INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal, Hyderabad – 500043

COURSE CONTENT

AEROSPACE STRUCTURES LABORATORY							
IV Semester: AE							
Course Code	**Category**	**Hours / Week**		**Credits**	**Maximum Marks**		
AAEC11	CORE	L	T	P	C	CIA	SEE	Total

Course Code	Category	L	T	P	C	CIA	SEE	Total
AAEC11	CORE	-	-	3	1.5	30	70	100

Contact Classes: Nil	Tutorial Classes: Nil	Practical Classes: 45	Total Classes: 45
Prerequisite: Mechanics of Solids			

I. COURSE OVERVIEW:

Analytical tools are introduced in the course from an engineering standpoint. The course emphasizes the significance of aircraft structures while attempting to provide a foundational understanding of analytical techniques. By encouraging undergraduate students to work on projects related to the structural analysis of thin-walled structural components, wings, fuselage, and landing gears, aircraft structural laboratories are utilized to improve student learning.

II. COURSES OBJECTIVES:

The students will try to learn:

I. The basic knowledge on the mechanical behaviour of materials like aluminium, mild steel, and cast iron.
II. The crack detection using various NDT methods and also discuss the changing strength due to these defects.
III. The concept of locating the shear centre for open and closed sections of beams.
IV. Buckling strength of both long and short columns using different elastic supports

III. COURSE OUTCOMES:

After successful completion of the course, students should be able to:

CO1   Use the amount of load for stress and strain to illustrate the characteristics of materials subjected to tensile loads in engineering applications.

CO2   Examine the purpose of aerospace structural design, to illustrate the deflections of beams subjected to transverse loads under various end circumstances.

CO3   Utilize the Beam test rig and apply Maxwell's reciprocal theorem to simplify the analysis through symmetry.

CO4   Inspect the crucial buckling loads of columns that are subjected to compression loads so that constructions can be designed efficiently under a range of end circumstances.

CO5   Determine which columns in the South-well plot are subject to axial loads in order to determine the critical loads.

CO6   Make use of a beam's asymmetrical bending behavior in terms of aerospace structure design.

EXERCISES FOR AEROSPACE STRUCTURES LABORATORY

1. Getting Started with Exercises

Introduction

The goal of this course is to familiarise students with current tools and methods while giving them the chance to conduct two subject experiments pertaining to solid and structural mechanics. The intention is to provide an illustration of how typical materials behave and how structural combinations used in aerospace applications work.

Data Recording and reports

Students must record their experimental values in the provided tables in this laboratory manual and reproduce them in the lab reports. Reports are integral to recording the methodology and results of an experiment. In engineering practice, the laboratory notebook serves as an invaluable reference to the technique used in the lab and is essential when trying to duplicate a result or write a report. Therefore, it is important to learn to keep accurate data. Make plots of data and sketches when these are appropriate in the recording and analysis of observations. Note that the data collected will be an accurate and permanent record of the data obtained during the experiment and the analysis of the results.

1.1 Aircraft Wings

Study about the Aircraft Wings

  I.   A wing is a kind of fin that moves through fluids such as air by creating lift.

  II.   As a result, wings have streamlined cross sections that function as airfoils when subjected to aerodynamic forces.

  III. A wing's lift-to-drag ratio indicates how aerodynamically efficient it is.

  IV. One to two orders of magnitude more lift can be produced by a wing at a given speed and angle of attack than total drag.

  V.   A high lift-to-drag ratio means that a much smaller effort is needed to get the wings airborne at a sufficient lift.

Fig. 1.1: Aircraft wing's cut out

Try

1. Scrutinize the ribs and assessing their structural integrity, aerodynamic features, and overall condition to ensure optimal performance and safety as shown in Fig.1.1.

2. Examine the spars and conducting a detailed inspection for their structural integrity.
3. Investigate the assembly of the webs and stringers in an aircraft wing.

