AEROSPACE STRUCTURES

LABORATORY MANUAL

B.TECH

(III YEAR – I SEM)

(2017-18)

Prepared by:

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Department of Aeronautical Engineering

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

(Autonomous Institution – UGC, Govt. of India)

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Affiliated to JNTUH, Hyderabad, Approved by AICTE - Accredited by NBA & NAAC – 'A' Grade - ISO 9001:2015 Certified) Maisammaguda, Dhulapally (Post Via. Hakimpet), Secunderabad – 500100, Telangana State, India

DEPARTMENT OF AERONAUTICAL ENGINEERING

VISION

Department of Aeronautical Engineering aims to be indispensable source in Aeronautical Engineering which has a zeal to provide the value driven platform for the students to acquire knowledge and empower themselves to shoulder higher responsibility in building a strong nation.

MISSION

a) The primary mission of the department is to promote engineering education and research.

(b) To strive consistently to provide quality education, keeping in pace with time and technology.

(c) Department passions to integrate the intellectual, spiritual, ethical and social development of the students for shaping them into dynamic engineers.

PROGRAMME EDUCATIONAL OBJECTIVES (PEO'S)

PEO1: PROFESSIONALISM & CITIZENSHIP To create and sustain a community of learning in which students acquire knowledge and learn to apply it professionally with due consideration for ethical, ecological and economic issues.
PEO2: TECHNICAL ACCOMPLISHMENTS To provide knowledge based services to satisfy the needs of society and the industry by providing hands on experience in various technologies in core field.
PEO3: INVENTION, INNOVATION AND CREATIVITY To make the students to design, experiment, analyze, interpret in the core field with the help of other multi disciplinary concepts wherever applicable.
PEO4: PROFESSIONAL DEVELOPMENT To educate the students to disseminate research findings with good soft skills and become a successful entrepreneur.
PEO5: HUMAN RESOURCE DEVELOPMENT To graduate the students in building national capabilities in technology, education and research.

PROGRAM SPECIFIC OBJECTIVES (PSO's)

1. To mould students to become a professional with all necessary skills, personality and sound knowledge in basic and advance technological areas.
2. To promote understanding of concepts and develop ability in design manufacture and maintenance of aircraft, aerospace vehicles and associated equipment and develop application capability of the concepts sciences to engineering design and processes.
3. Understanding the current scenario in the field of aeronautics and acquire ability to apply knowledge of engineering, science and mathematics to design and conduct experiments in the field of Aeronautical Engineering.
4. To develop leadership skills in our students necessary to shape the social, intellectual, business and technical worlds.

PROGRAM OBJECTIVES (PO'S)

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **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.
3. **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.
4. **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.
5. **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.
6. **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.
7. **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.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **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.
11. **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 multi disciplinary environments.
12. **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.

CONTENTS

CODE OF CONDUCT FOR THE LABORATORIES

- All students must observe the Dress Code while in the laboratory.
- Sandals or open-toed shoes are NOT allowed.
- Foods, drinks and smoking are NOT allowed.
- All bags must be left at the indicated place.
- The lab timetable must be strictly followed.
- Be PUNCTUAL for your laboratory session.
- Program must be executed within the given time.
- Noise must be kept to a minimum.
- Workspace must be kept clean and tidy at all time.
- Handle the systems and interfacing kits with care.
- All students are liable for any damage to the accessories due to their own negligence.
- All interfacing kits connecting cables must be RETURNED if you taken from the lab supervisor.
- Students are strictly PROHIBITED from taking out any items from the laboratory.
- Students are NOT allowed to work alone in the laboratory without the Lab Supervisor
- USB Ports have been disabled if you want to use USB drive consult lab supervisor.
- Report immediately to the Lab Supervisor if any malfunction of the accessories, is there.

Before leaving the lab

- Place the chairs properly.
- Turn off the system properly
- Turn off the monitor.
- Please check the laboratory notice board regularly for updates.

INTRODUCTION

COLUMNS

A long vertical bar subjected to an axial compressive load is called a column.

Terminology:

1. Slenderness ratio: It is the ratio of length of column to the minimum radius of gyration of the cross-section of the column. A column is said to short column when slenderness ratio is less than 32 and if the slenderness ratio is between 32 to 120 the column is said to be medium column and if the slenderness ratio is more than 120 the column is called long column.
2. Blucking load: It is the minimum load at which the column tends to have lateral displacement or tends to buckle. Buckling load is also called as crippling or critical load.
3. End Conditions: A loaded column can have any one of the following end conditions.

- Both ends hinged
- One end fixed and other hinged
- Both ends fixed
- One end rigidly fixed and other entirely free

Let L = length o f column

l_e = equivalent length

= L when both ends are hinged

=L/√2 when one ends is fixed and other hinged

=L/2 when both ends are fixed

= 2L when one end rigidly fixed and other entirely free

Crippling load is calculated as follows:

i). Using Euler's formula:

$P = \pi^2 EI/ l_e^2$

Where P = crippling load

E = Young's modulus of elasticity

I = moment of inertia

l_e = Equivalent length

ii). Using Rankine's Formula

$P = f_c .A / [1+ \alpha(l_e /K)^2]$

Where f_c =intensity of stress at yield point in compression

A = area of cross-section of column

K = Least radius of gyration of cross section of column

α = Rankine's constant (depending on end condition and material of column)

The values of f_c and constant 'α 'of some of the materials are shown in table below:

Material	**Compressive stress($\sigma_c$in M Pa)**	**Young's Modulus E, G Pa**	**Rankin's Constant 'α' or 'a'**
Cast iron	562.5	91.189	1/1600
Wrought iron	233.6	213	1/9000
Mild steel	276.3	210	1/7500
Medium carbon steel	414.5	210	1/5000
Aluminum	199.1	70	1/5000
Timber	473.6	96	1/2000

RIVETED JOINTS

In engineering practive, there are many items which are built up of a number of separate pieces rigidly attached together by means of permanent joints. For example, boilers, water-tanks and various other vessels which are subjected to internal pressure are constructed out of separate steel sheets joined together permanently. Further, steel structures, such as cranes, bridges, beams, trusses, etc., are also built up of separate steel sections rigidly fastened together. Riveting is one of the most commonly used methods of producing rigid and permanent joints in all such cases.

Rivet:

A rivet is a small metal rod of circular cross section. It consists of two parts,viz., head and shank. Mild steel, wrought iron, copper and aluminum are some of the metals commonly used for making rivests; the choice will naturally depend upon the application.

Riveting:

The rivet is placed in a hole drilled or punched through the two parts to be joined, and the shank end is made into a rivet head, either by cold working or by applying pressure in red-hot condition. If this is done under the application of a steady force by means of hydraulic or pneumatic pressure, the shank of the rivet will bulge uniformly, filling the rivet hole more tightly. The rivet hole is always made slightly larger in diameter than the rivet so as to facilitate the insertion of the rivet before riveting.

Classification of riveted joints:

Riveted joints in common use can be classified as structural joints and boiler joints.

Structural joints:

These joints are used in forming steel structures out of rolled steel sections of different shapes and sizes, some of which are shown in fig.

Fig shows an angle joint used to connect two plates at right angles to each other. Here the two plates are riveted to the two faces of an equal angle rolled steel bar, employing a single row of rivets. The position of the rivets and other proportions are also marked in the fig.
Fig. shows a column and beam and fig a compound girder illustrating some forms of the structural joints built up of roller steel sections.
In all sectional joints the length of the joints decided by the loads that are to be resisted by the joints.

TYPES OF RIVET HEADS

The rivet heads classified as follows:

i). Indian standard rivets for general and structural purposed below 12 mm diameter.
ii).Indian standard rivets for general and structural purposed 12 to 48mm diameter.
iii).Indian standards boiler rivets 12 to 48mm diameter.

Indian standard rivets for general and structural purposes below 12mm diameter are generally made of mild steel, brass, copper or aluminum depending upon the purpose and place where to be used. Fig. shows various types of rivet heads for rivets below 12mm diameter:

Fig. shows rivet heads used for rivets for structural and general purposes are 12 to 48mm diameter.

Indian standard boiler rivets heads are shown in Fig.

Rivet Hole Diameter

In structural and pressure vessel riveting, the diameter of the hole is usually 1.5mm larger than nominal of rivet.

Table 1 gives diameters of rivets and corresponding rivet holes in mm for boiler joints.

Table 1

Nominal diameter of rivet	**Rivet hole diameter**	**Nominal diameter of rivet**	**Rivet hole Diameter**
12	13.5	27	29
14	15.5	30	32
16	17.5	33	35
18	19.5	36	38
20	21.5	39	41
22	23.5	42	44
24	25.5	48	50

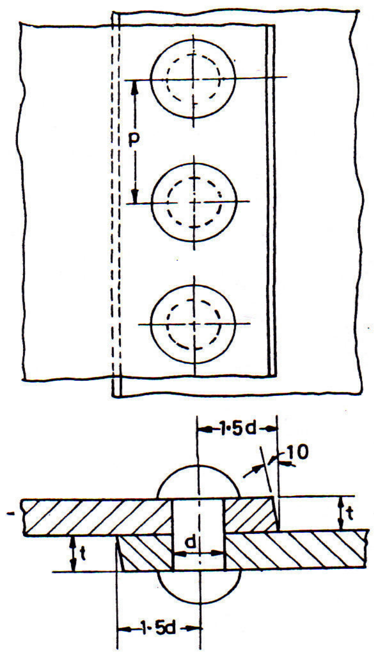


Fig. [illegible]. Single riveted lap joint.

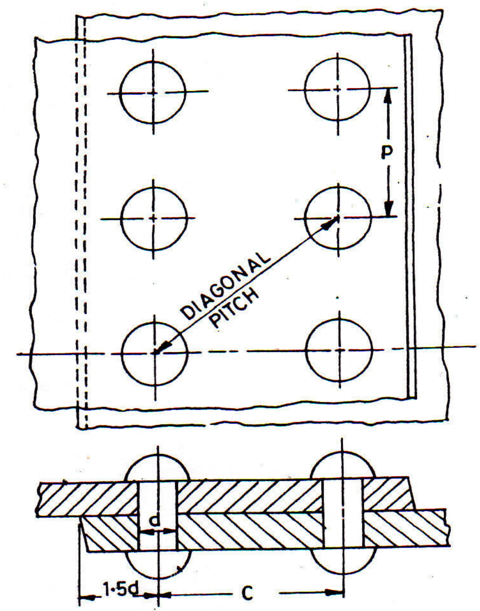


Fig. [illegible]. Double-riveted lap joint (Chain Riveting)

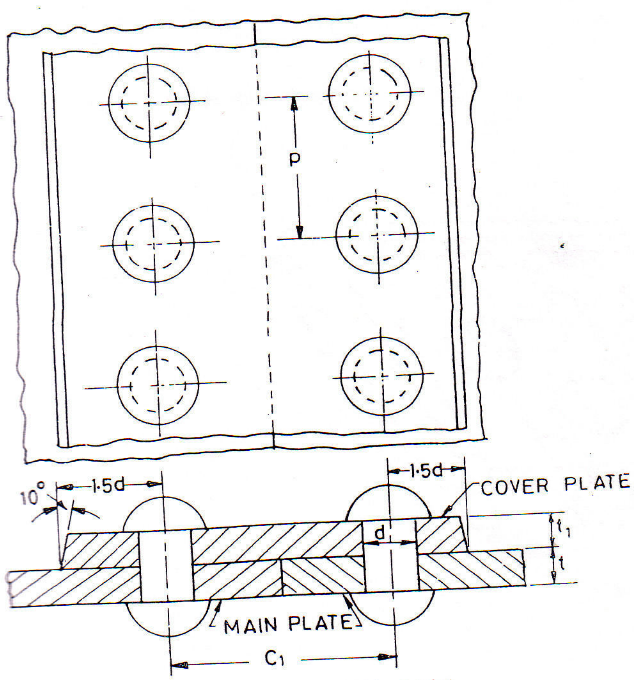


Fig. [illegible]. Single riveted butt joint.

