine the hardness of a material by measuring its resistance to permanent deformation when a load is applied through a hard spherical indenter. This test helps evaluate the material's ability to withstand surface indentation and deformation, which is directly related to its strength and durability.

AIM:

To determine hardness of a material by conducting Brinell hardness test.

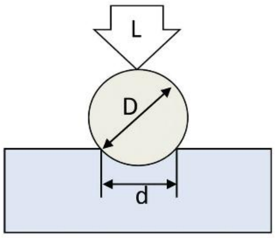
APPARATUS:

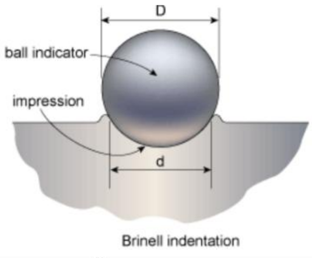
1. Brinell hardness testing machine.
2. Indenter.
3. Portable Microscope

THEORY:

The hardness of a material is the resistance offered by a material to indentation or penetration under a localized pressure or resistance to abrasion. Hardness tests provide an accurate, rapid and economical way of determining the resistance of materials to deformation. Hardness can be measured by the indentation made by a harder material. There are a number of indentation tests to measure the hardness of a material normally. The indenters usually a ball, a cone or a pyramid of a material much harder than that being used. Hardened steel, tungsten carbide or diamond indenters are generally used in indentation tests. A load is applied by pressing the indentor at right angles to the surface being tested. The hardness of the material depends on the resistance which it exerts during a small amount of yielding or plastic deformation.

In the Brinell test, a hardened steel or carbide ball is pressed into the surface of a material under a specified load. The diameter of the indentation left is measured. Hardened steel or carbide ball, typically 10 mm in diameter indentor is used for indentation. The typical load ranges from 500 kgf to 3,000 kgf, depending on the material’s hardness.





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

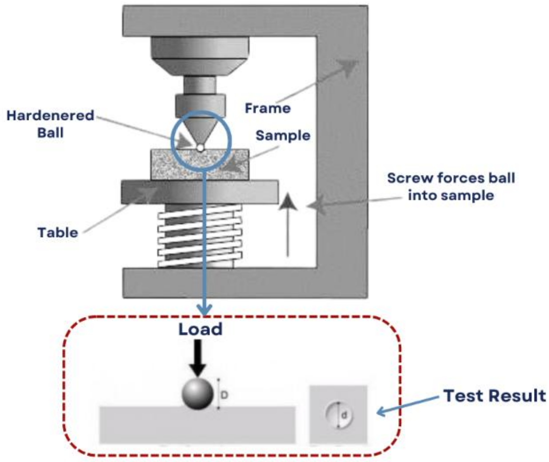


Fig. Schematic of Brinell Hardness Testing Machine

PROCEDURE:

1. The indenter is pressed into the sample by an accurately controlled test force.
2. The force is maintained for a specific dwell time, normally 10 - 15 seconds.
3. After the dwell time is complete, the indenter is removed leaving a round indent in the sample.
4. The size of the indentation is determined optically by measuring two diagonals of the round indent using either a portable microscope or one that is integrated with the load application device.

OBSERVATIONS:

1. Diameter of the Indenter (D) =

2. Diameter of indentation (d) =

FORMULAS:

The Brinell hardness number (BHN) formula

$$BHN = \frac{\text{Load Applied}}{\text{Area of Indentation}} = \frac{2F}{\pi D\left(D - \sqrt{D^2 - d^2}\right)} \quad - \frac{\mathrm{Kgf}}{\mathrm{mm}^2} - \frac{\mathrm{N}}{\mathrm{mm}^2} - \mathrm{MPa}$$

Where,

F = Load applied - Kgf

D = Diameter of the indentor - mm

d = Diameter of the indentation - mm

CALCULATIONS:

RESULT:

The Brinell hardness number (BHN) of the Specimens are

EXPERIMENT NO: - 3

BRICK COMPRESSION TEST

OBJECTIVE:

The objective of Brick Compression Testing is to determine the compressive strength of bricks, which is a critical parameter in assessing their suitability for construction purposes. This test evaluates the brick's ability to withstand axial loads without failure and ensures that it meets the required strength standards for structural stability.

AIM:

To determine the compressive strength of a given brick.

APPARATUS:

1. Vernier calipers
2. Steel Rule.
3. Compression testing machine.

THEORY:

Bricks are used in construction of either load bearing walls or in partition walls of framed structure as shown in the Fig.1. In load bearing walls total weight from slab and upper floor comes directly through brick wall and then it is transferred to the foundation. In this case the bricks are loaded with compressive nature of force on other hand in framed structure bricks are used only for construction of partition walls, in which layer comes directly on the lower layers of wall. However, in any case the bricks in actual practice are to be tested for their compressive strength.