1.2 Landing Gears

Investigation of Landing Gears

- Landing gear is located under the belly of the plane consisting of a wheel and strut to soften impact with the ground and may be retractable into the fuselage. Tricycle type wheels are common for general aviation with one wheel at the front and two behind or the reverse for tailwheels with two wheels at the front of the plane and one under the tail as shown in Fig. 1.2.1.
- All parts of an airplane are crucial for conducting safe flight. Pilots' huge responsibility is ensuring all aircraft components are in excellent condition before embarking on their flight journey.
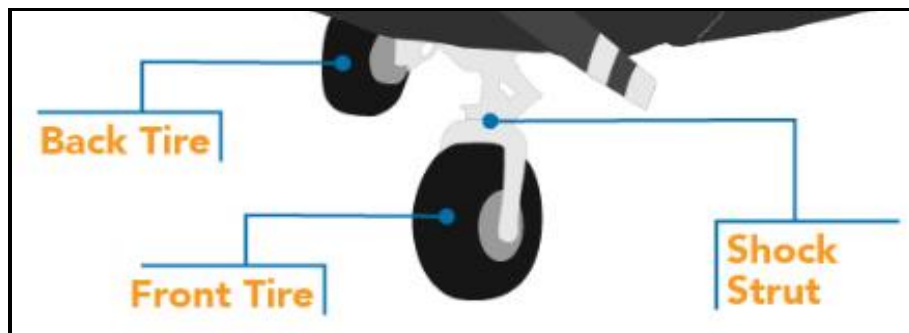- Actual landing of an aircraft is shown in Fig. 1.2.2.

Fig. 1.2.1: Landing gear

Fig. 1.2.2: Landing gear of an actual aircraft

Try
1. Scrutinize the landing gear of mechanism and assess their structural integrity.
2. Examine the landing gear of fighter jet and conducting a detailed inspection of assembly of landing gear.

2. VERIFICATION OF MAXWELL'S RECIPROCAL THEOREM

2.1 Maxwell's Reciprocal Theorem

I. Determine the deflection of a simply supported beam by keeping load at point 1 and finding the deflection at point 2 as shown in Fig. 2.1.
II. Determine the deflection by keeping load at point 2 and find the deflection at point.
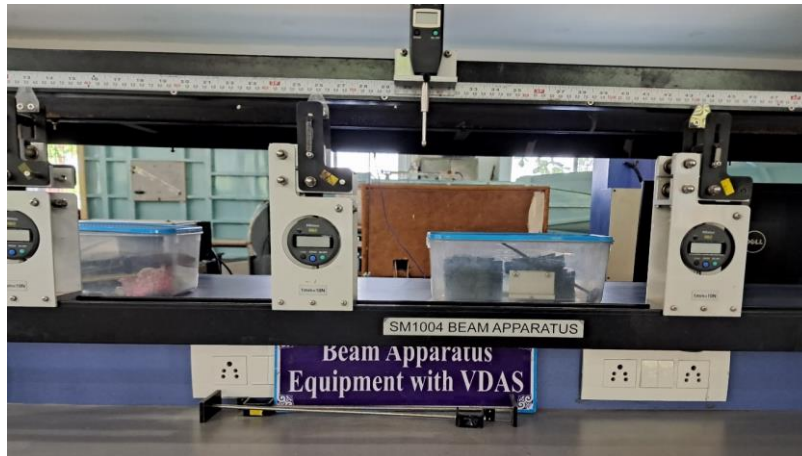III. Compare the deflection for both the cases.

Fig. 2.1: Beam apparatus

Try

1. Find the deflection at point C (L/4) due to unit load at point D (3L/4).
2. Find the deflection at point D (3L/4) due to unit load at point C (L/4).
3. Compare the deflection values for at both C and D.
4. Perform the experiments across a range of diverse loads, systematically analyze and assess the effects of varying conditions.

3. BUCKLING TEST

3.1 Determine the critical buckling loads by compression tests on long columns

I. Determine the critical buckling load for a long column with the help of buckling of struts equipment as shown in Fig. 3.1.
II. Determine the deflection by applying the various loads on a long column.