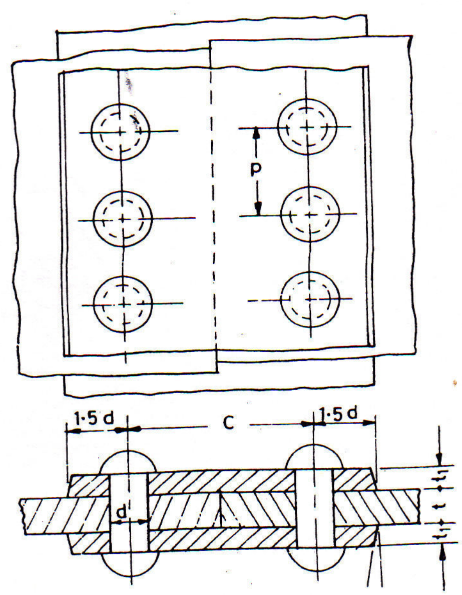


Fig. [illegible]. Single riveted butt joint.

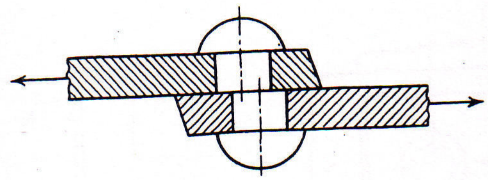


Fig. 5.20. Rivets in single shear.

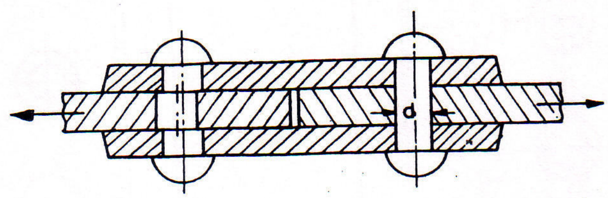


Fig. . . Rivets in double shear.

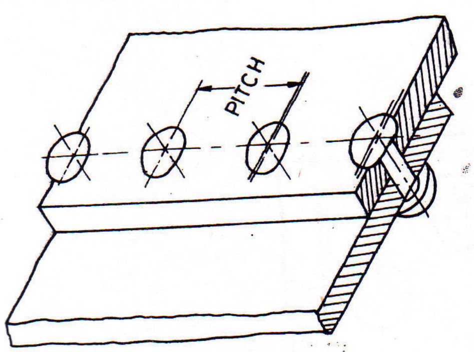


Fig. . . Single riveted lap joint.

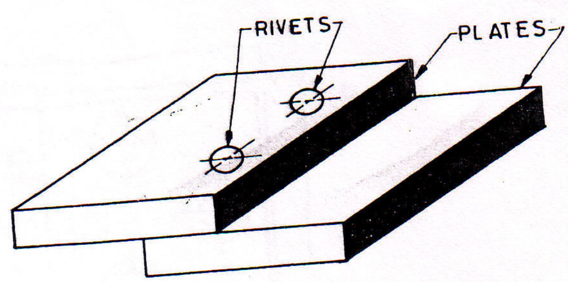


Fig. . Lap joint.

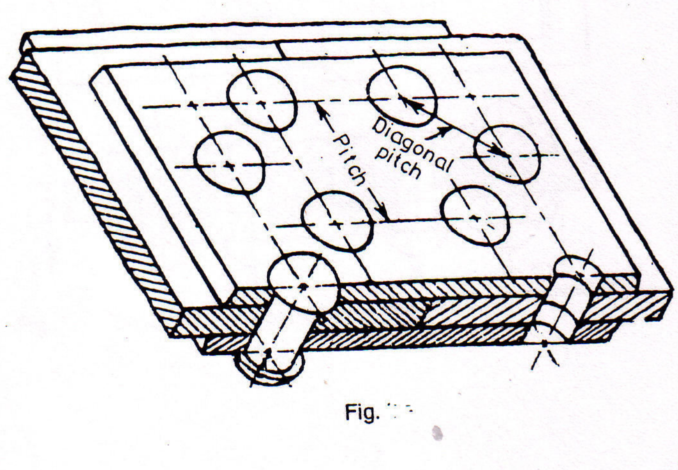


Fig. . .

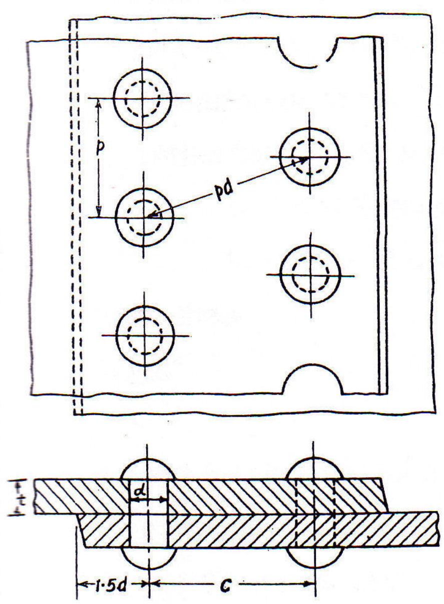


Fig. .. Double-riveted lap joint (Zig-zag riveting).

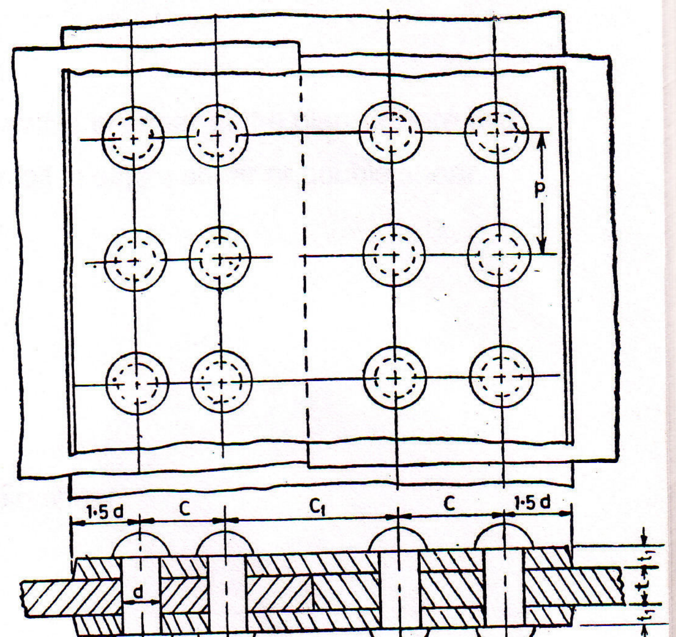


Fig. Double riveted double cover butt joint (Chain Riveting).

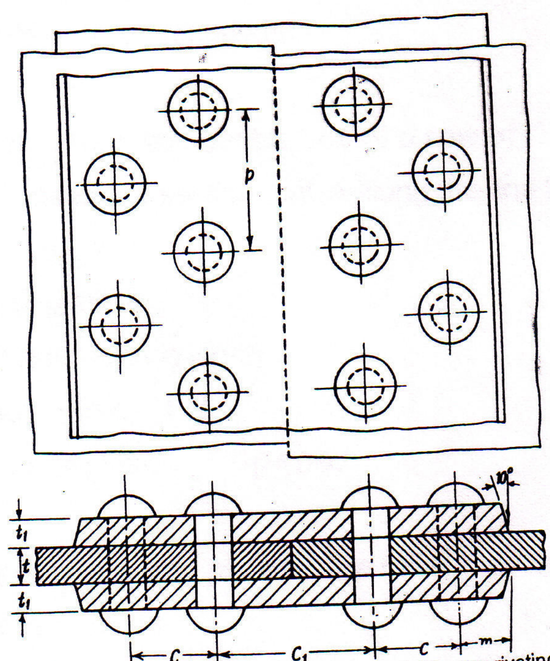


Fig. Double riveted double cover butt joint (Zig-zag riveting).

Failure of Riveted joints

A riveted joint may fall in the following ways.

I. Shearing of rivets. The rivets may fall in shear at the plane where two plates meet together. A rivet may fail in single shear or double shear.

d = Rivet diameter

f_s = Shear stress of rivets.

A = area_ shear

$$= K \times \frac{\pi . d^2}{4}$$

Where

k=1 for single shear and

for double shear

K=2(theoretically)

=1.75 to 1.875(practically)

P_s =shear strength =A x f_s

$$= n. K \times \frac{\pi . d^2}{4} \times f_s$$

n = Number of rivets in one pitch length

(ii)Tearing of plate along the center line of a row of rivets. The plate may tear along the line of minimum section that is along through the centre of holes.

f_t = tensile stress of plates

A = area of plate under tearing =(p-d).t

P_t = tearing strength = (p-d).t. f_t

Where t = thickness of plate; p = pitch

(iii).Crushing of rivets and plates. The rivets may fail under crushing.

f_c = crushing stress of rivets

A = area under crushing = n.d.t

P_c = crushing strength

$= A \times f_c = n.d.\ f_c\ .\ t$

Strength of a riveted joint. The least value out of shearing, tearing strength and crushing strength is called strength of the riveted joint.

Rivets should always be placed at right angles to the acting forces, and the maximum stress induced in them should be either shear or crushing. In a long rivet the initial stress set up at the junction of the shank and the point. When the rivet cools is dangerous. This initial stress increases with the relative length of the rivets, and in a very long rivet, it may cause the head to snap off without any load. For this reason, the length of the rivet between the heads should not exceed four or five times its diameter.

Efficiency of a riveted joint: It is the ratio of the strength of the joint to the tearing strength of the unpunched plate.

P = Tearing strength of unpunched plate

$= p \times t \times f_t$

η_s = Shearing efficiency

$$= \frac{P_s}{P} = \frac{n.k.(\pi/4)d^2 \times f_s}{p.t.f_t}$$

$$\eta_c = \text{Crushing efficiency} = \frac{P_c}{P} = \frac{n.\ d\ .t\ .f_c}{p \times t \times f_t}$$

$$\eta_t = \text{Tearing efficiency} = \frac{P_t}{P} = \frac{(p-d).t.f_t}{p \times t \times f_t}$$

$$= \frac{p - d}{p}$$

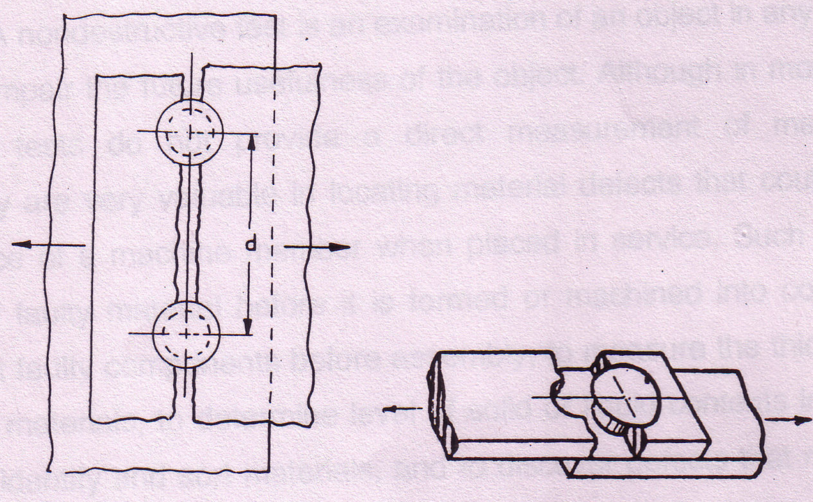
The lowest of the three efficiencies is called as the efficiency of the joint.

Table 2 indicates the average efficiency and the maximum pitch for some types of commercial boiler joints.

Table 2

Type of a joint	**Efficiency**	**Maximum pitch (cms)**
Lap joints		
Single riveted	45-65	1.31 t = 4.128
Double riveted	63-70	2.62 t = 4.128
Triple riveted	72-80	3.47 t = 4.128
Butt joints(2 cover plates)		
Single riveted		
Double riveted	55-60	1.75 t = 4.128
Triple riveted	70-85	3.5 t = 4.128
	80-90	6 t = 4.128

The Indian Boiler regulations (I.B.R) allows a maximum of 85% efficiency for the best riveted joint.



(a) (b) Tearing of plate.

Fig. [illegible]

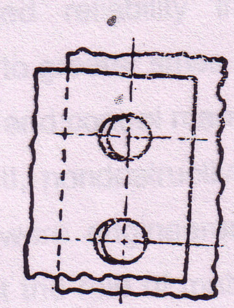


Fig. [illegible]

NON DESTRUCTIVE TESTING

Introduction:

Defects of many types and sizes may be introduced to a material or a component during manufacture and the exact nature and size of any defects will influence the sub salient performance of the component. Other defects such as fatigue cracks or corrosion cracks, may be generated within a material service. It is therefore necessary to have reliable means for detecting the presence of defects at the manufacturing stage and also for detecting & monitoring the rate of growth of defects during the service life of a component or assembly.