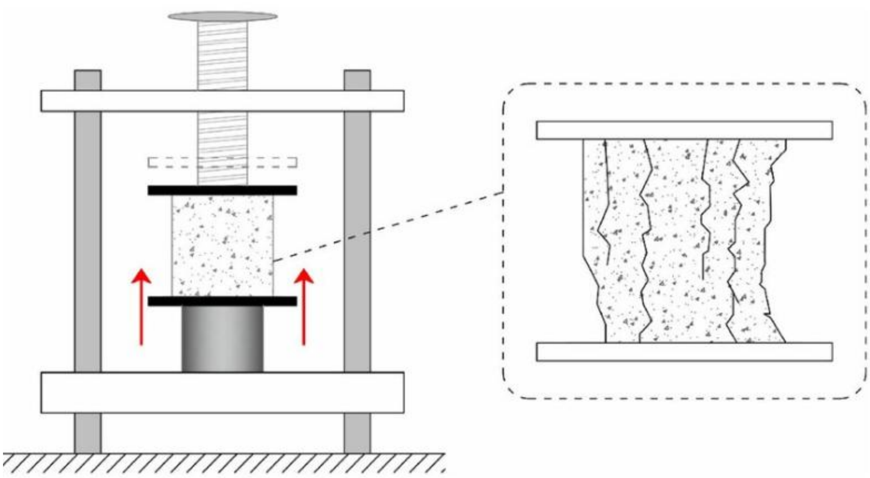


Fig. Schematic of Brick Compression Test.

PROCEDURE:

1. Measure the length and breadth of the specimen at the centre of the brick.
2. Place the specimen with flat faces horizontal, and mortar filled face facing upwards between
3. Apply load axially at a uniformly till failure occurs and note the maximum load at failure.
4. The load at failure shall be maximum load at which the specimen fails to produce any further increase in the indicator reading on the testing machine.
5. Repeat the test procedure for minimum of 3 bricks and report the average.
6. Calculate the compressive strength.

FORMULAS:

$$\text{Compressive Strength} = \frac{\text{Max.Load at failure}}{\text{Loaded Area of Brick}} \;\; - \;\; \frac{N}{m^2}$$

CALCULATIONS:

RESULT:

The compressive strength of Brick is

EXPERIMENT NO: - 4

IMPACT TEST

OBJECTIVE:

The objective of the Impact Test is to determine the ability of a material to absorb energy and resist sudden or dynamic loading conditions, such as impact or shock. This test assesses the material's toughness, which is a critical property for applications where materials are subjected to high strain rates or sudden forces.

AIM:

To determine the impact strength of a material by conducting

1. Charpy impact test.
2. Izod impact test

APPARATUS:

1. Impact testing machine.
2. Vernier calipers.
3. Steel rule.

THEORY:

An impact test signifies toughness of material that is the ability of a 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. Of all types of impact tests, the notched bar tests are most extensively used. Therefore, the impact test measures the energy necessary to fracture a standard notched bar by applying an impulse load. This test measures the toughness of material under shock loading.

Charpy Impact Test and Izod Impact Test are two common methods used to determine the impact toughness of a material. While both tests measure a material’s ability to absorb energy during sudden impact or shock loading, there are several differences between the two tests.

In the Charpy Impact Test, the specimen is placed horizontally, i.e. supported at both ends, like a simply supported beam, and the hammer strikes the side opposite the notch. In the

Izod Impact Test, the specimen is placed vertically like a cantilever beam and the hammer strikes the unnotched side.

The dimensions of the specimens are different, with typical sizes being 55 mm x 10 mm x 10 mm for Charpy and 75 mm x 10 mm x 10 mm for Izod. Additionally, the Charpy test strikes the specimen in the middle between the supports, while the Izod test strikes it at the top, opposite the clamped end. Both tests measure the energy absorbed during fracture, expressed in joules. The Charpy test is commonly used for evaluating materials in structural applications, while the Izod test is more suited for assessing toughness in tools and smaller components.