Fig. 3.1: Loading and buckling of struts equipment

Try

1. Determine the critical buckling of strut at the open lever condition.
2. Find the critical buckling of strut at closed lever condition.
3. Compare the open and closed lever condition and analyze the results.

4. COMPRESSION TEST

4.1 Determine the critical buckling loads, Southwell plot by compression tests on short columns

I. Determine the critical buckling load for a short column with the help of buckling of struts

equipment as shown in Fig. 4.1.

II. Determine the deflection by applying the various loads on a short column.

III. Draw the Southwell plot, load versus deflection.

Fig. 4.1: Loading and buckling of struts equipment for compression test

Try

1. Explore the critical buckling of strut at the open lever condition.
2. Find the critical buckling of strut at closed lever condition.
3. Compare the open and closed lever condition and analyze the results.

5. BENDING TEST

5.1 Determine the unsymmetrical bending of a beam

I. Determine the unsymmetrical bending of a given open section beam by using the apparatus shown in Fig. 5.1.

II. Determine the unsymmetrical bending of a given closed section beam by using the apparatus shown in Fig. 5.1.

III. Find the unsymmetrical bending of an open section beam by changing the eccentricity.

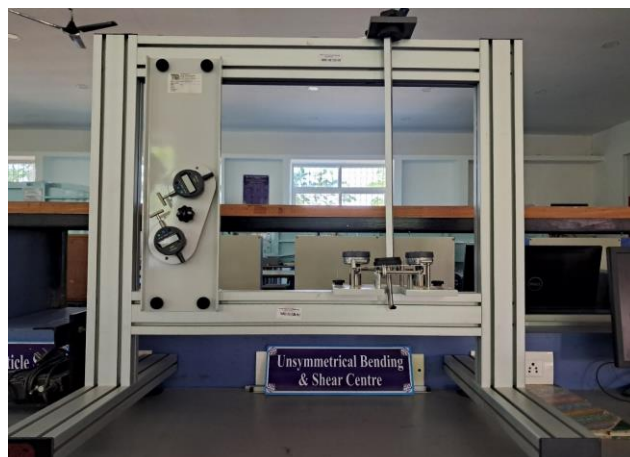IV. Find the unsymmetrical bending of a closed section beam by changing the eccentricity.

Fig. 5.1: Apparatus required for the unsymmetrical bending test

Try

1. Conduct a thorough analysis on the asymmetric bending characteristics exhibited by an open section (L Shape).
2. Determine the unsymmetrical bending of channel section (C Shape).
3. Perform the unsymmetrical bending characteristics exhibited by rectangular section.

6. SHEAR CENTRE FOR OPEN SECTION

6.1 Determination of shear centre of an open section beam

I. Determine the shear centre of a given open section beam by using the apparatus shown in Fig. 6.1.

II. Find the shear centre of an open section beam by changing the eccentricity.

Fig. 6.1: Equipment for determination of shear centre of an open section beam

Try

1. Find the shear centre of an open section beam L shape configuration.
2. Determine the shear centre of an open section beam I-shape configuration.
3. Compare the shear centre values of a L and I shape configurations and examine the results.

7. SHEAR CENTRE FOR CLOSED SECTION

7.1 Determination of shear centre of a closed section

I. Determine the shear centre of a given closed section beam by using the apparatus shown in Fig. 7.1.

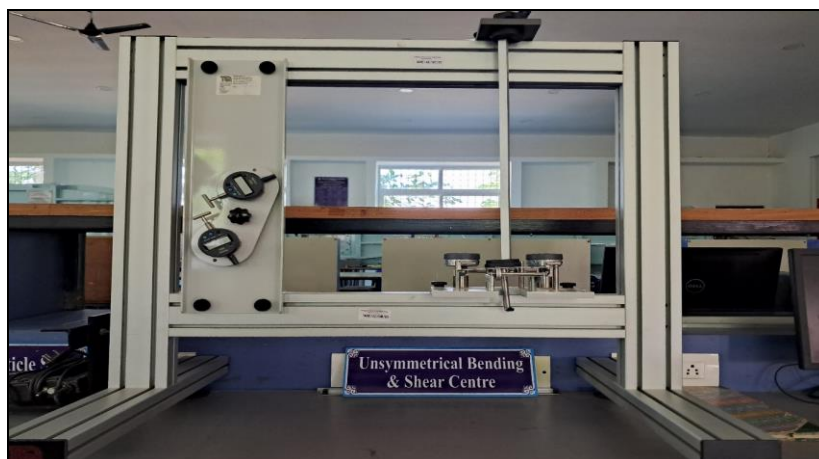II. Find the shear centre of a closed section beam by changing the eccentricity.

Fig. 7.1: Equipment for determination of shear centre of a closed section beam

Try

1. Find the shear centre of closed section beam hollow pipe configuration.
2. Determine the shear centre of closed section beam solid circular pipe configuration.
3. Determine the shear centre of closed section beam of square shape.
4. Investigate the shear centre of wood circular rod and compare the results with others.

8. SHEAR STRESS OF RIVETED JOINTS

8.1 Determine the shear strength of riveted joint (double riveted Zig-Zag lap joint) between two given metals

I. Determine the shear strength of a riveted joint as shown in Fig.8.1 using the Universal Testing Machine (UTM) machine as given in Fig. 8.2.

II. Consider d_2 as diameter of the rivet, apply the shear stress S_s and measure the strength of the rivet.

III. The rivet shearing: The rivet might shear as the figure illustrates in Fig 8.1. The joint's maximal force tolerance to stop this failure is:

$P^2 = S_s*((\pi/4) *d_2$ for lap joint
$P^2 = 2S_s*((\pi/4) *d_2$ for single strap butt joint

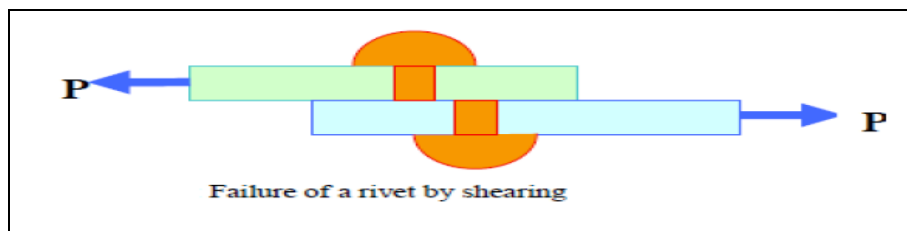Where S_s=allowable shear stress of the rivet material

Fig. 8.1: Riveted joint

Fig. 8.2: UTM machine for finding shear stress

Try
1. Determine the shear strength of the riveted triple joint between two given metals.
2. Explore the shear strength of the Lap joint.
3. Assess the shear strength of a riveted double joint connecting two dissimilar-sized metals.

9. SANDWICH PANEL TENSION TEST (Composite Materials)

9.1 Fabricate and determine the young's modulus of Sandwich Panel (Composite Materials)

I. Fabricate the Sandwich panel by using composite material.

II. Determine the young's modulus of the Sandwich panel by using the UTM machine as shown in Fig. 9.1.

Fig. 9.1: UTM Machine for finding young's modulus

Try

1. Fabricate the sandwich panel with inner material of wooden fiber.
2. Find the strain in the laminated sandwich panel.
3. Determine the Young's Modulus of the laminated sandwich panel.
4. Fabricate the sandwich panel with different materials and find the strain and Young's Modulus of the composite.