Much valuable information is obtained from test like tensile test, compression test, shear & impact tests for different properties of material, but such tests are of destructive nature.

In addition, the material properties as determined in a standard to destruction, do not necessarily give a clear guide to the performance characteristics of a complex- shaped component which forms part of some larger Engineering assembly.

Hence, many systems have been developed which will provide information on the quality of a material or component and which do not alter or damage the components or assemblies which are tested. These are nothing but NON – DESTRUCTIVE TESTING TECHNIQUES.

A nondestructive test is an examination of an object in any manner which will not impair the future usefulness of the object. Although in most cases nondestructive tests do not provide a direct measurement of mechanical properties, they are very valuable in locating material defects that could impair the performance of a machine member when placed in service. Such a test is used to detect faulty material before it is formed or machined into component parts, to detect faulty components before assembly, to measure the thickness of metal or other materials, to determine level of solid or liquid contents in opaque containers, to identify and sort materials, and to discover defects that may have developed during processing or use. Parts may also examined in service, permitting their removal before failure occurs.

Nondestructive tests are used to make the products more reliable, safe, and economical. Increased reliability improved the public image of the manufacturer, which leads to greater sales and profits. In addition, manufacturers use these tests to improve and control manufacturing processes.

Before World War II, nondestructive testing was not urgent because of large safety factors that were engineered into almost every product. Service failures did take place, but the role of material imperfection in such failures was not then fully recognized, and, therefore little concentrated effort was made to find them. During, and just after, World War II the significance of imperfections to the useful life of a product assumed greater importance. In aircraft design, in nuclear technology, and space exploration, high hazards and cost have made maximum reliability essential. At the same time, there has been extensive growth of all inspection methods in industrial and scientific applications.

There are five basic elements in any non destructive test.

1. Source: A source which provides some probing medium, namely, a medium that can be used to inspect the item under test.
2. Modification: This probing medium must change or be modified as a result of the variations or discontinuities within the object being tested.
3. Detection: A detector capable of determining the changes in the probing medium.
4. Indication: A means of indicating or recording the signals from the detector.
5. Interpretation: A method of interpreting these indications. While there are a large number of nondestructive tests in use, this section will concentrate on the most common methods and on one recent development. The most common methods of nondestructive testing or inspection are:

Radiography

Magnetic- particle inspection

Fluorescent – penetrant inspection.

Ultrasonic inspection

Eddy current inspection

Radiography of metals The radiography of metals may be carried out by using X-rays or gamma rays – short – wavelength electromagnetic rays capable of going through relatively large thickness of metal. Gamma rays may be obtained from a naturally radioactive material such as radium or a radioactive isotope such as cobalt -60. Gamma radiation is more penetrating than that of x- ray but the inferior sensitivity limits its application. There is no way that the source may be regulated for constrast or variable thickness, and it usually requires much longer exposure times than the x- ray method.

X – rays are produced when matter is bombarded by a rapidly moving stream of electrons. When electrons are suddenly stopped by matter, a part of their kinetic energy is converted to energy of radiation, or X – rays. The essential conditions for the generation of X- rays are (1) a filament (cathode) to provide the source of electrons proceeding towards the target, (2) a target (anode) located in the path of electrons,(3) a voltage difference between the cathode and anode which will regulate the velocity of the electrons striking the target and thus regulate the wavelength X- rays produced, and (4) a means of regulating tube current to control the number of electrons striking the target. The first two requirements are usually incorporated in an X-ray tube. The use of X-rays for the examination of a welded plate is shown schematically in Fig. X –rays are potentially dangerous, and adequate safeguards must be employed to protect operating personnel.

A Radiograph is a shadow picture of a material more or less transparent to radiation. The X – rays darken the film so that regions of lower density which readily permit penetration appear dark on the negative as compared to regions of higher density which absorb more of the radiation. Thus a hole or crack appears as a darker area, where as copper inclusions in aluminum alloy appear as lighter areas.

While the radiography of metals has been used primarily for the inspection of castings and welded products, it may also be used to measure the thickness of materials. Fig shows a simple radiation thickness gauge. The radiation from the source is influenced by the material being tested. As the thickness increases the radiation intensity reaching the detector decreases. If the response of the detector is calibrated for known thicknesses, the detector reading can be used to indicate the thickness of the inspected material. With the suitable feedback circuit the detector may be used to control the thickness between predetermined limits.

Magnetic – particle inspection (Magna flux): This is the method of detecting the presence of cracks, laps, tears, seams, inclusions, and similar discontinuities in ferromagnetic materials such as iron and steel. The method will detect surface discontinuities too fine to be seen by the naked eye and will also detect discontinuities which lie slightly below the surface. It is not applicable to nonmagnetic materials.

Magnetic particle inspection may be carried out in several ways. The piece to be inspected may be magnetized and then covered with the fine magnetic particles (iron powder). This is known as the residual method. Or, the magnetization and application of the particles may occur simultaneously. This is known as the continuous method. The magnetic particles may be held in suspension in a liquid that is flushed over the piece, or the piece may be immersed in the suspension (wet method). In some applications, the particles, in the form of a fine powder, are dusted over the surface of the work piece (dry method). The presence of a discontinuity is shown by the formation and adherence of a particle pattern on the surface of the work piece over the discontinuity. This pattern is called an indication and assumes the approximate shape of the surfaces projection of the discontinuity. The magnaglo method developed by the Magna Flux Corporation is a variation of the magna flux test. The suspension flowed over the magnetized work piece is then viewed under blank light, which make the indications stand out more clearly. When the discontinuity is open to the surface, the magnetic field leaks to the surface and form small north and poles that attract the magnetic particles (see fig).
When fine discontinuities are under the surface, some part of the field may still be deflected to the surface, but the leakage is less and fewer particles are attracted, so that the indication obtained is much weaker. If the discontinuity is far below the surface, no leakage of the field will be obtained and consequently no indication. Proper use of magnetizing methods is necessary to ensure that the magnetic field set up will be perpendicular to the discontinuity and give the clearest indication.

As shown in fig., for longitudinal magnetization, the magnetic field may be produced in a direction parallel to the long axis of the work piece by placing the piece in a coil excited by an electric current so that the long axis of the piece is parallel to the axis of the coil. The metal part then becomes the core of an electromagnet and is magnetized by induction from the magnetic field created in the coil. Very long parts are magnetized in steps by moving the coil along the length. In the case of circular magnetization also shown in fig. magnetic field transverse to the long axis of the work piece is readily produced by magnetizing current through the piece along the axis.

Direct current, Alternating current and Rectified alternating current are all used for magnetizing purposes .Direct current is more sensitive than Alternating current for detecting discontinuities that are not open to the surface. Alternating current will detect discontinuities open to the surface and is used when the detection of this type of discontinuity is the only interest. When Alternating current is rectified it provides a more penetrating magnetic field.

The sensitivity of the magnetic particle inspection is affected by many factors, including strength of the indicating suspension, time in contact with the suspension, time allowed for indications to form, time subject to magnetizing current, strength of the magnetizing current. Some examples of the cracks detectable by magna flux or magnaglo are shown in fig,

All machine parts that have been magnetized for inspection must be put through a demagnetizing,they will attract filings, grindings, chips and other steel particles which may cause scoring of bearings and other engine parts. Detection of parts which have not been demagnetized is usually accomplished by keeping a compass on the assembly bench.

Ultrasonic inspection: The use of sound waves to determine defects is a very ancient method. If a piece of metal is struck by a hammer, it will radiate certain audible notes, of which the pitch and damping may be influenced by the presence of internal flaws. However this technique of hammering and listening is useful only for the determination of the large defects.

A more refined method consists of utilizing sound waves above the audible range with a frequency of 1 to 5 million Hz (cycles per second) – hence the term ultrasonic .Ultrasonic is a fast, reliable nondestructive testing method which employs electronically produced high-frequency sound waves that will penetrate metals, liquids, and many other materials at a speed of several thousand feet per second. Ultrasonic waves for nondestructive testing are usually produced by piezoelectric materials. These materials undergo a change in physical dimension when subjected to an electrical field. This conversion of electrical energy to mechanical energy is known as piezoelectric effect. If an alternating electrical field is applied to a piezoelectric crystal will expand during the first half of the cycle and contract when the electrical field is reversed. By varying the alternating electric field, we can vary the frequency of the mechanical vibration (sound wave) produced in the crystal. Quartz is a widely used ultrasonic transducer. A transducer is a device for converting one form of energy to another.

Two common ultrasonic test methods, the through – transmission and the pulse – echo methods, in fig. The through – transmission method uses an ultrasonic transducer on each side of the object being inspected. If an electrical pulse of the desired frequency is applied to the transmitting, the ultrasonic waves produced will travel through the specimen to the other side. The receiving transducer on the opposite side receives the vibrations and converts them into an electrical signal that can be amplified and observed on the cathode- ray tube of an oscilloscope, a meter, or some other indicator. If the ultrasonic wave, travels through the specimen without encountering any flaw, the signal received is relatively large .if there is a flaw in the path of the ultrasonic wave, part of the energy will be reflected and the signal received by the receiving transducer will be reduced.

The pulse- echo method uses only one trasducer which serves as both transmitter and receiver. The pattern on an oscilloscope for the pulse-echo method would look similar to that shown in fig., As the sound wave enters the material being tested; part of it is reflected back to the crystal where it is converted back to an electrical impulse. This impulse is amplified and rendered visible as an indication or pip on the screen of the oscilloscope. When the sound wave reaches the other side of the material it is reflected back and shows as another pip on the screen farther to the right of the first pip. If there is a flaw between the front and back surfaces of the material, it will show as a third pip on the screen between the two indications for the front and back surfaces, since the indication on the oscilloscope screen measures the elapsed time between reflection of the pulse from the front and back surfaces, the distance between indications is a measure of the thickness of the material. The location of a defect may therefore be accurately determined from the indication on the screen.

In general, smooth surfaces are more suitable for the higher frequency testing pulse and there by permit the detection of smaller defects. Proper transmission of the ultrasonic wave has a great influence on the reliability of the test results. For a large part, a film of oil ensures proper contact between the crystal searching unit and the test piece. Smaller parts must be placed in a tank of water, oil, or glycerin. The crystal searching unit transmits sound waves through the medium and into the material being examined. Close examination of the oscilloscope in this picture shows the presence of three pips. The left pip indicates the front of the piece, the right pip the back of the piece, and smaller center pip is an indication of a flaw.

Ultrasonic inspection is used to detect and locate such defects as shrinkage cavities, internal bursts or cracks, porosity, and large nonmetallic inclusions. Wall thickness can be measured in closed vessels or in cases where such measurement cannot otherwise be made.

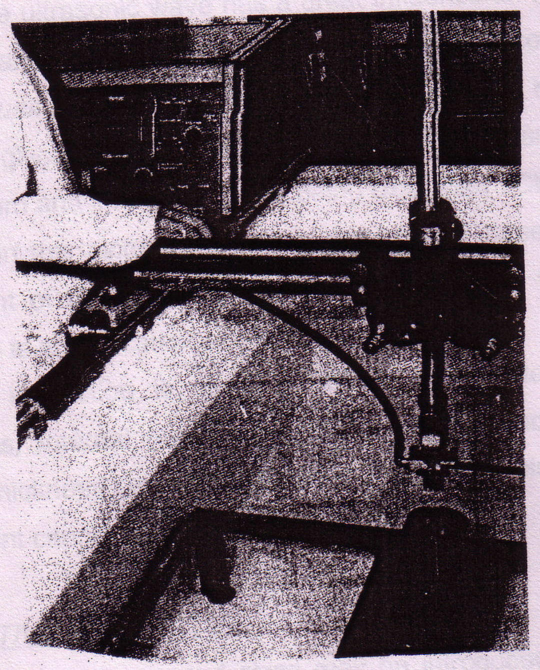


Fig. Ultrasonic inspection by immersion in a water tank. (Fansteel Metallurgical Corporation)

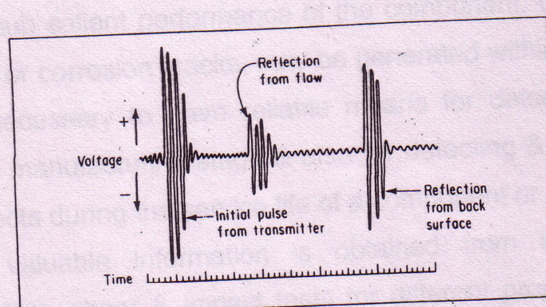


Fig. Oscilloscope pattern for the pulse-echo method of ultrasonic inspection.