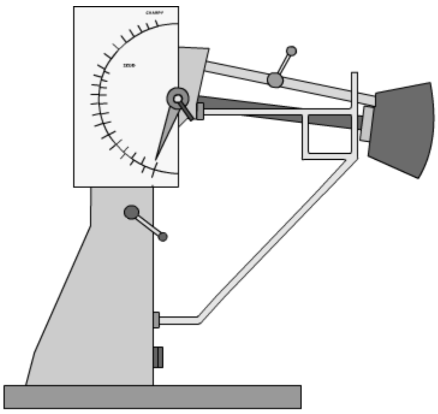


Fig-1. Schematic of Impact Testing Machine

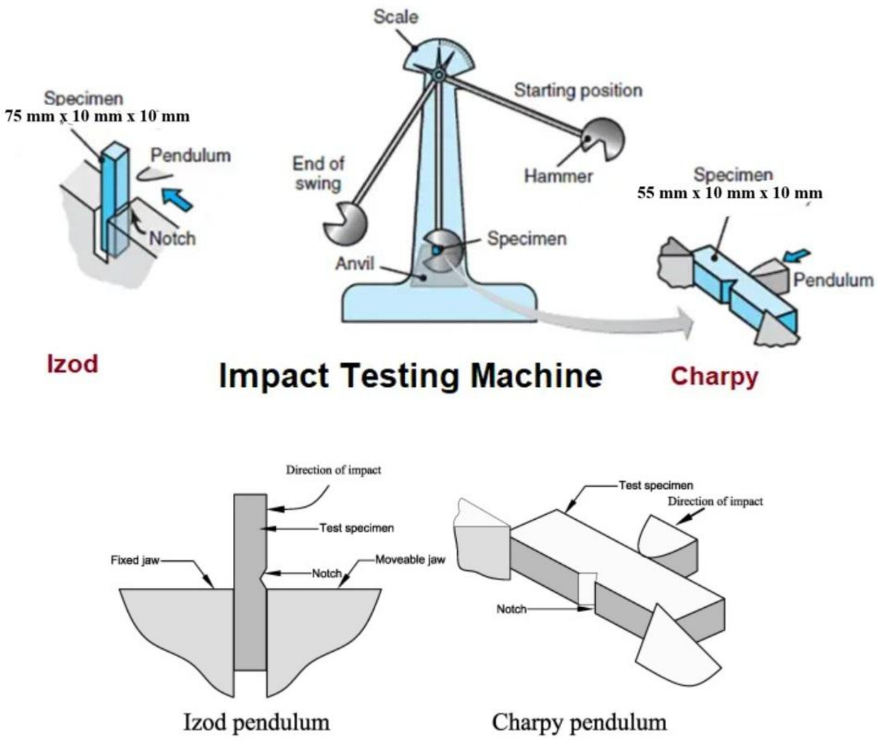


Fig-2. Schematic of Operating Positions

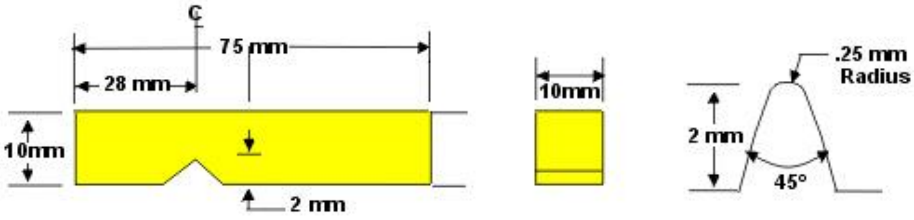


Fig-3. Schematic of Izod Test Dimensions

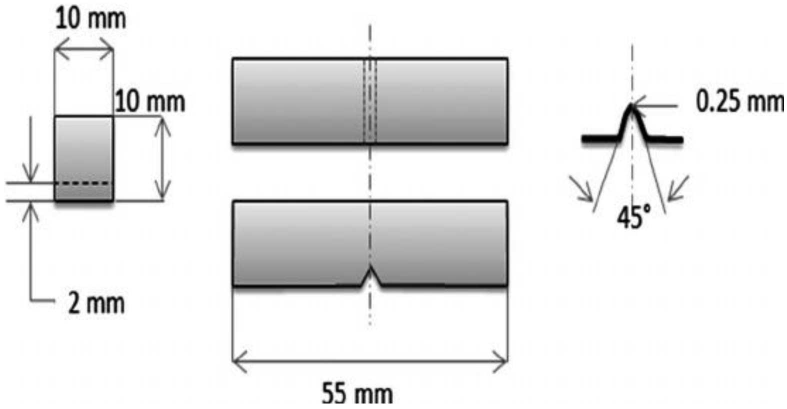


Fig-4. Schematic of CharpyTest Dimensions

All the forms of impact tests are conducted on swinging pendulum type of impact testing machines. In this type of impact testing machine, a heavy pendulum is allowed to strike a standard notched specimen (In Charpy impact test, the specimen is held between two grips, whereas in Izod impact test, the specimen is held at one end like a cantilever). The pendulum swings on after breaking the specimen. The energy absorbed by the specimen (E) before failure is observed by means of a dial indicator.

This energy absorbed by the specimen (E) per unit area of the specimen (A) is known as the impact strength of the material (I).

The impact strength can be calculated Mathematically,

$$\text{Impact Strength(I)} = \frac{\text{Actual Energy Absorbed}}{\text{Cross section area at Specimen}} - \frac{\text{Nm}}{\text{mm}^2} \text{ or } \frac{\text{J}}{\text{mm}^2}$$

PROCEDURE:

<u>1. CHARPY IMPACT TEST</u>

1. The Charpy striker is to be firmly secured to the bottom of the hammer with the help of clamping piece.
2. The machine should be checked for frictional and air resistance. If any, should be noted.

3. Adjust the reading pointer with pointer carrier to 300J dial reading, when the pendulum is hanging free vertically. Now raise the hammer by hands and latch it. Release the hammer by operating lever. The pointer will then indicate the energy loss due to friction.
4. Adjust the pointer along with pointer carrier on 300J reading on the dial when the pendulum is hanging free vertically.
5. The pendulum is raised to its highest position and then latch in. Place specimen on the specimen support touching the end stop.
6. The specimen should be placed in such a way that the notch is opposite to the direction of impact of the pendulum.
7. For correct centering of the specimen, the end stop is provided.
8. Operate the lever so that the pendulum is released and the specimen is hit.
9. Wait till the pendulum is reversing its direction of motion and begins to swing slow.
10. Thereafter, bring the pendulum carefully to stand still position by applying the pendulum brake.
11. Note down the impact energy from the dial.
12. Before proceeding to the next test, remove the broken specimen from the machine and bring reading pointer on 300 J dial marking and then repeat the above procedure.