10. NON-DESTRUCTIVE TESTING (Dye-Penetration Method)

10.1 Dye penetration test

I. Find the crack propagated in the given specimen by using the Dye Penetrant Test and Setup shown in Fig. 10.1 & 10.2.

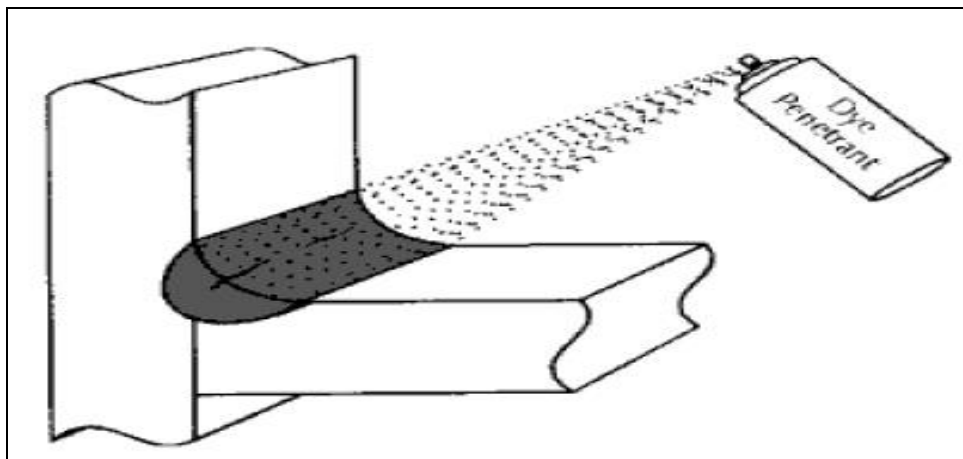II. Inspect the surface crack in the given specimen by using the Dye Penetrant Test.

Fig. 10.1: Dye Penetrant Test

Fig. 10.2: Dye Penetrant Test Setup

Try
1. Examine the components of a fighter jet aircraft to identify the onset of initial cracks.
2. Inspect the cracks with non-destructive test for a landing gear.
3. Investigate the propagating cracks in an airframe.
4. Investigate the solid V and T shaped specimen for finding the cracks.

11. NON-DESTRUCTIVE TESTING (Magnetic particle inspection)

11.1 Detect the flaws in the given specimen by conducting non-destructive testing procedures using magnetic particle inspection

I. Inspect the given specimen and find if any cracks are present by using Magnetic Particle Inspection (MPI) Test shown in Fig. 10.1.

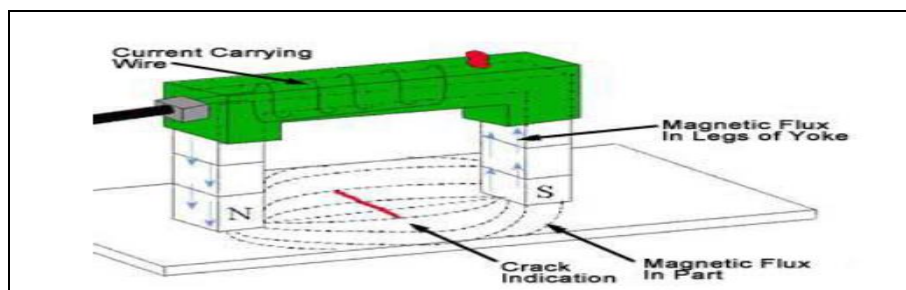II. Identify the growth of the cracks by using Magnetic Particle Inspection (MPI) Test setup shown in Fig. 10.2.

Fig. 11.1: MPI Test

Fig. 11.2: MPI Test Setups

Try
1. Scrutinize the components of a fighter jet aircraft to identify the onset of initial cracks.
2. Check the cracks with non-destructive test for a landing gear.
3. Investigate the propagating cracks in an airframe.
4. Explore the solid V and T shaped specimen for finding the cracks.

12. NON-DESTRUCTIVE TESTING (Ultrasonic techniques)

12.1 Non-destructive test using ultrasonic test

I. Take the given specimen and match with the C.R.T screen.
II. Find out the position of flaw using transducer as shown in Fig. 12.1.