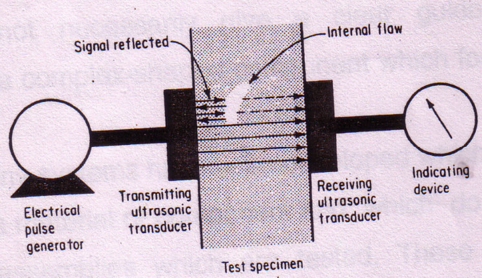


Fig. The through-transmission and pulse-echo methods of ultrasonic inspection.

Reliability of Defect detection:-

The reliability of any NDT technique is a measure of the efficiency of the technique in detecting flaws of a specific type, shape & size. After inspection has been completed it can be stated that there is a certain probability that a component is free of defects of a specific type & size.

It must be always borne probes may be inserted into cavities, ducts & pipes.

NDT systems coexist & depending on the application may either be used singly or in conjugation with one another.

There is some overlap between the various test methods but they are complementary to one another. The fact that, for example ultrasonic testing can reveal both internal & surface flaws does not necessarily mean that it will be the best method for all inspection applications.

Much will depend upon the type of flaw present & shape of the components to be examined.

Quality of inspection:-

When NDT systems are used, care must be taken & processes controlled so that not only qualitative but quantitative information is received and this information is both accurate and useful. If NDT is in mind that ND inspection is carried out for most part by human beings and number of people will perform same task all the time. Hence decision must be estimated from statistical data.

Benefits of NDT:-

Clear benefits of NDT is the identification of defects which if they remained undetected, could result in a catastrophic failure which would be very costly.

INSPEC-TION METHOD	WHEN TO USE	WHERE TO USE	ADVANTAGES	LIMITATIONS
Eddy current	Measuring variations in wall Thickness of thin metals or coatings; detecting longitudinal seams or cracks in tubing; determining heat treatments and metal compositions for sorting	Tubing and bar stock parts of uniform geometry, flat stock, or sheets and wire.	High speed, Non contact, automatic.	False indications result from many conductive materials; limited depth of penetration.
Radiography: X-rays	Detecting internal flaws and defects; finding welding flaws, cracks, seams ,porosity, holes, inclusions, lack of fusion; measuring variations in thickness	Assemblies of electronic parts, casting, welded vessels; field of testing of welds; corrosion surveys. Components of nonmetallic materials	Provides permanent record on film; works well on thin sections; high sensitivity; fluoroscopy techniques available; adjustable energy level.	High initial cost; power source required; radiation hazard; trained techniques needed.
Gamma X - ray	Detecting internal flaws, cracks, seams, holes, inclusions, weld defects; measuring thickness variations	Forgings, castings, tubing, welded vessels; field testing welded pipe; corrosion surveys.	Detects variety of flaws; Provides a permanent record; portable; low initial cost; source is small(good for inside shots)makes panoramic exposures	One energy level per source; radiation hazard; trained technicians needed; source loses strength continuously.

Magnetic particle	Detecting surface or shallow subsurface flaws, cracks, porosity, non metallic inclusions and weld defects;	Only for ferromagnetic materials; parts of any size, shape, composition or heat treatment.	Economical , simple in principle, easy to Perform; portable(for field testing);fast for production testing	Material must be magnetic; demagnetizing after testing is required power source needed; parts must be cleaned before finishing.
Penetrant	Locating surface cracks, porosity, laps, cold shuts, lack of weld bond, fatigue and grinding cracks.	All metals, glass and ceramics, castings, forgings, machined parts and cutting tools; field inspections	Simple to apply, portable, fast, low in cost; results easy to interpret; no elaborate setup required.	Limited to surface defects; surfaces must be clean
Ultrasonic pulse echo	Finding internal defects, cracks. lack of bond, laminations, inclusions, porosity, determining grain structure and thicknesses.	All metals and hard non metallic materials; sheets, tubing, rods, forgings, castings; field and production testing; in service part testing; brazed and adhesive bonded joints.	Fast dependable, easy to operate; lend itself to automation, results of test immediately known; relatively portable, highly accurate, and sensitive.	Requires contact or immersion of part; interpretation of readings requires training.

TENSILE TEST

Aim:-

To conduct tensile test on a mild steel specimen and determine the following.

- Ultimate strength
- Young's Modules.
- Percentage reduction in area.
- Malleability
- Percentage elongation
- True stress & true strain.

Test Material Required:

Tensile testing machine, specimen, steel rule, venires caliper, micrometer.

Theory:

In order to study the behavior of ductile material in tension, tensile test is conducted on standard specimen who is made up of ductile material, in a U.T.M up to destruction. The testing machine is called UTM because in this machine more than one test can be conducted

For ex:-tension, compression, bending, shearing etc.

The end of specimen is gripped in U.T.M and one of the gips moved apart, thus exerting tensile load on specimen. The load applied is indicated on a dial and extension is measured by using extensometer. Almost all the U.T.M's are provided with and autographic recorder which records load Vs deformation curve.

The figure shows a typical stress-strain curve for mild steel from stress-strain graph the mechanical behavior of the material is obtained.

The straight line portion from 0 to A represents the stress is proportional to strain. The stress at A is called "Proportionality limit". In this range of loading the material is elastic in nature. At B, elastic limit is reached. At point C, there is an increase in strain without appreciable increase in load is called Yielding.

Point C is called "Upper Yield Point".
Point D is called "Lower Yield Point".

After Yielding , any further increase in load will cause considerable increase in strain and the curve rises till the point 'E' which is known as point of Ultimate Stress.

The deformation in the range is plastic. At this stress, the bar will development break at point E.

Procedure:-

- Measure the original gauge length and diameter of the specimen.
- Insert the specimen into grips of the test machine.

- Begin the load application and record the load vs. elongation load.
- Take the readings more frequently as yield point is approached.
- Measure elongation values.
- Continue the test till fracture occurs.

Sl.No	Stress	Strain

Observation:

Graph:

Result:

VERIFICATION OF MAXWELL'S RECIPROCAL THEOREM

Aim:

To verify Maxwell's Reciprocal Theorem for a given simply supported beam.

Equipment:

- MS beams
- End supports
- Scale
- Weights
- Dial gauge

DIMENSIONS:

Length of the beam = ------------cm

Width = ----------------------------cm

Thickness = -----------------------cm

THEORY:

Maxwell's Reciprocal Theorem states that in any beam or truss the deflection at any point 'C' due to the load 'W' at any point 'D', is same as the deflection at 'D' due to the same load 'W' at point 'C'.

PROCEDURE:

1. Consider a simply supported beam.
2. Apply load in steps at point 'D', L/4 distance at one end and note the deflection at C , L/4 distance from the other end for each loading.
3. Now repeat the same at the point C and note the readings at D for each load.
4. Repeat the above procedure for different locations of loads and deflection point from each end.

PRECAUTIONS:

- Make sure that dial gauge tip should just touch the beam under stand.
- The dial gauge needle should be adjusted to zero before taking the initial reading without parallax error.

Sl.No	Load (gms)	Deflection (P)	Deflection (Q)

RESULT:

It is observed that Maxwell's Reciprocal Theorem is proved.

DEFLECTION OF CANTILEVER BEAM

Aim:-

To find the deflection of the cantilever beam.

Work Material Required:

Cantilever beam

Test Material Required:

- Dail gauge
- Loads
- Scale

Theory:

A beam fixed at one end and free at the other end is known as cantilever beam and when ever a cantilever beam is being loaded deflects from the original position. The amount of beam deflection depends upon the cross section and the Bending moment (B.M). The parameters in the basic design of cantilever are the following.

Strength

Stiffness

As there are many methods for finding the slope and deflection at a section in the loaded cantilever beam the following are widely used methods to find the deflection.

1. Double integration method
2. Moment area method.

1. DOUBLE INTEGRATION METHOD:-

The bending moment at a point is given by

$$M = EI.\frac{d^2y}{dx^2}$$

Now integrating

$$EI.\frac{dy}{dx} = \int M$$

Again integration

$$EI.y = \iint M$$

First equation gives slope, later one gives deflection

2. MOMENT AREA METHOD:-

This method gives the slope and deflection of the beam.

I method:-

The change of slope between any two points on an elastic curve is equal to the net area of B.M diagram between these points divided by EI

I= A / EI

II method:-

The intercept (between) taken on a given vertical reference line of tangents at any points on an elastic curve is equal to the moment of B.M diagram between these points about the reference line divided by EI

Y=A(x)/EI

PROCEDURE

- Measure the dimensions of the given cantilever beam.
- Fix the deflection angle gauge of some specified position and vary the loads of the free end of beam.
- By applying suitable conditions increasing loads at the free end note down the deflections reading at the specified position.

- Now in second experiment, reverse the position of the load and deflection gauge respectively.
- Note down the corresponding deflections for the varying loads.

ANALYSIS:

The cantilever is being tested for the design criteria i.e., for its strength and the stiffness purpose. It should be strong enough to resist the bending loads.
Shear stress and the deflection of the beam,

APPLICATIONS:

- Building constructions
- Aircraft design and fabrication of all structural elements
- Industrial applications
- Designing of huge and medium structures

PRECAUTIONS:

- Load the cantilever at the free end properly
- Place (or) get the initial readings of the gauge to zero
- Carefully note the deflection reading

CALCULATIONS:

Length of the Beam l = ______

Sl.No.	Load	Deflection by experiment			Deflection by Theoretical
		During Loading	During Un-loading	Average	

Theoretical deflection δ = ______

RESULT:

Deflection of the cantilever beam is _____

LONG COLUMN

Aim :

To find out the young's modulus of the given long column.

Formula:

$$P_{cr} = \frac{\Pi^2 E I}{l^2}$$

Euler formula for crippling load.

Where P_{cr} = crippling load

E=Young's modulus of elasticity

I=moment of inertia

l=Equivalent length

Specimen: long column

Machine: UTM

Instruments: scale , vernier calipers.

Description:

Here we are taking a long column and finding out its crippling load in the UTM machine by keeping it in between two flat plates. And then finding out its young's modules by applying Euler's formula.

For applications of Euler's theory the column should satisfy the following conditions

1) The column should be perfectly straight and axially loaded.
2) The section of column should be uniform.
3) The column material & perfectly elastic homogeneous and isotropic & obeys Hooke's law.
4) The length of the column is very compared to the lateral dimension.
5) The direct stresses are very small compared with the bending stress
6) The weight will fail by buckling alone.

Now we will consider a long column with both ends hinged.

Let AB be a column of length 'L' and uniform sectional area A hinged at both the ends A & B. Let P be the crippling load at which the column has just buckled.

Consider any section at a distance 'X' from the end B. Let 'y' the be the deflection (lateral displacement) at the section.

The bending moment at the section is given by El $\frac{d^2y}{dx^2}$ = $--P_y$

$$El\frac{d^2y}{dx^2} + P_y = 0$$

$$\frac{d^2y}{dx^2} + P_y / EI = 0$$

The solution to the above different equation is

$Y=c_1 \cos (x\sqrt{p/El}) + c_2 \sin (x\sqrt{p/El})$

Where c_1 & c_2 are constants of integration

At B, the deflection is Zero

Therefore At x=0, y=0

$C_1=0$

At A also, the deflection is Zero

Therefore At x=l, y=0

$0= c_2 \sin (l\sqrt{p/El})$

Since $c_1 =0$ we conclude that c_2 cannot be Zero.

Because if both c_1 & c_2 are zeros the column will not bend at all

Hence $\sin(l\sqrt{p/El}) = 0$

$l\sqrt{p/El}=0, \pi, 2 \pi, 3 \pi, 4 \pi$

Considering the least particle value

$l\sqrt{p/E}= \pi$

$$P= \pi^2 EI / l^2$$

Here the effective length of the column i.e, L= l because both ends are hinged putting

$l =AK^2$

$$P= \pi^2 EA/ (l/k)^2$$

Where l/k = slenderness ratio.

For long column it is >120

So the buckling load is

$$P= \pi^2 EI/l^2 = \pi^2 EA/(l/k)^2$$

Procedure:

1) Measure the specimen & find its moment of inertia.
2) Fix the specimen between the two plates.
3) Before starting the experiment the load gauge of deflection scale is kept at zero
4) Start the machine & apply the load over the column.
5) After the experiment is done i.e. when the column starts buckling we get the crippling load.