2. IZOD IMPACT TEST

1. A proper striker is fixed to the pendulum with the help of a clamping piece.
2. The frictional loss of the machine can be determined, if any. [Adjust the reading pointer with pointer carrier to 168J dial reading, when the pendulum is hanging free vertically. Now raise the hammer by hands and latch it. Release the hammer by operating lever. The pointer will then indicate the energy loss due to friction.]
3. With the striking hammer (pendulum) in safe position, firmly clamp the specimen in impact testing machine's vice with the help of clamping screw and setting gauge in such a way that the notch faces the hammer and is half inside and half above the top surface of the vice.
4. Bring indicator of the machine to 168J (Maximum impact energy of pendulum)
5. Bring the striking hammer (pendulum) to its top most striking position unless it is already there, and lock it at that position.
6. Operate the lever so that the pendulum is released and the specimen is broken.
7. Wait till the pendulum reverses its swing and carefully retard the swinging pendulum by operating the pendulum brake.
8. Note down the impact energy on the dial through pointer.

9. Remove the broken specimen by loosening the clamping screw and thus the machine will be ready to take the next reading.

OBSERVATIONS:

1. Impact Energy absorbed(E) =
2. Frictionaland air resistance,ifany$\left(E_{air}\right)$ =
3. Actualenergyabsorbedbythespecimen(E_{actual}) = $E - E_{air}$ =
4. Area of crosssection of specimen below the notch before test(A_c) = thickness$(t)\times$width(w) =

FORMULAS:

The Impact strength is calculated according to the following relation:

$$\text{Impact Strength(I)}=\frac{\text{Impact energy absorbed by the notch}}{\text{Cross section area at nortch}}$$

$$\text{Impact Strength(I)}=\frac{\text{Impact Energy absorbed-Frictionaland air resistance if any}}{\text{Cross section area at nortch}}$$

$$I=\frac{E_{actual}}{A_c}$$

$$I=\frac{E-E_{air}}{A_c}$$

Where,

I = Impact strength in -J/m^2

E_{act} = Impact energy absorbed by the notch in joules

A = Area of cross-section of specimen below the notch before test

CALCULATIONS:

RESULT:

The impact of Strength of Materials is

EXPERIMENT NO: - 5

SPRING TEST

OBJECTIVE:

The objective of the Helical Spring Test is to evaluate the mechanical properties like spring's stiffness (spring constant), modulus of rigidity (shear modulus), and spring index to performance of a helical spring under various loading conditions.

AIM:

To determine the stiffness of the spring and modulus of rigidity of the spring wire.

APPARATUS:

1. Spring testing machine.
2. Vernier caliper.
3. Steel Rule.
4. Micrometer.

THEORY:

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

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

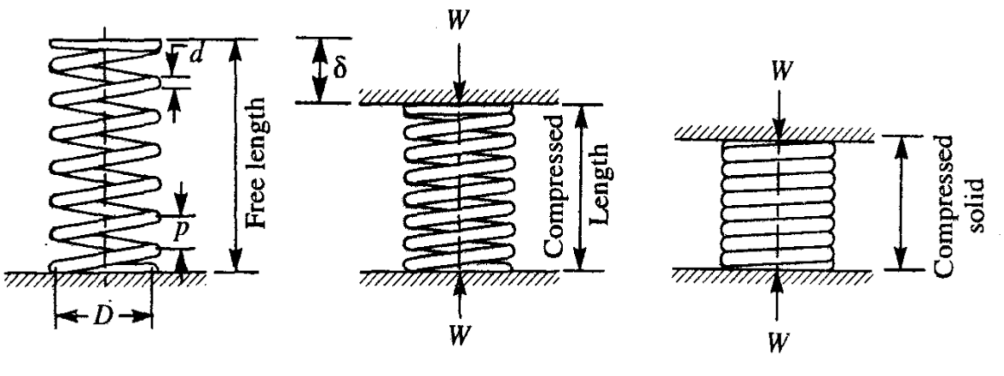


Fig. Open Coil Helical Spring

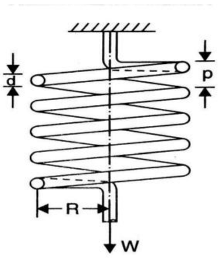


Fig. Closed Coil Helical Spring

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.

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 calliper
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.