Fig.12.1: Ultrasonic Test

Try

1. Observe the components of a fighter jet aircraft to identify the onset of initial cracks.
2. Examine the cracks with non-destructive test for a landing gear.
3. Inspect the propagating cracks in an airframe.
4. Explore the solid V and T shaped specimen for finding the cracks.

13. VIBRATION TEST

13.1 Determine of natural frequency of beams under free and forced vibration

I. Determine the natural frequency of beam under free vibration as shown in Fig.13.1.
II. Find the natural frequency of a beam by applying the force by the hammer as shown in Fig.13.2.
III. By using the trigger as shown in Fig.13.3, find the natural frequency of a beam.

Fig. 13.1: Showing Initial Set-up

Fig 13.2: Showing impact loading with hammer

Fig 13.3: Showing impact loading with trigger

Try
1. Determine the natural frequency 10, 100, 1000Hz under free vibration with hammer.
2. Find the natural frequency 10, 100, 1000Hz under free vibration with trigger.
3. Examine the natural frequency 10, 100, 1000Hz under forced vibration with trigger.
4. Assess the natural frequency 10, 100, 1000Hz under forced vibration with hammer.

14. AIRFRAMES

14.1 Investigation of aircrafts parts like fuselages, cockpit, engine, propeller

Fuselages: The plane's body, or fuselage, holds the aircraft together, with pilots sitting at the front of the fuselage, passengers and cargo in the back.

Cockpit: The cockpit is the area at the front of the fuselage from which a pilot operates the plane. The cockpit contains the:
- Instrument panel: This is similar to a car's dashboard, providing the pilot with information about the flight, the engine and the circumstances of the aircraft. Depending on the aviation electronics (avionics) installed in an aircraft this may be on an interactive screen or using the typical '6 Pack' for key pieces of information.
- Flight controls: In the cockpit are two seats, one for the pilot and the other for the co-pilot.
- Pilot seats: In the cockpit are two seats, one for the pilot and the other for the co-pilot.
- Rudder pedals: Rudder pedals control yaw in flight and are used for steering on the ground during a taxi.
- Overhead panel: The overhead panel contains aircraft systems, such as air conditioning, electrical, fuel and hydraulics.
- Side consoles: Side consoles are for communication instruments and documentation, depending on the aircraft.

Engine: The engine(s), or powerplant, of an aircraft creates thrust needed for the plane to fly.

Propeller: An aircraft's propeller(s) are airfoils, similar to a wing, installed vertically to create thrust to drive the plane forward. Attached to the engine, they spin quickly, creating lift from the pressure difference they create, only instead of this lift causing the plane to move upwards, it drives the plane forward creating thrust. This thrust and forward motion in turn causes air to pass over the wings, creating the vertical lift.

Airframe containing aircraft parts like fuselages, cockpit, engine, propeller is shown in Fig. 14.1.

Fig. 14.1: Airframe

Try

1. Visualize the assembly of the propeller and wing.
2. Scrutinize the empennage of the aircraft.
3. Study the fuselage and wing interaction and assembly.
4. Examine the engine configuration of the Rollce-Royce.

V. TEXTBOOKS:

1. R.K Bansal, Strength of Materials., Laxmi publications, 5th edition, 2012.
2. T. H. G. Megson, Aircraft Structures for Engineering Students., Butterworth-Heinemann Ltd, 5th edition, 2012.
3. Gere, Timoshenko, Mechanics of Materials., McGraw Hill, 3rd edition,1993.

VI. REFERENCE BOOKS:

1. Peery, D.J. and Azar, J.J., "Aircraft Structures", McGraw-Hill, 2nd edition,1982, ISBN0-07-049196-8.
2. Bruhn.E.H, "Analysis and Design of Flight Vehicles Structures", Tri-state Off-set Company, USA, 1965.
3. Lakshmi Narasaiah, G., "Aircraft Structures", BS Publications, 2010.

VII. ELECTRONICS RESOURCES:

1. https://akanksha.iare.ac.in/index?route=course/details&course_id=1645.

VIII. MATERIALS ONLINE

1. Course Template
2. Laboratory Manual