And hence the Young’s modulus of the material can be found out by Euler’s formula.

Precautions:

1) Keep the column perfectly perpendicular to the jaws.

Calculations:

Cross-sectional area of the specimen = A =

Moment of the inertia ,M.I. = I =

Radius of gyration, K =

$P_{cr} = \pi^2 EI/l^2 =$

E =

Result:

The young's modulus of the given specimen is MPa

SHORT COLUMN

Aim:

To find the compressive stress of a short column for a given material.

Equipment:

1. Universal testing machine
2. Test specimen (short column)
3. Scale, Vernier callipers.

Dimensions:

- Diameter = __________ mm or Cross section of the specimen = ________
- Length = __________mm

Theory:

- slenderness ratio = length of the column (l) / Least radius of gyration

- If slenderness ratio is less than 20 then the column is short column.
- A very short column will fail by crushing load, given by

$P_C = F_C. A$

Where,
F_C --- Ultimate crushing stress
A ----Uniform cross sectional area of short column,

By adding the crushing load of a suitable factor of safety, safe load for the member can be computed.

Rankine's Formula:-

- Short columns fail by crushing the load at the failure point given by $P_C = F_C. A$
- Long columns fail by buckling and the buckling load is given by $P_b = \pi^2 EI/l^2$

The struts and columns which we come across are neither too short nor too long but the failure is due to combined effect of direct and bending stress.

Rankin revised an empirical formula which converts both the cases,

$1/p = 1/p_e + 1/p_b$

p --- Actual crippling load.

$P = \frac{F_C. A}{1+\alpha(l/k)^2}$ where $\alpha = \frac{F_C}{\pi^2 E}$ constant for given material.

Procedure:

- Place the given short column specimen in the UTM.
- Ensure that the specimen is vertical with its end or cross section is in contact with the

loading surfaces.

- Now gradually apply the compressive load.
- Note the failure load from the universal testing machine.

Precautions:

- Place the given short column specimen in the UTM.
- Ensure that the specimen is vertical with its end or cross section is in contact with the loading surfaces.
- Column should be firmly gripped without any slip.
- Maintain a safe distance from the UTM during the experiment.

Calculations:

Cross-sectional area of the specimen = A =

Moment of the inertia ,M.I. = I =

Radius of gyration, K =

$$P = \frac{F_C . A}{1+\alpha(l/k)^2} =$$

Result:

The compressive stress of the given material is ___________ MPa.

RIVETED JOINT

Aim:-

To make a riveted joint (double riveted Zig-Zag lap joint) between two given metal pieces.

Work Material Required:-

- Two aluminum plates (60 x 90 x6) mm.
- Aluminum rivets.

Tools Required:-

- Sheet metal cutter
- Steel rule
- Mallet
- Files
- Bench vice
- Centre punch

- Dolly and snap
- Drilling machine
- Scriber

Theory:-

Riveted joints are permanent fastening and riveting is one of the commonly used method manufacture of boilers , storage tanks etc, involve joining of steel sheets, by means of riveted joints. A rivet is a round rod of circular cross section. It consists of two parts viz., head, shank. HS, WI and AL-alloys are some of the metals commonly used for rivets the choice of particular metal will depend upon the place of application. Riveting is the process of forming. Riveted joints for this, a rivet is first placed in the hole drilled through the two parts to be riveted then the shank end is made into a rivet head by applying pressure, when it is either cold or hot condition.

The pressure may be applied to form the second rivet head, either by direct hammering or through hydraulic or pneumatic means, The commonly used riveted joints are of two types.

1. Lap joint.
2. Butt joint.

In the lap joint the plates to be connected overlap each other when the joint is made only with one row of rivets it is called single – riveted lap joint. A joint is said to be double riveted it’s according to the no. of row of rivets. In butt joint the edges of the plates are connected against each other and the joint between them is covered by butt plates.

Procedure:-

1. Take the given Aluminum sheet and cut it in to the required dimension with the help of sheet metal cutter.
2. Place the cut end aluminum sheet in the bench vice and files for the right angles.
3. Mark the dimensions of the rivet hole with the help of the scriber, dot punch and center punch.
4. Drill the holes on the two aluminum plates with the help of the drilling machine.
5. Now take the rivets and punch them with the ball peen hammer in the required holes.
6. Before driving the rivets, clamp them properly and make the riveting and be sure that the plates are properly joined.

Analysis:-

The riveted joint are usually performed in the areas where other means of joints are impossible. It makes a strong joint with less material and less applied force.

Applications:

The riveted joint usually finds the application in the

- Ship building
- Construction of steel buildings
- Bridges
- Boilers and Tanks
- Wings and fuselage construction of aircraft.

Precautions:

- Cut the aluminum sheets in the required size
- Clamp the plates properly
- Properly drill the holes on the punched areas

FAILURE STRENGTH OF RIVETED JOINT

Aim: To analyze the strength of the riveted joint

Equipment: universal testing machine, riveted joint, specimen

Dimension:

- Al sheet of size = -------
- Al rivets diameter = --------

Theory:

A riveted joint may fail in any of the following manner

- By tearing of the plate between the rivet hole and the edge of the plate

- By tearing of the plates between rivets .The safe tensile load that the plate can withstand for one pitch length is called the tearing strength

  Tearing strength per pitch length = P x t

  $P_t = F_t$ x net area of the plate

  $P_t = F_t\ (p-d)\ t$

- Failure due to shearing of rivet for a lap joint if load /pitch length is large it is possible that the rivet may shear off

  $P_s = F_s \times \pi d^2/4$

  In general in a lap joint if rivets are covered load per pitch length would be

  $P_s = n \times F_s \times \pi d^2/4$

where n = number of rivets per pitch length.

- Failure by bearing or crushing of rivet or plate .The safe load on rivet

  $P_b = F_b x d t$ where

  P_b= allowance bearing stress

  F_b = bearing value of rivet

Efficiency of a joint:

Let P_t, P_s, P_b be the safe load per pitch length from tearing, shearing and bearing considerations.

Let p be the pitch of the rivets and t is the thickness of the plate

Safe pull on a solid plate for a length would be

$$P = F_t .p. t$$

$$\eta = \frac{\text{least of } P_t, P_s, P_b}{p}$$

Procedure:

- Place the riveted joint in the universal testing machine.
- Make sure that plates are held at equal distance from both ends
- Gradually apply tensile load
- Note the readings from universal testing machine at which rivet joint fails
- Observe the type of failure

Precautions:

Check that the plates are firmly gripped without any slip

Calculations:

Diameter of the rivet d =

Pitch p =

Thickness of the plate t =

Tearing strength P_t =

Shearing strength P_t =

Crushing or Bearing strength P_b =

Solid plate strength P =

$$\text{Efficiency of the rivet, } \eta = \frac{\text{least of } P_t, P_s, P_b}{p}$$

Result:

Failure of riveted joint is due to the ___________________________

BLOTED JOINT

Aim:

To make a lap bolted joint of two aluminum plates.

Work Materials:-

- Two aluminum plates
- Bolts and nuts.

Tools required:

- Bench vice
- Files
- Scriber and scale
- Drilling machine
- Metal sheet cutter

Theory:

Bolted joints are used for connecting two parts in structural connections, where strength is required. Screw fastenings are different types.

- Tap bolts and cap screws.
- Machine screws
- Jet screws.
- Studs

Procedure:

1. Cut 2 Al plates as per given dimensions(60 X90)
2. File the edges to set the correct dimensions.
3. With the help of scriber, make the holes as per the dimensions.
4. Drill the holes with the drilling machines at the markings.
5. Insert the bolts and nuts and fit the nuts on them.
6. Tighten the bolts with help of spanner.

For bolted joints we use through bolts. These bolts and nut are subjected to axial and shear loads in the joints and they can withstand.

Precautions:

- Take the dimensions without any error.
- While drilling, put the plates in proper position and hold firmly.
- Use the appropriate tools for various specific operations.

Result:

Hence, required lap bolted is obtained.

FAILURE STREGNTH OF BOLTED JOINT

Aim:-

To analyze the strength of the bolted joint.

Equipment:-

Universal testing machine(UTM), bolted joint specimen.

Dimensions:-

90 X 60 mm – 2 AL sheets.

Theory:-

A bolted joint may fail in any of the following manner.

By tearing of the plate between bolt hole and the edge of the plate.

By tearing the plates between bolts. The safe load that the plate can

withstand for one pitch length is called the tearing strength.

Tearing strength per pitch length = P_t

$P_t = F_t$ x net area of the plate.

$P_t = F_t (P-d) t$

Failure due to shearing of bolt for a lap joint if load / pitch length is large it is possible that the bolt may shear off

$P_s = F_s . \pi \ d^2 / 4$; $F_s \rightarrow$ safe shearing stress.

In general in a lap joint n no. of bolts are covered load per pitch length would be

$P = F_t . P.t$

$$\eta = \frac{\text{least of } P_t,\ P_s,\ P_b}{P}$$

Procedure:-

- Place the lap joint in the Universal testing machine.
- Make sure that plates are held at equal distance from both ends.
- Gradually apply tensile load.
- Note the readings from Universal testing machine at which bolted joint fails.
- Observe the type of failure.

Precautions:-

Check that the plates are firmly gripped without any slip.

Results:-

Failure of bolted joint is due to the _____________..

ULTRASONIC TEST

Aim:-

To detect the internal defects in the given specimen.

Equipments:-

Specimen, Ultrasonic 4400AV.

Theory:-

Ultrasonic techniques are very widely used for detecting of internal defects in materials, but they can also be used for the surface cracks. Ultrasonic are used for quality control, inspection of finished components, parts processed materials such as rolled steel slabs etc...

Elastic waves with frequency higher than audio range are described as Ultrasonic. The waves used for NDT inspection of materials are usually within the frequency range of 0.5 MHz - 20 MHz .In fluids sound waves are zero longitudinal comp.type in which particle displacement in the direction of wave propagation but in solids, they are shear waves, with particle displacement normal to the direction of wave travel.

In solids, velocity of compression waves is given by

V_c = [E (1-Y)/ (1+Y) (1-2Y) e]   Y= gama-poissons ratio

Where E → Young's modules

Y → Poisson's ratio.

In most ultrasonic test (U.S) equipment, the signals are displayed on the screen of a C.R. oscilloscope. The presence of a defect within a material may be found using U.S. with either a transmission technique or reflection technique.

Test probes & U.S equipment can be calibrated by using reference blocks & calibration standards.

Ideally a smooth surface is required on a material for effective U.S inspection. The rough surface of casting or forging may present a problem. The use of a thick grease as coolant may overcome this.

Procedure:-

1. Take the given specimen and match with the C.R.T screen.
2. Place the transducer where the flaws to be detected and find out the position of flaw.
3. Repeat the same procedure for specimen.

Precautions:-

1. See that the battery of U.S flaw detector is properly charged.
2. Note the reading without any parallax error.

Result:-

Position of discontinuity & flaw is detected.

DYE PENETTRATION TEST

Aim:

To detect the flaws on the surface of a given material.

Apparatus:

The required apparatus to perform the experiment are:

(i) Cylindrical specimen
(ii) Developer orion 115PD
(iii) Red dye penetration orion 115P
(iv) Penetration remover, orion 115 PR

Theory:

Liquid penetration inspection is a technique which can be used to detect defects in a wide range of components, provided that the defect breaks the surface of the material.

The principle of the technique is that a liquid is drawn by capillary attraction into the defect and after subsequent development, any surface –breaking defects may be under visible to the human eye. In order to achieve good defect visibility, the penetrating liquid should be bright colored. In general the dye is red and developed surface can be viewed in natural or artificial light, but in later case, the component must be viewed under ultra violet light if defect indications are to be seen.

Liquid penetration inspection is applicable to any type of configuration. It is employed for inspection of wrought and cast products in both ferrous and some polymer components.

There are five essential steps in Penetrant inspection method. They are,

a) Surface preparation
b) Application of Penetrant
c) Removal of excess Penetrant
d) Development
e) Observation and inspection.