OBSERVATIONS:

1. Diameter of the spring wire (d)=
2. Diameter of the spring coil (D)=
3. Numberofturns (N)=n+1=

TENSILE SPRING:

S. No.	Load W (N)	Deflection, (δ) (mm)	Stiffness K = W / δ (N/ mm)
1			
2			
3			
4			
5			
Mean			

COMPRESSION SPRING:

S. No.	Load W (N)	Deflection, (δ) (mm)	Stiffness K = W / δ (N/ mm)
1			
2			
3			
4			
5			
Mean			

FORMULAS:

1. Stiffenss (K) = $\dfrac{W}{\delta} \quad - \dfrac{\mathrm{N}}{\mathrm{mm}}$

2. Modulus of Rigidity (G) = $\dfrac{8WD_m{}^3N}{\delta . d^4} \quad - \dfrac{\mathrm{N}}{\mathrm{mm}^2}$

where, $D_m \text{(Mean Coil Diamter)} = D - 2d$

CALCULATIONS:

RESULT:

The Stiffness & Modulus of Rigidity of Spring is

EXPERIMENT NO: - 6

TENSILE TEST (UTM)

OBJECTIVE:

The objective of the tensile test is to determine the mechanical properties of materials under a uniaxial tensile force. This includes measuring properties such as Yield strength, Ultimate strength, elongation, and Young's modulus. The test provides valuable information about the material's strength and ductility.

AIM:

To Determine Young's Modulus, Yield strength, Ultimate Strength, Percentage Elongation and Percentage Reduction in area by conducting tensile test on given specimen by using Universal Testing Machine (UTM).

APPARATUS:

1. Tensile testing machine or Universal Testing Machine.
2. Steel rule.
3. Vernier Callipers.

PRINCIPLE:

The tensile test is performed by applying a gradually increasing axial tensile force on the specimen until it fractures. The UTM measures and records the force and elongation during the test. The stress-strain behaviour of the material is then plotted, and various mechanical properties are derived from this plot.

In a tensile test, a specimen of known dimensions is subjected to a tensile load until failure. The test follows Hooke's Law within the elastic region, where stress is proportional to strain. The relationship between stress and strain is expressed as:

THEORY:

The tensile test is most applied one, of all mechanical tests. In this test ends of a test piece are fixed into grips connected to a straining device and to a load measuring device. If the applied load is small enough, the deformation of any solid body is entirely elastic. An elastically deformed solid will return to its original form as soon as load is removed. However, if the load is too large, the material can be deformed permanently. The initial part of the tension curve which is recoverable immediately after unloading is termed as elastic and the rest of the curve which represents the manner in which solid undergoes plastic deformation is termed as plastic. The stress below which the deformations essentially elastic is known as the yield strength of material. In some material the onset of plastic deformation is denoted by a sudden drop in load indicating both an upper and a lower yield point. However, some materials do not exhibit a sharp yield point. During plastic deformation, at larger extensions strain hardening cannot compensate for the decrease in section and thus the load passes through a maximum and then begins to decrease. As this stage the "ultimate strength" "which is defined as the ratio of the load on the specimen to original cross- sectional area, reaches a maximum value. Further loading will eventually cause "neck" formation and rupture.

Usually, a tension test is conducted at room temperature and the tensile load is applied slowly. During this test either round or flat specimens as shown in Fig-1. may be used. The round specimens may ane smooth, shouldered, or threaded ends. The load on the specimen is applied mechanically or hydraulically depending on the type of testing machine Fig-2 below shows a hydraulically operated