A liquid Penetrant must posses certain characteristics for inspection to be efficient.

a) Penetration
b) Body
c) Fluidity
d) Solution ability
e) Stability

f) Wash ability

g) Drying characteristics

h) Visibility

Procedure:

- Take the specimen on which NDT red dye Penetrant test will be performed
- Clean the specimen with remover-ORION 115PR
- Shake well before the use of the remover to clean the foreign materials which are present on the surface.
- Now apply the red dye Penetrant ORION 115P to specimen, take necessary care that red dye Penetrant will cover total surface of specimen.
- Allow it to penetrate into the flaws for 2-5 min.
- After penetration, remove the excess red dye Penetrant remover ORION 115PR gently.
- Now apply developer ORION-115PD on complete specimen, and then the cracks on the surface will be visible in 'Red' color.

Precautions:

1. Use adequate ventilation.
2. Don't use in vicinity of fire.
3. Use in ambient temperature, don't store in direct sunlight
4. Contents are highly inflammable.
5. Don't throw empty cans in fire.
6. Apply the developer and Penetrant from a distance of 8-10 inches from the specimen.

Result: The flaws on specimen are detected.

MAGNETIC PARTICLE DETECTION

Aim:

To analyze the intensity of cracks or surface and sub layer flaws in a given specimen.

Apparatus:

Electro Magnetic yoke, steel specimen, iron oxide powder etc.,

Theory:

Magnetic particle inspection is used for Ferro magnetic components. When a Ferro magnet is magnetized, magnetic discontinuities that lie in a direction approximately perpendicular to the field will results in form of a strong 'Leakage field'. This leakage field is present at above the surface of magnetized component and its presence can be visibly detected by utilization of finely divided magnetic particles. The application of dry or wet particles in a liquid carrier, over surface of component results in a collection of magnetic particles at a discontinuity. The magnetic bridge, so formed indicates the location, size and shape of discontinuity.

Magnetization may be introduced in a component by using permanent magnets, (E.Ms) or by passing high currents through or around component.

Procedure:

- Clean the surface of a given specimen.
- Place the EM yoke on specimen vertically with its foldable legs on it.
- Switch on the power supply.
- Pour the iron oxide powder on the specimen.
- After the observation, demagnetize the specimen.

Observation:

We observe the lines of accumulation of powder on the surface of crack position depending upon its intensity of crack.

Precautions:

1. The power should be distributed uniformly on the specimen.
2. The iron oxide powder should not be distributed during the experiment.

Result:

Flaws are detected. _____ lines of accumulation of iron oxide are observed.

BONDING

Aim:

To prepare a bonded structure made up of wood and aluminum with the aid of glue (araldite).

Work material:

1. Wood
2. Two Al sheets

Theory:

Bonding is a method of joining of components with the help of a bonding material called glue, which is to be placed between the members to be joined. Generally, bonding is done between the members so that the resultant bonded structure will have hybrid properties i.e., the combustion of properties of both the materials.

Bonded structures are widely used in the construction of various aircraft components like wing, fuselage etc., as a bonded joint between aluminum and wood has an increased strength to weight ratio compared with the individual materials, which is the primary requirement for an aircraft.

Procedure:

- Take a given wooden piece and saw it to the required dimensions.
- With the help of rasp, give the surface finish.
- Make the Al sheet to 75x75mm with the help of scale and scriber and cut it from the main sheet by using cutter.
- With the aid of metal file, give the metals a good edge finish.
- Finally bond the aluminum sheets and wooden piece with adhesive araldite.
- Change it in order to make the bond dry and strong.

Precautions:

- Mark the dimensions without any parallax error.
- Proper care is to be taken which sawing the wood piece and filing of the aluminum sheet.
- Only adequate quantity of glue is to be used.

- Bonded structure is properly clamped and is allowed to dry properly.

Result:

The required bonded structure is obtained.

STUDY AND CALIBRATION FOR

MEASUREMENT OF SPEED

Aim:

To study the speed of the shaft of a motor using stroboscope and to compare it with manual tachometer reading.

Apparatus:

Stroboscope, RPM indicator, tachometer.

Theory:

Tachometer is designed to measure the speeds of rotating shafts, gear turbines etc. The sensor employed to sense is of the variable reluctance type. This sensor picks up tachometer pulses from any rotating ferrous object such as a gear. The number of such pulses being equal to the number of times, the flux lines emanating from the sensor is cut by the alternate presence of gap and teeth of the gear. The sensor is mounted in close proximity to the rotating body to ensure a sufficiently large voltage output for accurate indication of speed in RPM.

The indicating instrument consists of a 4 – digit counter, one second clock generation circuit. Input signal conditioning preamplifier, latches and decoding circuit etc. Bright RED, seven segment LEDs are used for clear display of speed in RPM.

Tachometers with 5 digit for measurements of speeds more then 10,000rpm are also available. Tachometer with analog voltage output or 4-20 mA current output for feed back control application also can be available as per the users requirements.

Specifications:

1.Display	: 4 digit display of RED, 7 segment LED of 12.7mm character height.
2.RPM range	: 0-9999 rpm
3.Accuracy	: Within + 0.1%, F.S.R + 1 count
4.Input	:From non-contact reluctance type sensor models.
5.Measuring time	: 1 second (one sample per second)

6.Over-range indicator :For reading in excess of 9999 rpm, display indicates 0.0.0.0.

7.Operating temperature : $10^{o}C$ to $45^{o}C$.

8.Power supply requirement: 230 V + 10%, 50Hz, AC mains

9.Cabinet(W x H x D) :96 x 96 x 150mm

Procedure:

1.Before connecting power to the indicator, verify whether the power available matches with the requirements of the indicator as mentioned on the rear panels. After verification, connect one end of the mains cable to the socket on the rear panel and the other end to the power supply source.

2.Connect the cable to input socket on the rear panel.

3.Switch on the indicator.

4.Mount the tachometer in proximately to the gear wheel on the rotating shaft whose speed is to be measured. The distance between the sensor force and the gear wheel teeth should not be more than 1.5mm.

5.The display indicates the speed of the rotating shaft directly in RPM if only 60 teeth gear wheel is used.

6.For any other gear wheel of N teeth, the RPM is to be calculated as follows:

$$RPM = \frac{\text{Displayed value} \times 60}{N}$$

7.When the speed being measured goes beyond 9999 rpm, over range is indicated by lighting off all four decimal points of the display.

Observations:

S.No	Stroboscope	Tachometer reading(rpm)	Digital tachometer reading(rpm)	Error(rpm)	% Error
1	929	920	927	9	0.96
2	1284	1279	1283	5	0.38
3	1370	1365	1368	5	0.36
4	1459	1457	1458	2	0.137
5	1610	1601	1610	9	0.55
6	1650	1642	1648	8	0.48
7	1797	1790	1796	7	0.389
8	1867	1860	1866	7	0.374

Sample Calculation:

Stroboscope reading : 929 rpm

Tachometer reading :920 rpm

Error :Stroboscope reading – tachometer reading

: 929 – 920 = 9 rpm

We have % error : 9/929 = 0.96

Graph:

A graph is drawn by taking % error on X-axis and stroboscope reading (rpm) on Y-axis.

Model Graph:

Result:

The speed of shaft of given motor is found out and the readings of hand tachometer are compared with digital tachometer readings and the graph is drawn.

SHEAR CENTER OF OPEN SECTION

DESCRIPTION OF APPARATUS

The Apparatus consists of:

1. Thin walled section of the OPEN CHANNEL of material Aluminium or GI or Mild steel is provided.
2. Two dial gauges to monitor the deflection is provided.
3. Weights of 500gm upto 5000gm has being provided for loading purpose.
4. Loading is applied by means of hanger on the section.
5. Vernier Caliper to measure the sizes.
6. Sturdy Frame for attachment is provided with good aesthetic looks.

EXPERIMENTATION:

i. AIM:

The experiment is conducted to determine the shear center of the OPEN SECTION

ii. PROCEDURE:

1. The given channel section consisting of two flanges and one web is first fixed in a particular position.
2. The dimensions of the flange are calculated so as to facilitate determination of shear centered.
3. Mount two dial gauges on the flange at a known distance apart at the free end of the beam.
4. Place a two kilogram load on left side hook and note the dial gauge readings
5. Remove one load from the left end and place on right end, note the dial gauge readings.
6. Transfer carefully all the load pieces and finally the hook one by one to the other hook, noting each time the dial gauge readings. Calculate the distance 'e' of the line of action from the web thus

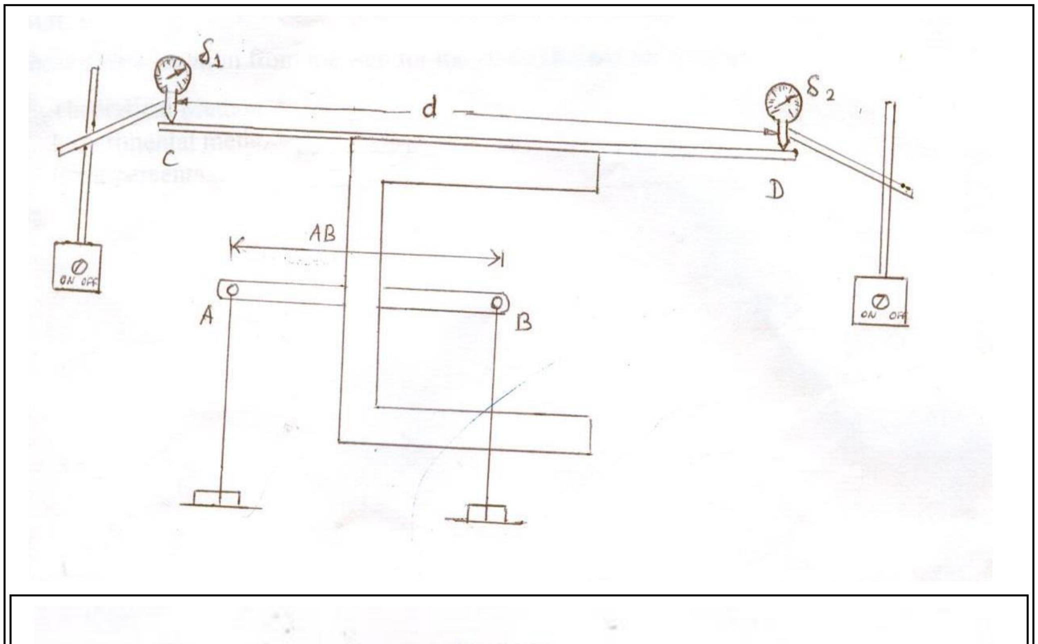
$$e = \frac{AB}{2} + \frac{w_a - w_b}{w_t}$$

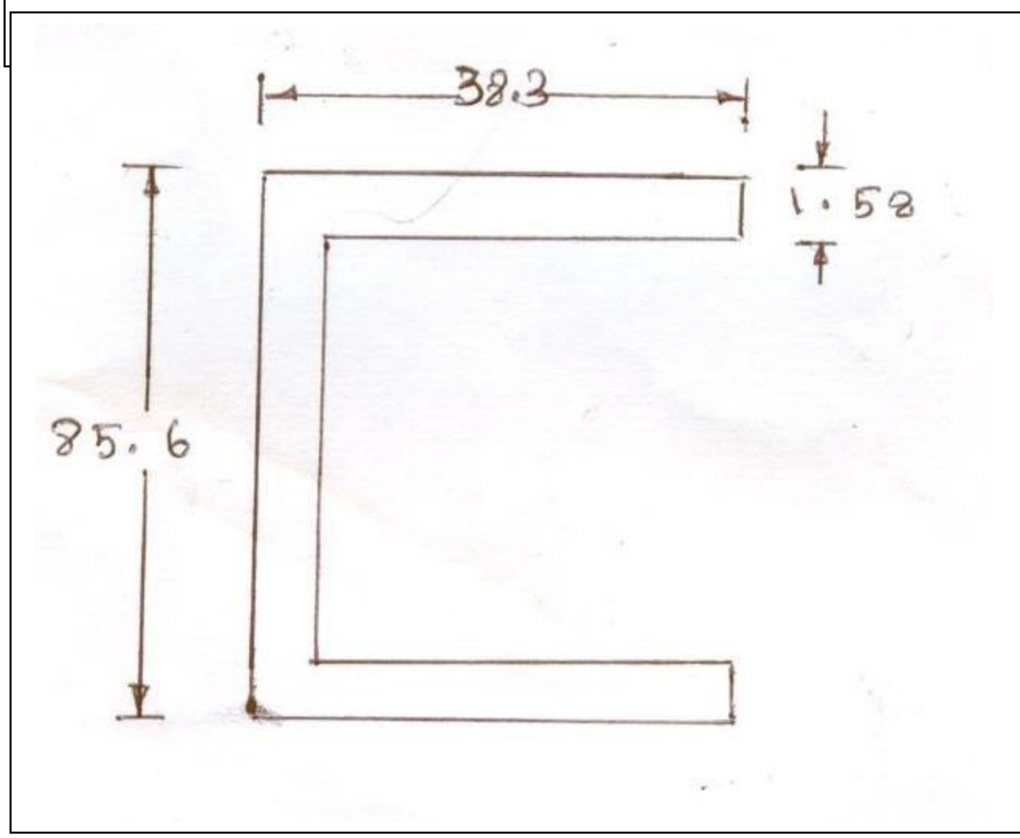
7. For every load case calculate the algebraic difference between the dial gauge readings as the measure of the angle of twist θ suffered by the section.
8. Plot θ against e and obtain the meeting point of the curve (a straight line in this case) with the e-axis (i.e., θ, the twist of the section is zero for this location of the resultant vertical load). This determines the shear center.
9. The distance from the origin to the point where the curve crosses the x-axis is given as the distance of the shear center of origin.

OBSERVATIONS:

DIMENSION MEASURED	MSR mm	VSR	VSC mm	TOTAL READING mm
Thickness Of Flange And Web				
Breadth Of Flange				
Height Of The Section				

iii. PICTORIAL REPRESENTATION:





iv. CALCULATION:

1. Theoretical Location of Shear Center, eth

$$e_{th} = \frac{3b^2 t_f}{6bt_f + ht_w}$$

2. Experimental Location of Shear Center, eexp

$$\boldsymbol{e_{exp}} = \frac{AB}{2} + \frac{w_a - w_b}{w_t}$$

3. Vertical Weight, Wt

$$\boldsymbol{W_t} = (\boldsymbol{W_a} + \boldsymbol{W_b})$$

4. Angle of plane of displacement, θ

$$\theta = \frac{\delta_1 - \delta_2}{d}$$

Where,

AB- Distance between the 2 loads

W_a – Load applied at point A

W_b – Load applied at pouint B

W_t – Total load applied

e- Location of shear centre from the web

b – width of the flange

h- height of the web

t_f – Thickness of the flange

t_w –Thickness of the web

δ_1- Deflection at point 1

δ_2 - Deflection at point 2

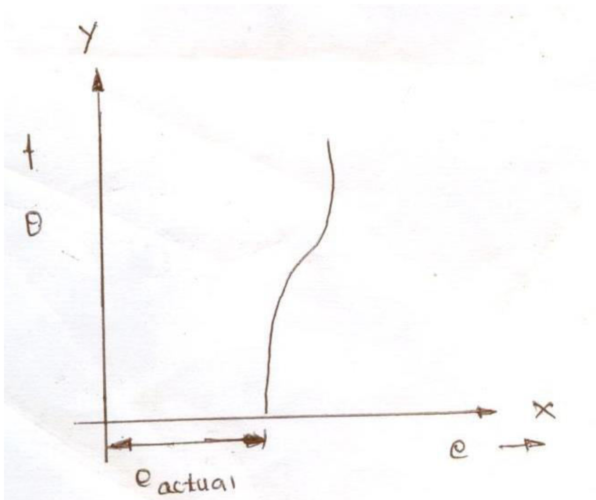
$d -$ Distance between point 1 and point 2

θ - Angle of plane of displacement

TABULATIONS:

SL	W_a	W_b	W_t	δ_1 mm	δ_2 mm	θ	e

Model Graph



RESULT:

The shear center location from the web for the given channel section of

a. Theoretical Method = ____________________
b. Experimental Method = ____________________
c. Error Percentage = ____________________

SHEAR CENTER OF CLOSED SECTION

DESCRIPTION OF APPARATUS

The Apparatus consists of:

1. Thin walled section of the closed box of material Aluminium or GI or Mild steel is provided.
2. Two dial gauges to monitor the deflection is provided.
3. Weights of 500gm upto 5000gm has being provided for loading purpose.
4. Loading is applied by means of hanger on the section.
5. Vernier Caliper to measure the sizes.
6. Sturdy Frame for attachment is provided with good aesthetic looks.

EXPERIMENTATION:

i. AIM:

The experiment is conducted to determine the shear center of the CLOSED SECTION

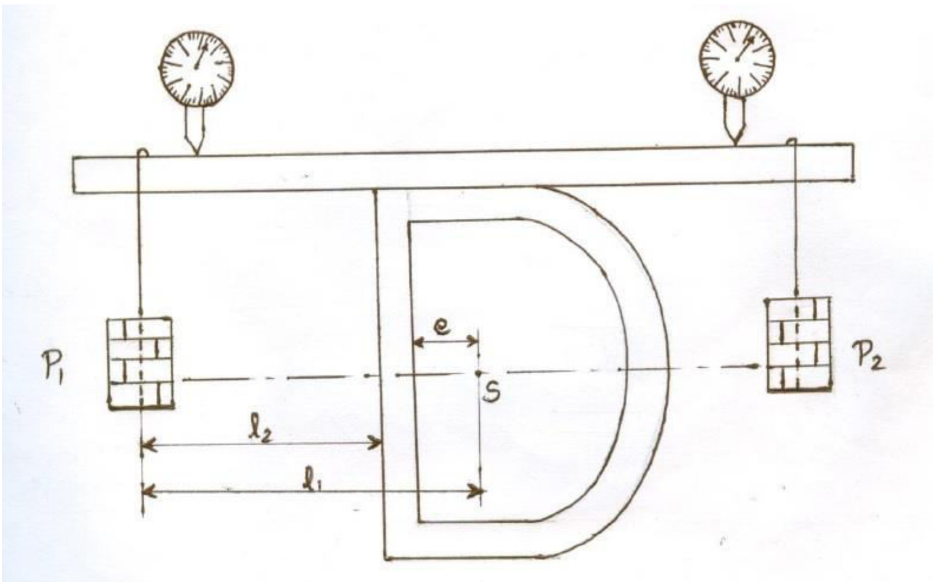
ii. PROCEDURE:

1. Set the apparatus by properly placing the Dial gauges on the Closed Section.
2. Apply the load P1 (say 500gm) on pan1 and then load the weights on P2 pan such that the dial gauges read same values.
3. Repeat the above procedure for increasing loads say 1000, 1500gm etc upto required.
4. Now Calculate L1 and Shear Center using the formula given.

OBSERVATIONS:

Sl. No.	Load Applied	
	P1	P2

iii. PICTORIAL REPRESENTATION:



iv. CALCULATION:

Shear Center, L1

$$l1 = \left(\frac{P_1}{P_2}\right) * (l - l_2)$$

Where,

P1 = load on Pan 1

P2 = load on Pan 2

l = Distance b/w P1 and P2

l2 = Distance b/w P1 to vertical web

Eccentricity, e

$$\boldsymbol{e = (l_1 - l_2) \quad mm}$$

RESULT:

1. Location of Shear Center from Vertical Web = ____cm.
2. The eccentricity measure is ______ cm.

BEAM SETUP

INTRODUCTION:

The problem of bending probably occurs more often than any other loading problem in design. Shafts, axels, cranks, levers, springs, brackets, and wheels, as well as many other elements, must often be treated as beams in the design and analysis of mechanical structures and system. A beam subjected to pure bending is bent into an arc of circle within the elastic range, and the relation for the curvature is:

$$\frac{1}{\rho} = \frac{M(x)}{EI} \qquad (1)$$

Where: ρ is the radius of the curvature of the neutral axis

X is the distance of the section from the left end of the beam

The curvature of a plane curve is given by the equation :

$$\frac{1}{\rho} = \frac{\frac{d^2y}{dx^2}}{\left[1+\left(\frac{dy}{dx}\right)^2\right]^{\frac{3}{2}}} \qquad (2)$$

(dy/dx) is the slope of the curve and in the case of elastic curve the slope is very small :

$$(dy/dx)=0$$

$$\frac{1}{\rho} = \frac{d^2y}{dx^2}$$

$$\frac{d^2y}{dx^2} = \frac{M(x)}{EI} \qquad (3)$$

Multiply both sides by EI which is constant and integrating with respect to x:

$$EI\left(\frac{dy}{dx}\right) = \int M(x)dx + C_1 \qquad (4)$$

Noting that

(dy/dx)= tan θ θ= θ(x) because the angle θ is very small. And integrating the equation again.

$$EI\ y = \int dx + \int M(x)dx + C_1x + C_2 \qquad (5)$$

The constants C_1 and C_2 are determined from the boundary conditions (constants) imposed on the beams by its supports

1. Simply supported beam
2. Cantilever beam

Case: 1. Simply supported beam

At the supports, deflections are zero y=0 (at A & B)

Now we have two equations to be solved for C_1 & C_2, solving equations (Eq-5) and substituting boundary conditions give us

$$y = \frac{Pbx}{6EIL}(x^2 + b^2 - l^2) \qquad \text{(Between A\&C)}$$

$$y = \frac{Pa(l-x)}{6EIL}(x^2 + a^2 - 2lx) \quad \text{(Between C\&B)}$$

Case: 2 Cantilever beam

The deflection and slope is zero at A

$$y = \frac{Px^2}{6EI}(x - 3a) \quad \text{(Between A\&C)}$$

$$y = \frac{Pa^2}{6EI}(a - 3x) \quad \text{(Between C\&B)}$$

DESCRIPTION OF APPARATUS:

The apparatus consists of :

1. Aluminium sections of C , L and flat type of cantilever beams are provided for conducting the experiments at different loads.
2. All sections are gauged into measure the strain in the beam and are indicated using the strain indicator
3. Loading is applied by the means of gear box assembly and the applied load is indicated by means of load indicator which is attached with load cell
4. Lateral deflection can also be found using the similar loading arrangement as the one for direct loading
5. Option for the movement of the loading point is provided to apply the load at different point of the beam.
6. Sturdy frame for attachment of different types of cantilever beams is provided.

EXPERMENTATION:

AIM:

The experiment is conducted to determine the deflection of beam on different cross section and loading points and comparing the theoretical values.

PROCEDURE:

1. Fix the beam of required cross section.
2. Adjust the load unit at the required distance.
3. Connect the under test beam strain wires to the strain indicators.
4. Connect the loads cell cable to the load indicator respectively.
5. Fit the dial guage at required position and set to Zero.
6. Provide necessary electrical connections (230V 1Ph 5Amps with neutral and earthing) to the indicator provided .
7. Now on the digital multi strain indicator set the display knob (right hand side of the display) to first position and set to zero using zero adjustment knob(below the display)
8. Similarly do the above step for other positions.
9. Now, using the hand wheel provided load the beam slowly.
10. Note down the deflections from the dial guage at different load conditions (max deflection is 10mm).
11. Also, note the strain guage reading at different positions of the beam.
12. Repeat the steps 10 and 11 for different load conditions.

13. Now calculate the deflections from the standard formula and compare with measured deflections.
14. Using the strain reading calculate the stress induced different directions of the beam.