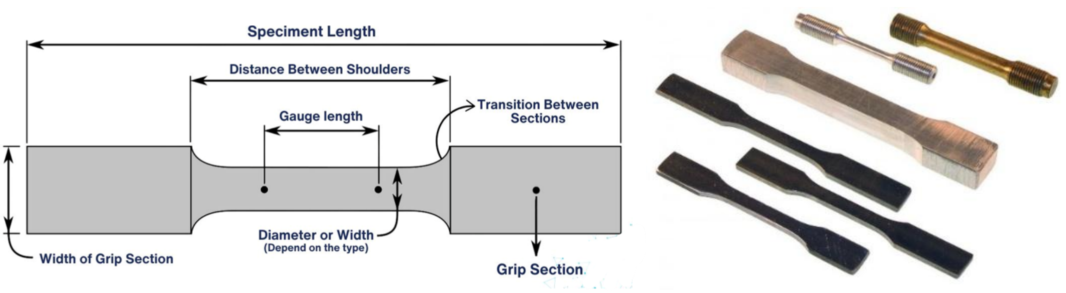


Fig-1: Tensile Test Specimens

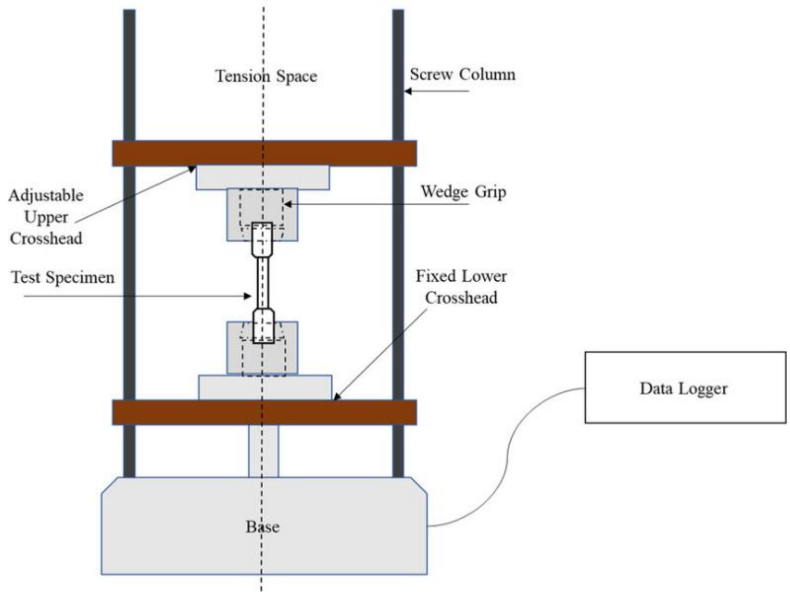


Fig-1: Schematic of UTM

PROCEDURE:

1. Mark the gauge length of the specimen with the help of a chalk and steel rule.
2. Measure the diameter of the specimen using Vernier callipers.
3. Make sure that the control valve and the relief valve are in a closed position and then switch on the Universal Testing Machine (UTM).
4. Now slowly open the control valve keeping the relief valve in the closed position. Load value in the display system increases until there is some resistance in the opposite direction. This will obviously become a stationary value when all the resistance in the opposite direction gets balanced.
5. Set the load value and the deflection value in the display system to zero. This is nothing but the removal of dead weight of the piston. Now close the control valve.
6. Grip the specimen in between the middle cross-head under upper cross-head jaws perfectly so that a tensile load is induced in the specimen.
7. Again, open the control valve. Now whatever load, the display system is showing is the load acting on the specimen.
8. Tabulate the load values and corresponding deformation values, until the specimen fails or gets fractured. If the specimen is of ductile material, a cup and cone fracture will take place.
9. Take out the specimen from the grips, join them and measure the final gauge length and the neck diameter.

OBSERVATIONS:

1. Original diamter of the specimen$\left[d_o\right]=$
2. Original gauge length of the specimen$\left[L_o\right]=$
3. Final diamter of the specimen$\left[d_f\right]=$
4. Final gauge length of the specimen$\left[L_f\right]=$

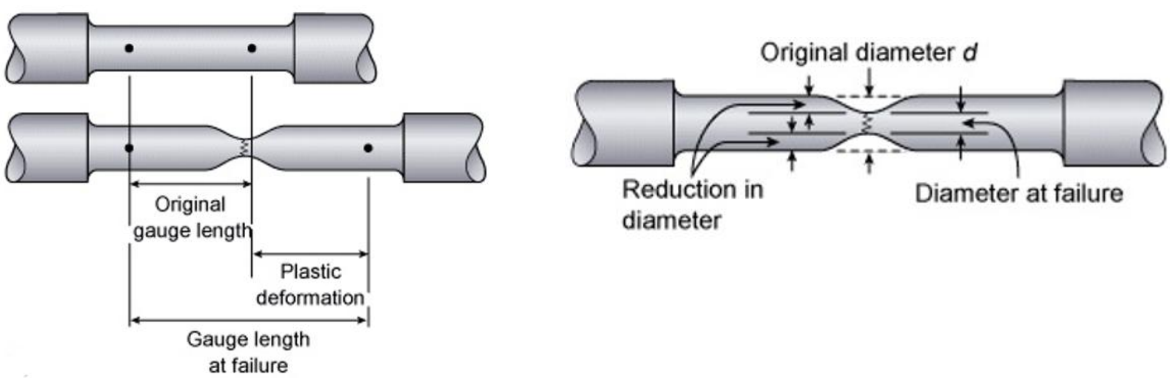


Fig-2: Schematic of Failure of Material

OBSERVATION TABLE:

S. No.	Load (P)- KN	Deformation (δL)- mm	Stress (σ)- N/mm^2	Strain (e)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

FORMULAS:

1. Original cross sectional area of the specimen $\left[A_O\right] = \frac{\pi}{4} d_o{}^2$
2. The average neck diameter of the specimen $\left[d_f\right]$
3. Final cross sectional area of the specimen $\left[A_f\right] = \frac{\pi}{4} d_f{}^2$
4. Change in Length of the Specimen $\left[\delta L\right] = L_f - L_o$
5. Stress induced in the Specimen $\left[\sigma\right] = \frac{\text{Load}}{\text{Area}}$
6. Strain induced in the Specimen $\left[e\right] = \frac{\text{Change in length}}{\text{Original length}}$
7. Young's Modulus $\left[E\right] = \frac{\text{Stree}(\sigma)}{\text{Strain}(e)}$

$$8.\ \text{Yield Strentgh}\left[\sigma_{yt}\right]=\frac{\text{Yield load}}{\text{Original cross section area}}$$

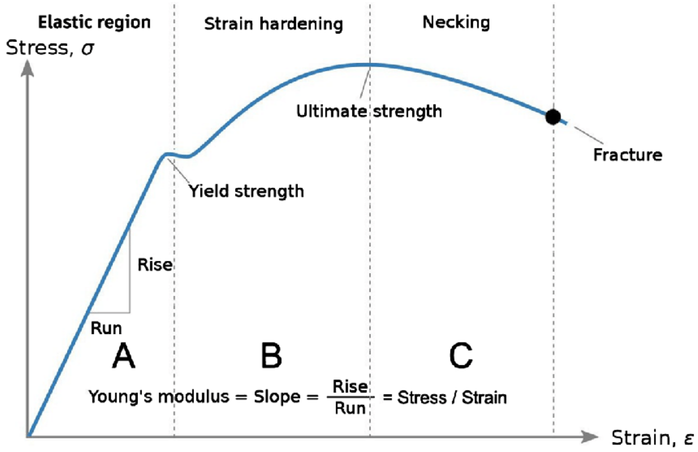
$$9.\ \text{Ultimate Strentgh}\left[\sigma ut\right]=\frac{\text{Maximum load}}{\text{Original cross section area}}$$

$$10.\ \text{Percentage Elonagtion}=\frac{\text{Final Length - Original Length}}{\text{Original Length}}\times 100$$

$$11.\ \text{Percentage Reduction in Area}=\frac{\text{Original Area - Final Area}}{\text{Original Area}}\times 100$$

CALCULATIONS:

MODEL GRAPH:



RESULTS:

$$1.\ \text{Young's modulus}\left[E\right]$$

$$2.\ \text{Yield Strentgh}\left[\sigma_{yt}\right]=$$

$$3.\ \text{Ultimate Strentgh}\left[\sigma ut\right]=$$

$$4.\ \text{Percentage Elonagtion}=$$

$$5.\ \text{Percentage Reduction in Area}=$$

EXPERIMENT NO: - 7

TORSION TEST

OBJECTIVE:

The objective of the Torsion Test is to evaluate the mechanical properties of a material when subjected to twisting forces. The test aims to determine the strength of the material by measuring the maximum shear stress it can withstand before failure and also to calculates the modulus of rigidity (shear modulus) to assess the material's resistance to deformation under torsional loads

AIM:

To determine the torsional strength and modulus of rigidity of the given specimen.

APPARATUS:

1. Torsion testing machine.
2. Vernier calipers.
3. Steel rule.

THEORY:

A torsion test is quite instrumental in determining the value of modulus of rigidity of a metallic specimen. The value of modulus of rigidity and torsional shear strength can be found out through observations made during the experiment by using the torsion equation.

$$\frac{T}{J} = \frac{\tau}{R} = \frac{G\theta}{L}$$

where, $T =$ Torque applied – N-mm

$J =$ Polar moment of inertia – mm^4

$\tau =$ Torsional shear strength of the Material – N/mm^2

$R =$ Distance of extreme fibre – mm

$G =$ Modulus of Rigidity – N/mm^2

$\theta =$ Angle of twist – radians

$L =$ length of the specimen – mm

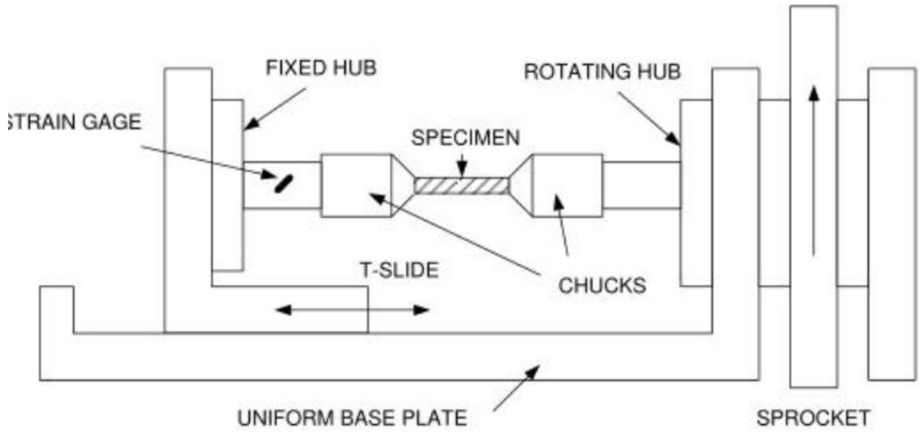


Fig. Schematic of Torsion Test Principle.

For calculating modulus of rigidity, a graph of Torque (T) Vs Angle of twist (θ) is plotted. For getting the value of Torque (T) and Angle of twist (θ), the motor shaft is gradually rotated manually by the handle provided. Note down the values of torque corresponding to the angle of twist of the specimen till there is a linear relationship between T and θ. As the relationship ceases, start the motor so that the torque is applied to the specimen up to the failure of the specimen. The peak value of torque and corresponding θ value will be withheld on the D.A.S Indicator. With these readings of T& θ, T- θ graph can be plotted. Select two points T1 and T2on the graph such that T1 is approximately at 10% peak value and T2 is approximately at 2/3 of peak value of torque, the values of T & θ can be calculated. These values can be used for calculating modulus of rigidity G.

PROCEDURE:

1. Select proper set of insets depending upon the specimen to be tested and fill it in the jaw head. For fitting it in the jaw heads, it needs only insertion.
2. Hold and tighten the specimen into the insets of both chucks by rotating the flange for jaw head sleeve.
3. Use the tommy bar for tightening.
4. Adjust the position of stopper bush-2 of limit switch assembly behind the stopper with approximately 5mm gap in between.
5. Start the geared motor with the help of starter and select the direction of rotation of geared motor with the help of switch.
6. Now the torque will be applied to the specimen and the D.A.S panel will start indicating the torque until the specimen fails.
7. The angle through which the specimen twists will be indicated on D.A.S indicator.

OBSERVATIONS:

1. Length of the specimen(L) =
2. Diameter of the specimen(d) =

Torque (T) (Nm)	1	2	3	4	5	6	7	8	9	10
Angle of Twist (Degrees)										
Angle of Twist (Radians)										

FORMULAS:

1. Torsional Strength(τ)= $\frac{T}{J}R - \frac{\mathrm{N}}{\mathrm{mm}^2}$
2. Modulus of Rigidity(G) = $\frac{TL}{J\theta} - \frac{\mathrm{N}}{\mathrm{mm}^2}$

where, $\mathrm{J} = \frac{\pi D^4}{32} - \mathrm{mm}^4$ for Circular Shaft

CALCULATIONS:

RESULTS:

1. Torsional Shear Strength of the Specimen(τ) =
2. Modulus of Rigidity(G) =

EXPERIMENT NO: - 8

COMPRESSION TEST (UTM)

OBJECTIVE:

The objective of the Compression test UTM is to determine the mechanical properties of materials under a uniaxial compressive force. This includes measuring properties such as Stress, Strain, Young's modulus, and Compressive Strength.

AIM:

To Determine Compressive Strength of given specimen by conducting Compression test on Universal Testing Machine (UTM).

APPARATUS:

1. Universal Testing Machine (UTM).
2. Steel Rule.
3. Vernier Caliper

THEORY:

The compression test is conducted to determine the behavior and mechanical properties of materials when subjected to compressive forces. This test helps evaluate a material's ability to withstand loads that tend to reduce its size, making it critical for materials used in construction and structural applications.

When a material is subjected to compressive forces, it experiences deformation. The Universal Testing Machine (UTM) applies a gradually increasing compressive load to the material until failure occurs or the load reaches a predefined limit. During the test, the material's response to the applied load, such as deformation, stress, and strain, is recorded.

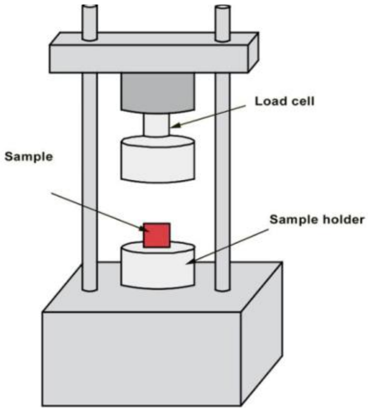


Fig-1: Schematic of Compression Test by UTM

OBESERVATION:

1.Original Dimensions

Length(L)=

Breadth(B)=

Height(H)=

2.Final Dimensions

Length(L)=

Breadth(B)=

Height(H)=

3. Breaking Load(P)=

OBSERVATION TABLE:

S. No.	**Load (P)- KN**	**Deformation (δL)-mm**	**Stress (σ)-N/mm²**	**Strain (e)**
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

FORMULAS:

1. Cross-sectional Area(A_c)

2. Compressive Strength(σ_c)=$\frac{\text{Maximum load at the failure}}{\text{Original cross sectional araea}}$

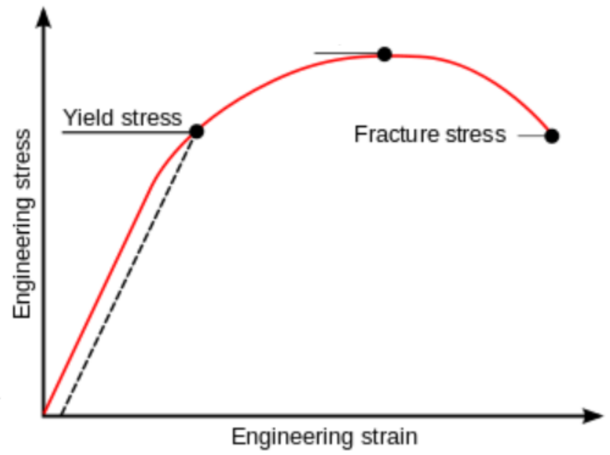
3. Stress(σ) = $\frac{\text{Load}}{\text{Area}}$

4. Strain(e) = $\frac{\text{Chnage in dimension}}{\text{Original dimension}}$

5. Young'Modulus(E) = $\frac{\text{Stress}(\sigma)}{\text{Strain(e)}}$

CALCULATION:

MODEL GRAPH:



RESULT:

The compressive Strength of Brick is