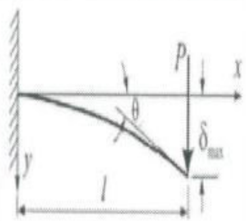
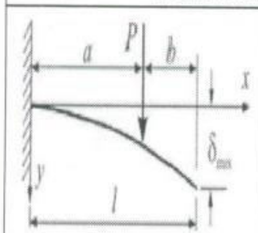
OBSERVATIONS:

S.No	Load Applied		Deflection, δ mm	Micro strain at different directions		
	Kg	N		X	Y	z

CALCULATIONS:

1. USE THE BELOW FORMULA TO CALCULATE MAXIMUM DEFLECTION AND DEFLECTION AT ANY POINT OF CROSS SECTION

BEAM DEFLECTION FORMULAE

BEAM TYPE	SLOPE AT FREE END	DEFLECTION AT ANY SECTION IN TERMS OF x	MAXIMUM DEFLECTION
1. Cantilever Beam – Concentrated load P at the free end			
	$\theta = \frac{Pl^2}{2EI}$	$y = \frac{Px^2}{6EI}(3l - x)$	$\delta_{max} = \frac{Pl^3}{3EI}$
2. Cantilever Beam – Concentrated load P at any point			
	$\theta = \frac{Pa^2}{2EI}$	$y = \frac{Px^2}{6EI}(3a - x)$ for $0 < x < a$ $y = \frac{Pa^2}{6EI}(3x - a)$ for $a < x < l$	$\delta_{max} = \frac{Pa^2}{6EI}(3l - a)$

Where,
P=load applied, N
E=Young's modulus, GPa
a=load distance from fixed end, in mm
b=load distance from free end, in mm
L=length of the beam
I=moment of inertia of the given cross section

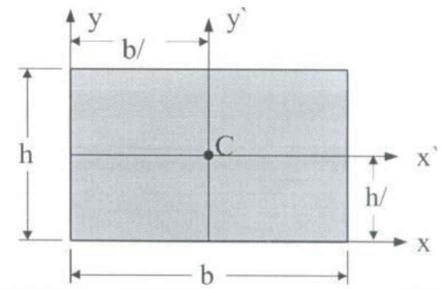
2. MOMENT OF INERTIA OF DIFFERENT SHAPES

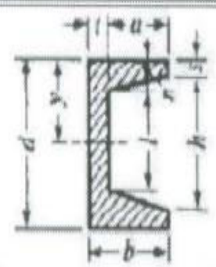
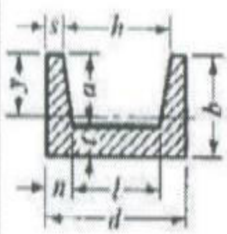
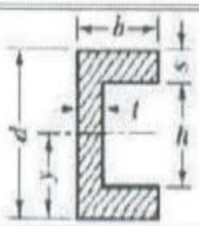
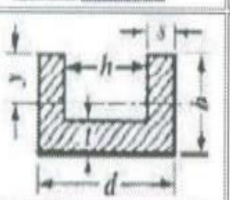
Rectangle:

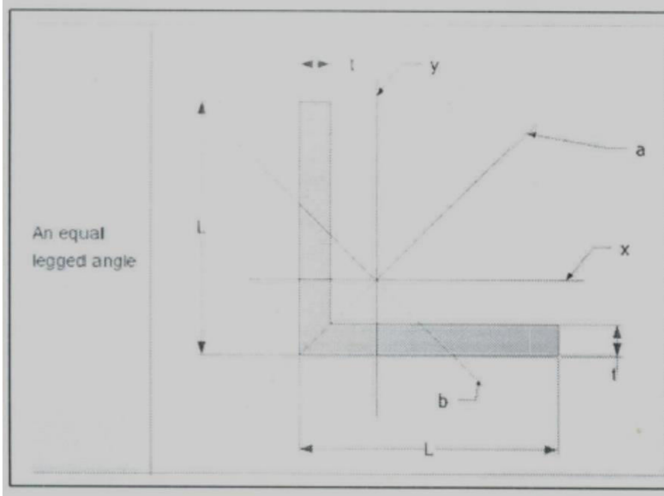
$\bar{I}_{x'} = \frac{1}{12}bh^3 \qquad I_x = \frac{1}{3}bh^3$

$\bar{I}_{y'} = \frac{1}{12}b^3h \qquad I_y = \frac{1}{3}b^3h$

$\bar{I}_{xy'} = 0 \qquad Area = bh$



Section	Moment of Inertia	Radius of Gyration	Area	y
	$\frac{1}{12}\left[bd^3 - \frac{1}{8g}(h^4 - l^4)\right]$ g = Flange slope (Standard Channels) $= \frac{h-l}{2(b-t)}$	$\sqrt{\frac{\frac{1}{12}\left[bd^3 - \frac{1}{8g}(h^4 - l^4)\right]}{dt + a(s+n)}}$	$dt + a(s+n)$	$\frac{d}{2}$
	$\frac{1}{3}\left[2sb^3 + lt^3 + \frac{g}{2}(b^4 - t^4)\right]$ $-A(b-y)^2$ $= \frac{h-l}{2(b-t)}$	$\sqrt{\frac{I}{A}}$	$dt + 2a(s+n)$	$b - \left[b^2s + \frac{ht^2}{2} + \frac{g}{3}(b-t)^2 \times (b+2t)\right] \div A$ g = slope of flange $= \frac{h-l}{2(b-t)}$
	$\frac{bd^3 - h^3(b-t)}{12}$	$\sqrt{\frac{bd^3 - h^3(b-t)}{12[bd - h(b-t)]}}$	$bd - h(b-t)$	$\frac{d}{2}$
	$\frac{2sb^3 + ht^3}{3} - A(b-y)^2$	$\sqrt{\frac{I}{A}}$	$bd - h(b-t)$	$b - \frac{2b^2s + ht^2}{2bd - 2h(b-t)}$



$$I_x = I_y = \frac{t(5L^2 - 5Lt + t^2)(L^2 - Lt + t^2)}{12(2L - t)}$$

$$I_{(xy)} = \frac{L^2 t(L - t)^2}{4(t - 2L)}$$

$$I_a = \frac{t(2L - t)(2L^2 - 2Lt + t^2)}{12}$$

$$I_b = \frac{t(2L^4 - 4L^3t + 8L^2t^2 - 6Lt^3 + t^4)}{12(2L - t)}$$

3. STRESS AT DIFFERENT DIRECTIONS

$$\sigma_{DIRECTION} = (E * \varepsilon_{DIRECTION})MPa$$

S.No	Load Applied N	Deflection, δ mm		Micro strain at different directions		
		Actual	Calculated	X	Y	z

PRECAUTIONS:

1. Clean the equipment regularly and grease all visual rotational parts periodically say for every 15days.
2. Do not run the equipment if the voltage is below 180V.
3. Do not leave the load to the maximum.
4. Check all the electrical connections before running.
5. Before starting and after finishing the experiment the main control valve should be in closed position.
6. Do not attempt to alter the equipment as this may cause damage to the whole system.

THICK / THIN WALL CYLINDER

INTRODUCTION:

In relation to stress analysis, cylinders are divided into two groups: thick and thin. The distinction between the two relates to the ratio of internal diameter to wall thickness of particular cylinder. A cylinder with a diameter to thickness ratio of more than 20 is considered to be thin. A ratio of lee than 20 is considered to be thick. This distinction is made qas the analysis of a cylinder can be simplified by assuming it is thin.

Thin cylinders or shells are common place in engineering.

Examples of thin walled cylinders are:

- Pressure pipes,
- Aircraft fuselages and
- Compressed gas containers.

Thick walled cylinders are less common, an example being a gun barrel.

For a closed cylinder with an internal pressure there can be three direct stresses acting upon it.

- **Longitudinal stress**- the cylinders resistance to stretching a long its length (axis).
- **Hoop or circumferential stress**- the cylinders resistance to grow in diameter.
- **Radial stress**: gas or fluid compressing there walls of the cylinder. It is equal to the pressure on the inside and zero on the outside.

The longitudinal stress and hoop stresses are directly proportional to the pressure and the ratio of diameter to thickness of the cylinder. However the radial stress is related to the pressure alone.

Because of their relationship to the geometry, the Longitudinal and Hoop stresses are far greater and more significant than the radial stress in a thin cylinder. It is reasonable and recognized to assume that the radial stress is small enough for it to be ignored for basic calculations.

DESCRIPTION OF APPARETUS

The Apparatus consists of:

1. CYLINDER of thickness mm and 100mm diameter made of SS304 material. (t/D ratio of 1/50).
2. Drain value and Pressure gauge fitting option is provided on the cylinder.
3. Cylinder is mounted between the studs with End plates for good aesthetic looks.
4. Gauging has being done on Longitudinal and Circumferential plane to measure the strain in their respective directions.
5. Pressure gauge is provided to measure the pressure exerted on the system.
6. Hydraulic Hand pump is provided to create the required pressure in the cylinder.
7. Digital strain Indicator is provided to measure the strains at different positions.
8. The whole setup is mounted on the table frame for easy and better operation.

EXPERIMENTATION:

AIM:

The experiment is conducted to

- Determine the **CIRCUMFERENTIAL AND LONGITUDINAL strain** at different Pressure condition.
- Also, Compare the calculated values with the obtained values.

PRESSURE

1. Fill clean water in the Hydraulic Hand pump.
2. Fix the connecter of the pump to the pressure vessel or cylinder provided.
3. Provide necessary electrical connection (230 V 1ph 5Amps with neutral and earthing) to the indicator provided.
4. Now on the digital Multi-strain indicator set the display knob (right hand side of the display) to first position and set to zero using zero adjustment knob (below the display).
5. Similarly do the above setup for the second position.
6. Now, using the Hand pump provided load the vessel/cylinder.
7. Set the pressure by noting the value on the pressure gauge.
8. Note the strain reading at the Longitudinal and circumferential positions from the indicator and display knob.
9. Repeat steps 6 & 8 until loaded maximum. (25 kg/cm^2)
10. Once completed release the drain so the pressure inside the cylinder reduces to zero.

CALCULATIONS

NOMENCLATURE USED:

P =Pressure measured in kg/cm^2

D =Mean Diameter of the cylinder = 102mm

L = Length of the Cylinder =500mm

σ_D= Circumferenctial or Hoop's stress, Mpa

σ_L =Longitudinal Stress, Mpa

γ =Poisson's ratio = 0.305 for SS304 material.

E = Youngs modulus, Gpa

t =Thickness of the cylinder = 2mm

TABULATIONS:

SL No.	Pressure on the cylinder		Micro Strain	
	Kg/cm^2	Mpa	Longitudinal	Circumferential

CALCULATIONS:

1. **HOOP'S STRESS OF CIRCUMFERENTIAL STRESS,**

$$\sigma_D = \frac{P\,D}{2t} Mpa$$

2. **LONGITUDINAL STRESS,**

$$\sigma_L = \frac{P\,D}{4t} Mpa$$

3.CALCULATED STRAIN ALONG THE CIRCUMFERENCE,

Calculated $\mathcal{E}_D = \frac{(P\,D)*(2-\gamma)}{4\,t\,E}\ \mu\mathcal{E}$

4. **CALCULATED STARIN ALONG THE LONGITUDE**

Calculated $\mathcal{E}_L = \frac{(P\,D)*\ (1-2\gamma)}{4\,t\,E}\ \mu\mathcal{E}$

TABULAR COLUMN

Sl No	Pressure on the cylinder		Micro Strain			
	Kg/ Cm^2	Mpa	Longitudinal		Circumference	
			Measured	Calculated	Measured	Calculated

Sl No	Pressure on the cylinder		Stress, Mpa	
	Kg/Cm^2	Mpa	Longitudinal	Circumference

PRECAUTIONS

1) Clean the water tank regularly, say for every 15days.
2) Do not run the equipment if the voltage is below 180V.
3) Check all the electrical connections before running.
4) Before starting and after finishing the experiment the main control valve should be in close position.
5) Do not attempt to alter the equipment as this may cause damage to the whole system.

DETERMINATION OF FLEXURAL STRESS AND STRAIN OF A SIMPLY SUPPORTED BEAM

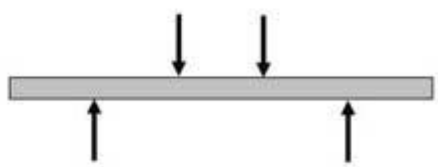
Aim: To determine the flexural stress and strain of a simply supported beam subjected to four point loading.

Apparatus: Simply supported beam setup, Work piece, and loads

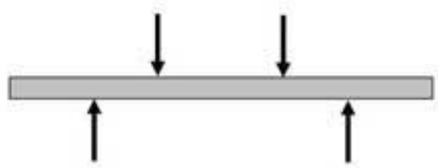
Theory: A simply supported beam is a type of beam that has pinned support at one end and roller support at other end. Depending on the type of the load applied, it undergoes shearing and bending. The following is the beam which illustrates simply support conditions.

Simply Supported Beam

the above beam is subjected to a four point loading as shown in the figure to find out the flexural stress and flexural strain in the beam element when subjected to loading.



Loading Span equals 1/3 of Support Span



Loading Span equals 1/2 of Support Span

Procedure

1. The beam has to be placed on the two supports provided (roller and pinned)
2. Measure the geometric properties length, breadth and width of the beam
3. Apply the loads at the both ends with different loading conditions.
4. Measure the reading in dial gauge
5. Find the flexural modulus and flexural stress and flexural strain of the beam

Formulae

$$E_{\text{bend}} = \frac{L^3 F}{4wh^3 d}$$

$$\sigma_f = \frac{3FL}{4bd^2}$$

Readings

S.NO	Load(F) KN	E_{Bend}	σ_f

Result: