

Unit - V Stress Analysis of wing & fuselage.

Procedure - Shear and bending moment distribution of Semicantilever and other types of wings and fuselage. Thin walled beams with Parallel and non-parallel flanges, Shear resistant, web beams, Thin field beam (Wagner beam).

FAQ(Unit - V)

1. List out the various components of a typical wing structures and explain the use of each component. Draw Shear force and bending moment diagram of cantilever beam with UDL.
2. Write short notes on.
 1. Semi monocoque structure.
 2. Bulk heads.
 3. List three functions of fuselage.
 4. Three functions of rear spar.
 5. Semi tension field beam.
 6. Advantage of Semicantilever type wing.
3. Thin walled beams with parallel & non-parallel flanges
 - (i) Wagner beam.
4. loads acting on structural components and functions of structural components (Megson book).
5. Structural idealization (Megson book).

Unit - W

1. Needham and Gerard's method.
2. Buckling of thin plates.
3. Write short notes on
 1. Effective width.
 2. Inter rivet buckling
 3. Sheet wrinkling failures.
- A. Critical strength, compressive load problems.

[Refer ^{also} the _{1 2} Question papers attached here with)

Beams with Parallel Flanges!-

Wagner has developed eqns for the condition where stiffeners are placed @ an angle with parallel flange members.
Yield strength

$$V_{ty} = \left(F_{ty} - \frac{F_{scr}}{k_r} \right) k_r R_{ht} \cos \alpha \sin \alpha$$

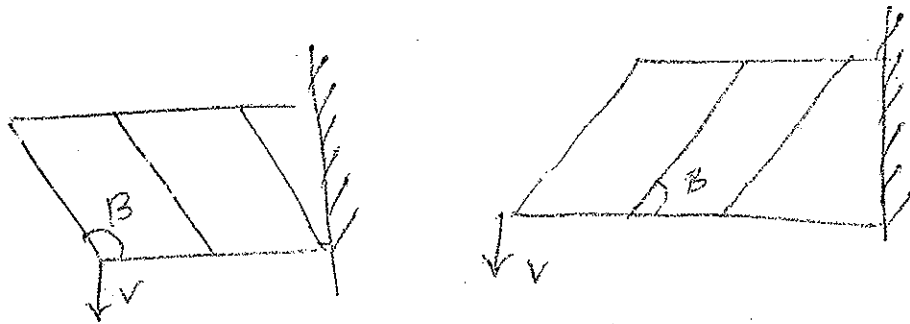
ultimate

$$V_{tu} = \left(F_{tu} - \frac{F_{scr}}{k_r} \right) k_r R_{ht} \cos \alpha \sin \alpha$$

the above eqn multiplied by $(1 - \tan \alpha \cot \beta)$
where β - upright angle.

$$V_{ty} = \frac{1}{2} \left(F_{ty} - \frac{F_{scr}}{k_r} \right) k_r h t \frac{1 - \cos \beta}{\sin \beta}$$

$$V_{tu} = \frac{1}{2} \left(F_{tu} - \frac{F_{scr}}{k_r} \right) k_r h t \frac{1 - \cos \beta}{\sin \beta}$$



Rivet load @ web buckling stress!-

$$P_{scr} = \frac{V_{cr} I_f}{h t}$$

where load on to
 P_{scr} = rivet let flange
 V_{cr} = buckling shear stress
 I_f = m.o.I of flange
 I = m.o.I of total beam

Beams with Non-parallel Flanges :-

In many cases the flanges are not parallel, but have a slight taper.

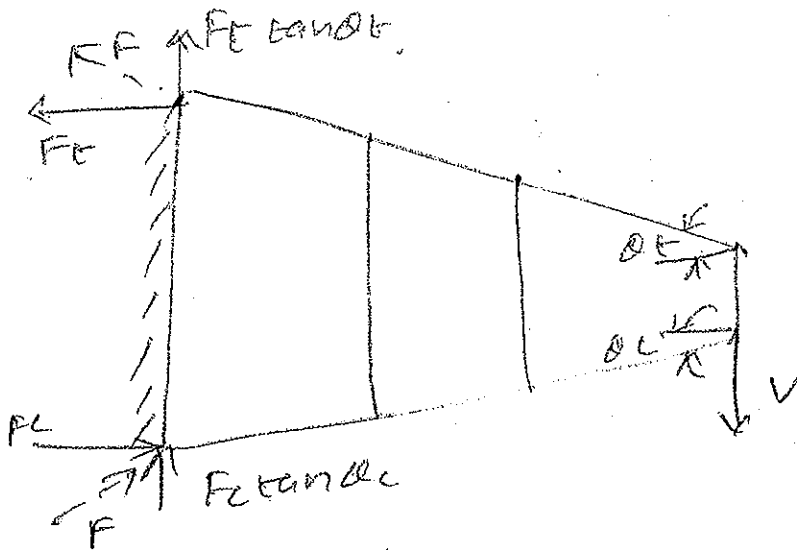
Total Flange forces & their vertical components can be computed from the horizontal components & slope of flanges.

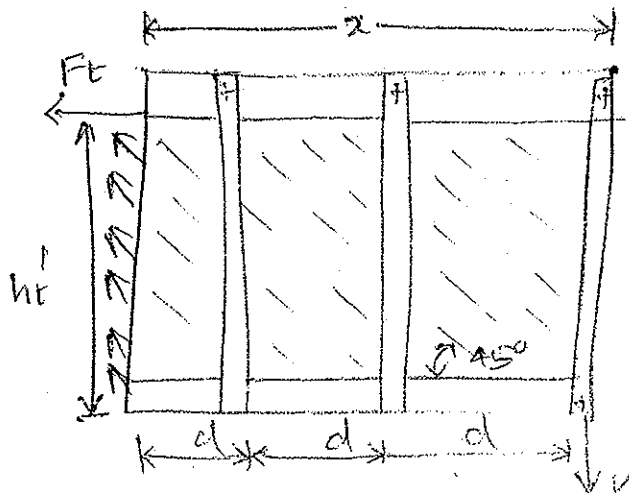
Net web shear load

$$V_{Wn} = V_w - (F_t \tan \alpha_t + F_c \tan \alpha_c)$$

V_{Wn} = net web shear for Non parallel

V_w = web shear for parallel.





Taking moments about P & B.

$$\sum M_B = M_{OL} - F_c h' - f_c \cos 45^\circ h' \cdot \frac{h'}{2} - \cos 45^\circ \frac{h'}{2} = 0$$

$$f_c = 2f_s$$

$$f_c = \frac{V}{h'} \quad \therefore f_c = \frac{2V}{h'}$$

$$M_{OL} - \frac{2V}{h'} h' - \frac{2V}{h'} \times \frac{1}{\sqrt{2}} h' \times \frac{1}{\sqrt{2}} \frac{h'}{2} = 0$$

$$M_{OL} + F_c h' - \frac{V h'}{2} = 0$$

$$F_c = \frac{M_{OL}}{h'} + \frac{V}{2}$$

Similarly

($\sum H = 0$ on section AB)

$$F_c = \frac{M_{OL}}{h'} + \frac{V}{2}$$

General Wagner Equations

Diagonal tensile stress in web

$$f_t = \frac{2V}{ht} \frac{1}{\sin 2\alpha}$$

axial load in tension flange

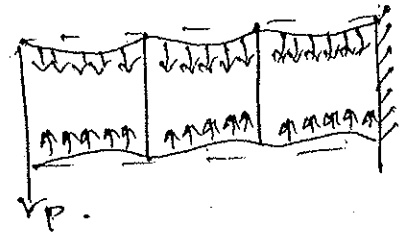
$$F_t = \frac{M}{h'} - \frac{V}{2} \cot \alpha$$

axial load in compression flange

$$F_c = \frac{M}{h'} + \frac{V}{2} \cot \alpha$$

Axial force in stiffeners

$$F_{stiff} = -v \frac{d}{n} \tan \alpha$$



where v - applied shear load

h - distance between centroids of flange rivets.

h' - dist between centroids of flange section

d - vertical web stiffener spacing.

α - angle of web buckle.

The stress ratio factor equation

$$w_d = 1.25 d \sin \alpha \sqrt{\frac{F}{(I_t + I_c) h}}$$

E_t, I_c - m.o.I @ upper & lower

web angle

$$\alpha = 1 + \frac{hb}{A_c + A_u}$$



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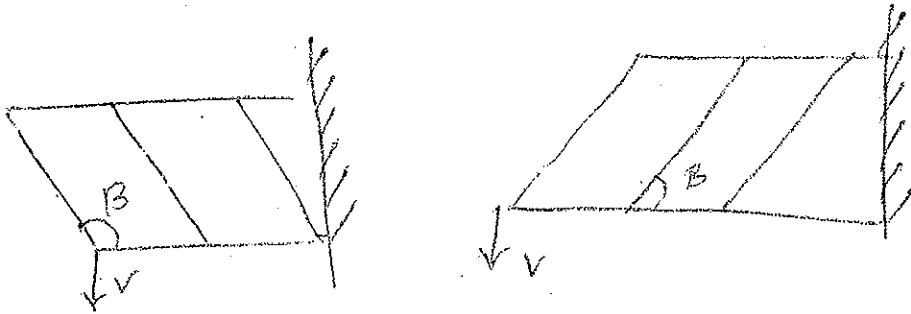
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Beams with Non-parallel Flanges

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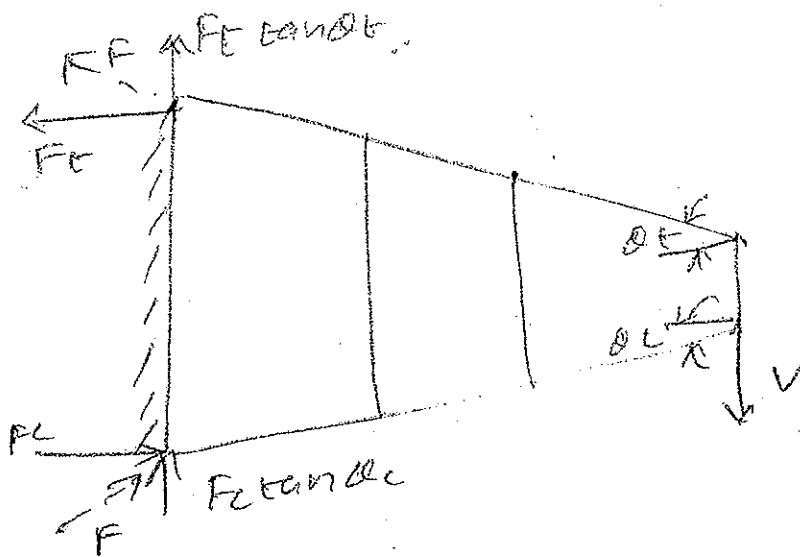
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Net web shear load

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V_{Wn} = net web shear for Non parallel

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1) Von Karman's effective width.

In this method, when F_{cr} was equal to the yield stress of the material. Since experiments had shown that the material ultimate strength of a sheet simply supported at the edges was independent of the width of the sheet.

$$F_{cr} = \frac{K C \pi^2 E}{12(1-\nu^2)} \left(\frac{t}{b}\right)^2$$

instead of (b) we put width w .

$$F_{cr} = F_{cy}$$

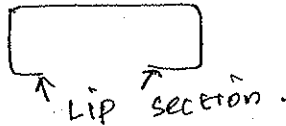
$$F_{cy} = -360E (t/w)^2.$$

$$K C = 4; \nu = -0.3$$

where, $w = 1.905 \sqrt{E/F_{cy}}$.

2) Lip:-

Lip section is sufficiently large enough to provide a simple support to the adjacent plate element. It is used to increase the value of coefficient, and it produce a more coefficient load carrying element.



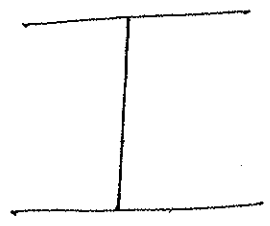
3) Monocoque & semimonocoque:-

The basic functions of an aircraft's structure are to transmit and resist the applied loads to provide an aerodynamic shape. These requirements in most a/c, result in thin shell structures where the outer surface or skin of shell is usually supported by longitudinal stiffening members to enable it to resist bending, compressive & torsional loads without buckling. Such structures are known as semi-monocoque while thin shells which rely entirely on their skins for their capacity to resist loads are referred to as monocoque.

4) Semi tension Field beam

The development of a structure in which buckling of the webs is permitted with the shear loads being carried by diagonal tension stresses in the web is serving example of the departure of the design of aerospace structures from the standard structural design methods in other field of structures, such as beam design for bridges & buildings. The first study & research on this new type of structural design involving diagonal semi tension field action beam.

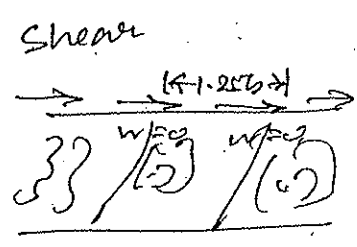
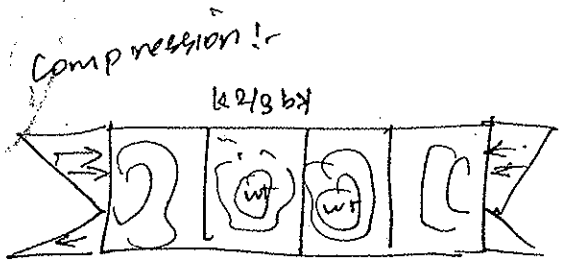
5) Give any one moment of inertia of I section



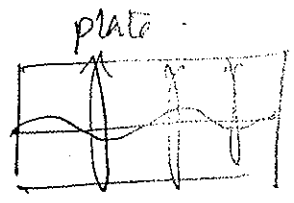
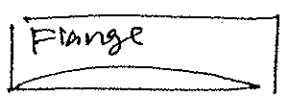
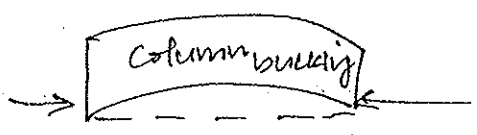
$$I_{yy} = \frac{h t^3}{12} + \frac{t x h^3}{12} \times 2$$

$$I_{yy} = \frac{h t^3}{12} + \frac{t h^3}{6}$$

6) Buckling modes of plate in (a) compression
 (b) shear



Column:-



the axis in its
moment of area of
subjected to any strain
zero stress.

tion

$$u dA = 0$$

in the cross section
with applying shear load
bending deflection.

angle section

tion

across I section

7) Symmetric bending!

- * Plane of loading and plane of bending are same.
- * N.A of beam is \perp to the plane of loading or plane of bending.
- * Plane of bending co-inside with the plane containing principal centroidal axis of cross section of beam.

Unsymmetric bending!

- * Plane of loading does not \parallel to the plane of bending
- * Plane of bending does not lie in plane \parallel to the plane containing the principal centroidal axis
- * The N.A. is not \perp to the plane of bending!

8) Principal axis and give expression to determine them!

There are two axis of an area about given point about which moment of inertia of area have maximum and minimum value & they are \perp to each other.

These axis are taken known as principal axis - (or)

The axes about which the product of second moment of inertia is zero.

$$x_p = y \sin \theta + x \cos \theta$$

$$y_p = y \cos \theta - x \sin \theta$$



11) Effective width:-

It is the equivalent width of panel in which the total strength of uniform stress distribution is taking as uniform stress distribution with same total strength.

12) Semi monocoque structure & name the parts:-

The thin shell structure where the outer surface or skin is usually supported by longitudinal stiffening member and transverse frames to resist bending; compressive and torsional load.

- 1) Longirons
- 2) Bulkhead
- 3) Stringer
- 4) Skin
- 5) Stiffeners.



Thin shell which rely entirely on their skin for their capacity to resist the loads referred to as (monocoque):-

13) Method of finding stresses in unsymmetrical bending:-

In unsymmetrical bending, first the principal stress are known & load is applied through shear centre then, stress can be obtained as follows

$$\sigma_z = \frac{M_x P}{I_{xx}} y_p + \frac{M_y P}{I_{yy}} x_p.$$

14) Distinguish

between strength & stiffness.

* Strength, criteria deals with the direct stress & their action in beam in axial direction.

* Stiffness deals with bending stress and shear loads & their resultant deformations.

15) Explain how a thin beam subjected to shear resists the load :-

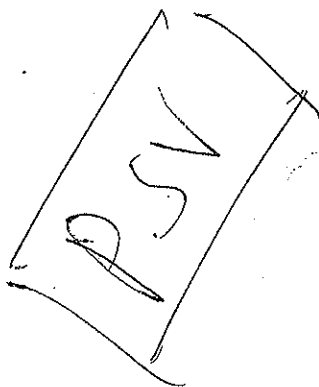
The curved web will resist a high stress buckling than plate web of similar dimension. @ the flat web will carry ultimate load higher than its buckling load. Curved section may collapse entirely buckling load.

16) Ribs :-

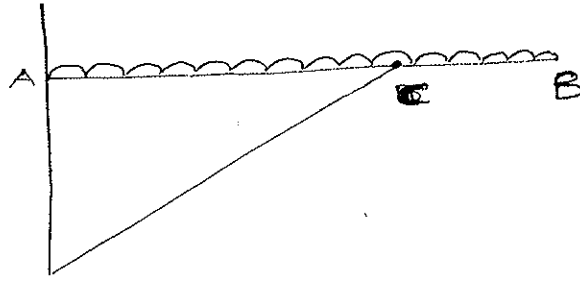
The shape of the wing cross section is maintained by one or transverse frame called ribs. and also named as aerodynamic surfaces.

Used to

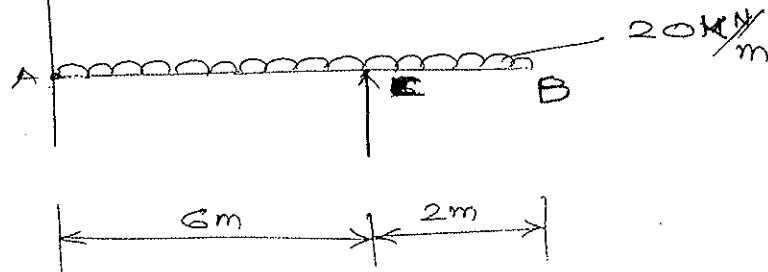
- 1) maintain cross sectional shape
- 2) distribute concentrated load in structure & redistribute stress around discontinuity.



Semi Cantilever Beam - Propped cantilever Beam



Cantilever beam having additional support is called propped cantilever beam.



$$E = 200 \times 10^6 \text{ KN/m}^2 \quad I = 120 \times 10^4 \text{ m}^4$$

Downward deflection at the free end B of the cantilever AB without prop.

$$\delta_{\text{deflection}} = \frac{wl^4}{8EI} = \frac{(20)(8)^4}{8EI} = \frac{20 \times 8^3}{EI} = \frac{10240}{EI}$$

upward deflection at end B of the cantilever beam at B

$$\begin{aligned} \delta_{\text{deflection}} &= \frac{R_c(l^3)}{3EI} + \frac{R_c l^2}{2EI} (l-x) \\ &= \frac{R_c(6^3)}{3EI} + \frac{R_c(6^2)}{2EI} (8-6) \\ &= \frac{108 R_c}{EI} \end{aligned}$$

For having no deflection at the free end B:
Equate the above two deflection.

$$\frac{10240}{EI} = \frac{108 R_c}{EI}$$

$$\therefore R_c = 94.8 \text{ KN}$$

Shear force at B is zero.

Shear force (just before) C

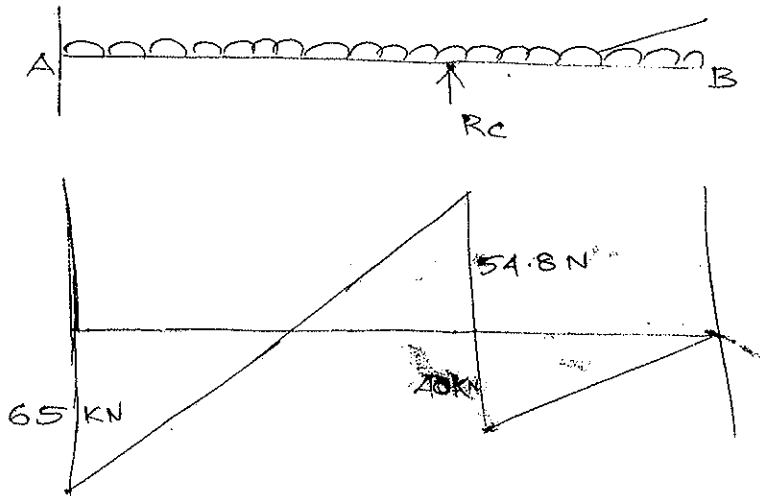
$$\text{is } -20 \times 2 = -40 \text{ KN.}$$

Shear force at support is

$$SF = -20 \times 8 + R_c$$

$$= -160 + 94.8 = 54.8 \text{ KN.}$$

$$R_A = +160 - 95 = 65 \text{ KN}$$



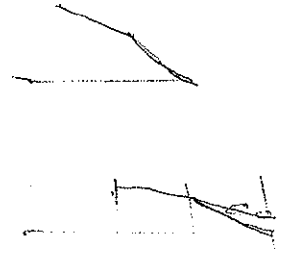
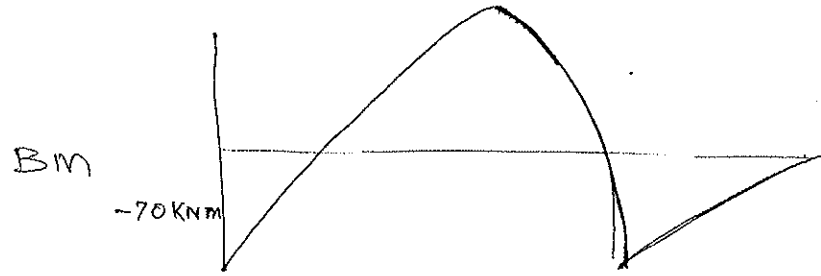
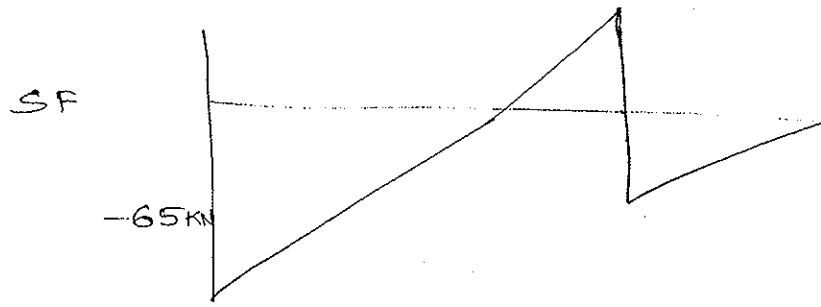
Bending moment B = 0

$$\text{At C} = q \cdot l \cdot \frac{l}{2} = 20 \times 2 \times \frac{2}{2} = -40 \text{ KN}\cdot\text{m}$$

$$\text{At A} = 20 \times 8 \times \frac{8}{2} + R_c \times 6$$

$$= -640 + 568.8$$

$$\Delta L \sim 70 \dots$$



DEPARTMENT OF AERONAUTICAL ENGINEERING

Subject: Aircraft Structures -II

Model Test

Class : B.E.,(Aero) V Semester

Answer all the questions

Part – A (2 X 10 = 20 marks)

1. Explain unsymmetrical bending with examples.
2. Define Neutral axis and Neutral plane.
3. Define shear centre and locate shear centre for channel section.
4. Sketch shear stress variation across depth for an I-Section.
5. State Bredt – batho assumptions.
6. A thin walled circular tube subject to a torque T . Show that $T = 2Aq$, where q is the shear flow and A is the enclosed area.
7. What is a shear resistant web.
8. Explain various methods used to compute the crippling stress.
9. State the advantage of having a semi cantilever type of wing construction.
10. Give examples of monocoque and semi monocoque structure.

Part –B (5 X16 = 80 marks)

11.(a) Compute bending stresses at the points A,B and C of section shown in Fig.1. $M_y = 5000$ Nmm and $M_x = 0$ Nmm. All dimensions are in mm. Thickness is uniform and the moment applied about centroidal axes x and y .

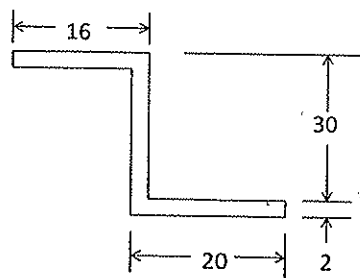


Fig.1

Or

11. (b) Compute bending stresses at the points 1,2,3,4,5,6,7,8 of the section shown in Fig.2. $M_y = 500$ Nmm and $M_x = 100$ Nmm. All dimensions are in mm. Thickness is uniform and the moment applied about

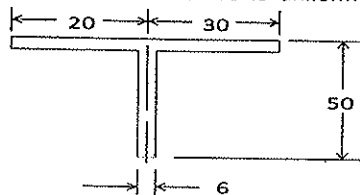


Fig.2

centroidal axes x and y .

12 (a) Determine the shear flow and shear centre for the section shown in Fig.3. The section is subjected to a vertical load of 5000 N.

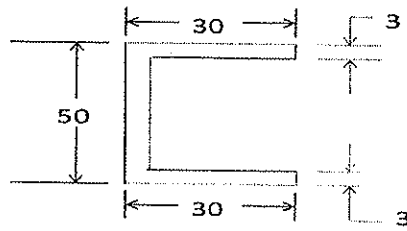


Fig.3

Or

12 (b) Determine the shear flow and shear centre for the section shown in Fig.4

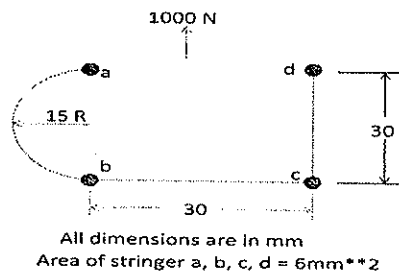


Fig.4

13. (a) Determine the shear flow and shear centre for the section in Fig.5

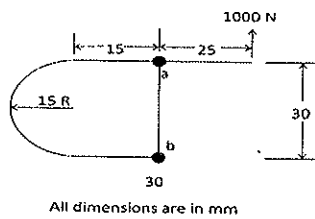


Fig.5

Or

13. (b) Find the shear flow and twist per unit length of the two cell structure shown Fig.6. The material used is Aluminium with $E = 70 \text{ GPa}$ and poisson's ratio = 0.3. Torque is 75 KN-mm in clockwise direction.

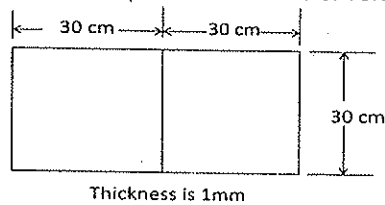


Fig.6

14. (a) Explain the Needham and Gerard method of crippling strength calculation with examples.

Or

14. (b) State the differences between shear resistant web and complete tension field web. What purpose vertical stiffeners serve in case of these webs.

15.(a) List down various components of a typical aircraft wing and explain the use of each component. Draw a shear force and bending moment diagram for semi cantilever beam with Uniform distribution Load.

Or

15. (b) Write short notes on any four of the following.

- i) Semi monocoque structure
- ii) Bulk heads
- iii) List three functions of fuselage bulk head
- iv) List three functions of the rear spar
- v) Semi tension field beam
- vi) Explain the advantage of using semi cantilever type wing.

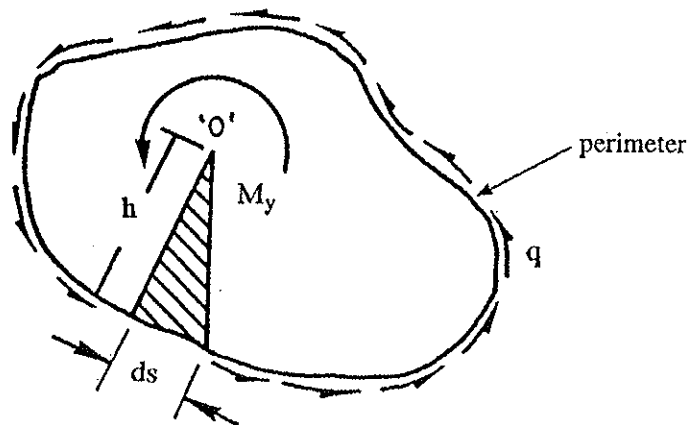


Fig. 8.2.2 Torque around a Closed Section

The moment of the force $q \times ds$ about any arbitrary selected point (reference point 'o') is the product of the force and the moment arm, h . Since the term of $ds \times h$ (segment area) is twice the area of the shaded triangle, and summing all torque and triangles around the section,

$$\text{Torque: } M_y = q \times 2A \quad \text{Eq. 8.2.2}$$

$$\text{or Shear flow: } q = \frac{M_y}{2A} \quad \text{Eq. 8.2.3}$$

where: A – Enclosed area along the entire perimeter

Such a uniform torsional shear flow applied to the end of a closed section structure develops constant reacting shear flows in the full structure identical to those developed in single flat panels by in-plane loads as discussed in Chapter 6.0.

(B) TORSION OF CELLULAR SECTIONS

Analysis of single-cell structures subjected to torsion has already been discussed. They could be analyzed in a straight forward manner by consideration of static load (e.g., equilibrium) alone. With multi-cell sections this is not possible and as in the indeterminate (redundant) structures already discussed, both equilibrium and compatibility have to be considered to develop enough relationships to evaluate all the unknowns (see References 8.6 and 8.7 for further information).

Fig. 8.2.3 shows a cellular section subjected to a torque, M_y . Consider the element a-b-c-d subjected to a shear flow, q , due to the torque. Let δ be the deflection due to the shear flow, and the strain energy stored in the element is given as:

From the strain energy equation:

$$dU = \frac{\text{Force} \times \text{displacement}}{2} = \frac{q \, ds \, \delta}{2}$$

$$\text{Shear strain in element} = \gamma = \frac{\delta}{1.0} = \frac{f_s}{G} \text{ per unit length}$$

where f_s = shear stress due to torsion = $\frac{q}{t}$ (q is shear flow and t is thickness)

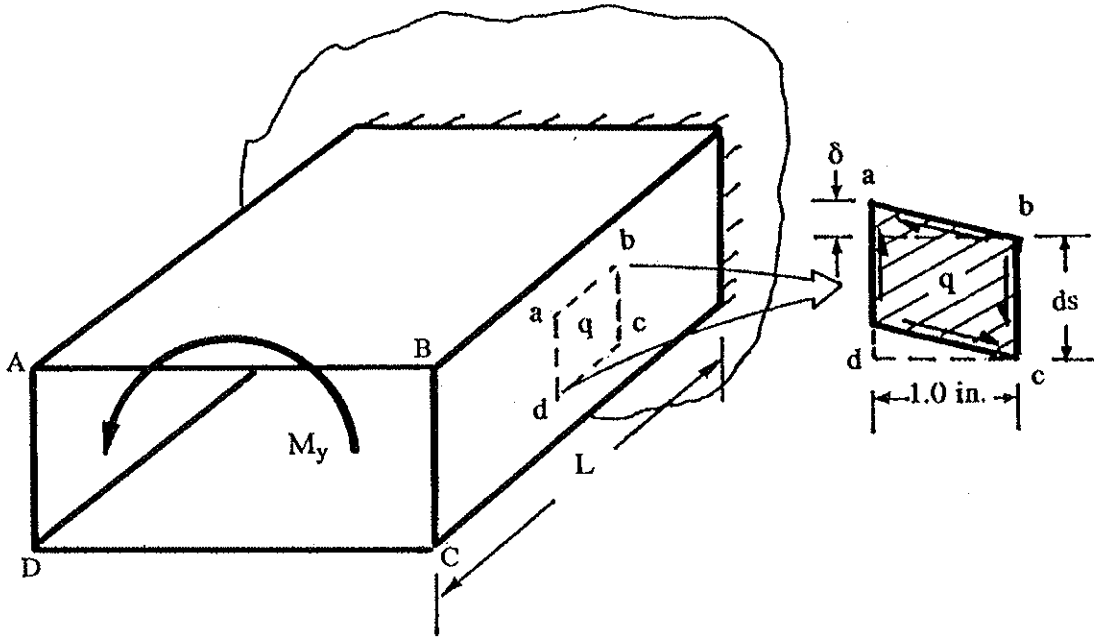


Fig. 8.2.3 Twist of Single Cell

Also $q = \frac{M_y}{2A}$

$$\delta = \frac{f_{is}}{G} = \frac{q}{Gt} = \frac{M_y}{2AGt}$$

where: A = Enclosed area of the box A-B-C-D

Strain energy:

$$\begin{aligned} dU &= \frac{q \delta ds}{2} \\ &= \left(\frac{M_y}{2A}\right) \left(\frac{M_y}{2AGt}\right) \left(\frac{ds}{2}\right) \\ &= \left(\frac{M_y^2}{8A^2Gt}\right) ds \end{aligned}$$

Total strain energy:

$$\begin{aligned} U &= \oint \left(\frac{M_y^2}{8A^2Gt}\right) ds \\ &= \left(\frac{M_y^2}{8A^2G}\right) \oint \frac{ds}{t} \end{aligned}$$

where $\oint \frac{ds}{t}$ is the line integral and is the integral of the expression $\frac{ds}{t}$ around the cell. If web thickness is constant for each wall, $\oint \frac{ds}{t}$ is the summation of the ratio of wall length to wall thickness for the cell.

Using Castigliano's Theorem, the twist angle 'θ' will be obtained by:

$$\begin{aligned} \theta &= \frac{\partial U}{\partial M_y} = \frac{\partial \left(\frac{M_y^2}{8A^2G} \right) \oint \frac{ds}{t}}{\partial M_y} \\ &= \left(\frac{M_y}{4A^2G} \right) \oint \frac{ds}{t} \\ &= \left(\frac{q \cdot 2A}{4A^2G} \right) \oint \frac{ds}{t} \\ &= \left(\frac{1}{2AG} \right) \oint q \frac{ds}{t} \end{aligned}$$

The above expression has been derived from a unit length of the box. The twist over the entire length, L , of the box will therefore be obtained by:

$$\theta = \left(\frac{L}{2AG} \right) \oint q \frac{ds}{t}$$

The above equation can be rewritten for a single section as below:

$$\theta = \left(\frac{L}{2AG} \right) \left(\frac{M_y}{2A} \right) \left(\frac{4A^2}{J} \right) = \frac{M_y L}{GJ}$$

where: $\oint \frac{ds}{t} = \frac{4A^2}{J}$ (From Eq. 6.8.4)

$$q = \frac{M_y}{2A} \quad \text{(From Eq. 8.2.3)}$$

Consider the two cell structure shown in Fig. 8.2.4 and let q_1 be the shear flow on the free walls of cell 1 and q_2 the shear flow for the free walls of cell 2.

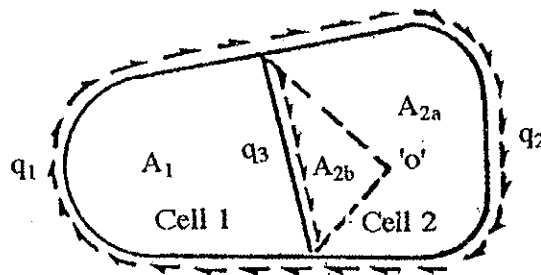


Fig. 8.2.4 Shear Flow Distribution of Two-Cell Box

Torsional moment in terms of internal shear flow:

Taking moment of shear flow about a joining point 'o',

$$\begin{aligned} M_{y,o} &= 2q_1(A_1 + A_{2b}) + 2q_2A_{2a} - 2q_3A_{2b} \\ &= 2q_1A_1 + 2q_1A_{2b} + 2q_2A_{2a} - 2q_3A_{2b} \\ &= 2q_1A_1 + 2q_1A_{2b} + 2q_2A_{2a} - 2(q_1 - q_2)A_{2b} \\ &= 2q_1A_1 + 2q_2A_2 \end{aligned}$$

When a given torque is applied to the multi-cell box beam, consideration of equilibrium requires that

$$M_y = \sum_{i=1}^n (2q_i A_i) \quad \text{Eq. 8.2.4}$$

The moment of internal shears for a multi-cell box structure is equal to the sum of twice the area of each cell multiplied by the shear flow in its free walls.

If q_3 is the shear flow in the common wall, then for equilibrium:

$$q_3 = q_1 - q_2$$

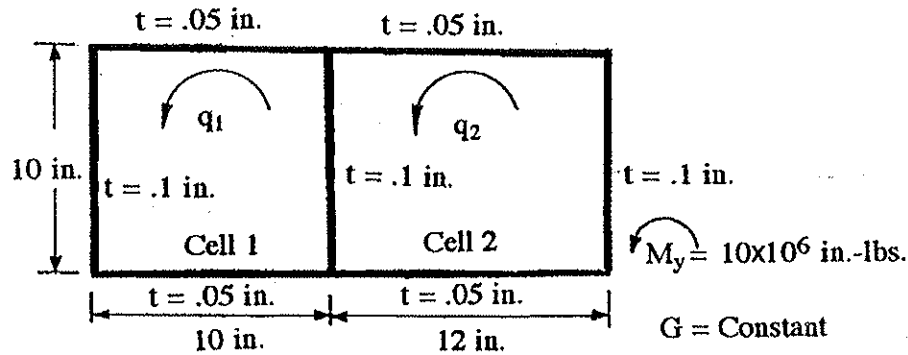
Also condition of compatibility requires that the twist of all the cells must be the same, i.e.

$$\theta = \left(\frac{q_i}{2A_i G}\right) \oint \frac{ds}{t} \quad \text{Eq. 8.2.5}$$

Combining of Eq. 8.2.4 and Eq. 8.2.5 to obtain the values q_1 and q_2, \dots, q_n and θ in a multi-cell box structure.

Example:

Determine shear flows in all walls as shown below:



Assume the shear flow in cell 1 is q_1 and in cell 2 is q_2 . Their angles of rotation are:

$$\theta_1 = \left(\frac{1}{2A_1 G}\right) \oint q \times \frac{ds}{t}$$

$$2G\theta_1 = \left(\frac{1}{10 \times 10}\right) [q_1 \left(\frac{10}{0.1} + \frac{10}{0.05} + \frac{10}{0.1} + \frac{10}{0.05}\right) - q_2 \left(\frac{10}{0.1}\right)]$$

$$2G\theta_1 = 6q_1 - q_2$$

$$\theta_2 = \left(\frac{1}{2A_2 G}\right) \oint q \times \frac{ds}{t}$$

$$2G\theta_2 = \left(\frac{1}{10 \times 12}\right) [q_2 \left(\frac{12}{0.05} + \frac{10}{0.1} + \frac{12}{0.05} + \frac{10}{0.1}\right) - q_1 \left(\frac{10}{0.1}\right)]$$

$$2G\theta_2 = \left(\frac{17}{3}\right)q_2 - \left(\frac{5}{6}\right)q_1$$

But $\theta_1 = \theta_2$

$$6q_1 - q_2 = \left(\frac{17}{3}\right)q_2 - \left(\frac{5}{6}\right)q_1$$

$$q_2 = \left(\frac{41}{40}\right)q_1$$

Eq. (A)

Also for equilibrium:

$$M_y = 2A_1 q_1 + 2A_2 q_2$$

$$10^6 = 200q_1 + 240q_2$$

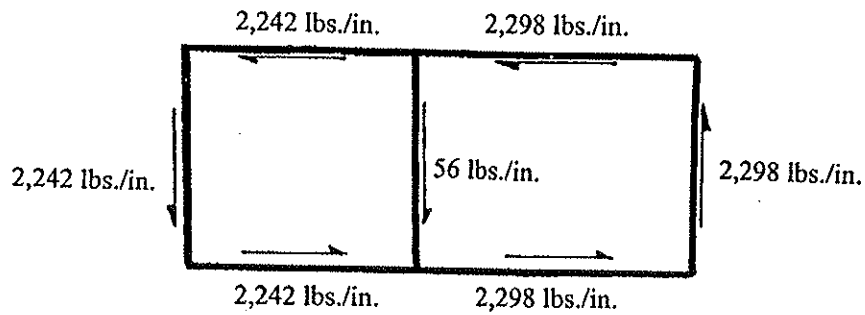
Eq. (B)

Solve Eq. (A) and Eq. (B), obtain:

$$q_1 = 2,242 \text{ lbs./in.}; \quad q_2 = 2,298 \text{ lbs./in.}$$

$$q_{12} = q_1 - q_2 = -56 \text{ lbs./in.}$$

Final loading:



(C) SHEAR CENTER

The shear center for any beam bending becomes a main reference point for both shear and torsion loading. Since the torsional stiffness and strength of an open section is quite small, it is recommended to keep the applied load at or close to the shear center as shown in Fig. 8.2.5 and for any segments of shell structures, the following rules should be kept in mind:

- The applied load acts parallel to a straight line connecting the centroids of the two adjacent flanges (or stringers)
- Passes through the shear center a distance $e = \frac{2A_o}{h}$ from this straight line.
- Has the magnitude = $q h$

The shear center for open cells is located by maintaining rotational equilibrium between the applied load and reactive web shear flows.

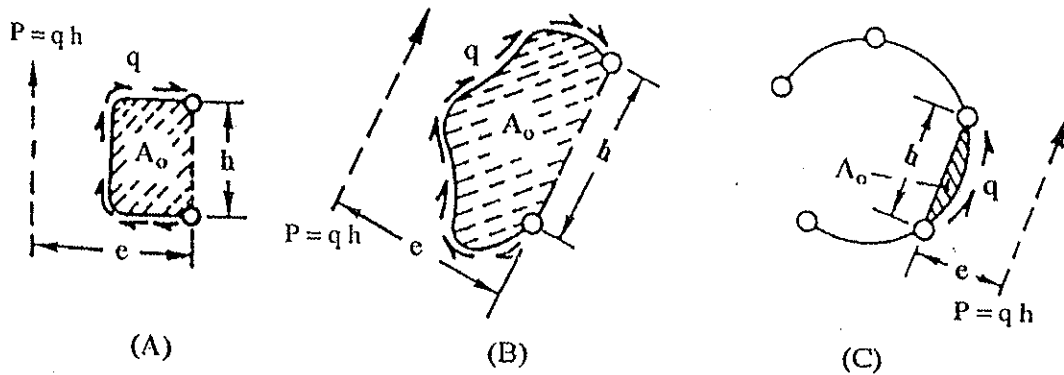


Fig. 8.2.5 Shear Center of Three Open Shell Sections

The familiar D section, shown in Fig. 8.2.6, which is a part of a nose section of an airfoil, is used for ailerons, elevators, rudder, flaps, etc., on general aviation and small aircraft airframes. The D-section may be considered a combination of a beam and a torsion box. Since this closed cell is stable under bending and torsion loads, a different procedure is required:

P_n – Resultant of shear flow on nose skin
 P_w – Resultant of shear flow on vertical web

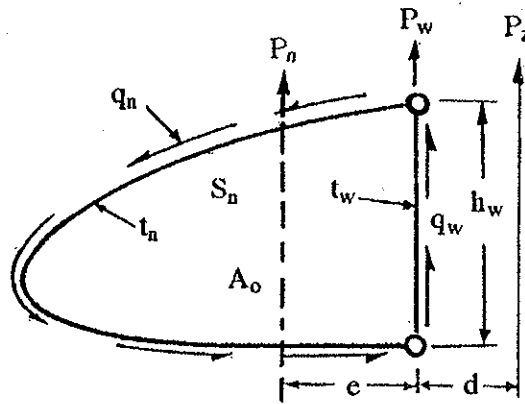


Fig. 8.2.6 Shear Center of a D-Cell Section

D-CELL WITH TWO-STRINGERS SECTION:

Assumptions

- (a) Bending moment is taken by beam stringers only:
 - The vertical load, P_z , must act parallel to the vertical web of the D-cell beam
 - There can be no component of load in any other direction since there is no stringer to resist it
- (b) Torsion moment is taken by the cell (the shear flows are carried by both the nose skin and vertical web).
- (c) The total shear load acting on the cell may be resolved into two components:
 - The shear load P_w acting in the web plane
 - The shear load P_n in the forward or aft skin acting at the shear center of the section

From static:

$$\Sigma F_x = 0: P_z = -P_w - P_n$$

$$\Sigma M_w = 0: P_z d = P_n e_n \quad \therefore P_n = \frac{P_z d}{e_n}$$

Since $e_n = \frac{2A_o}{h}$ then, $P_n = \frac{P_z d h}{2A_o}$

Therefore, $P_w = -P_z - \frac{P_z d h}{2A_o} = -P_z \left(1 + \frac{d h}{2A_o}\right)$

Also, $q_n = \frac{P_n}{h} = -\frac{P_z d}{2A_o}$ Eq. 8.2.6

$q_w = \frac{P_w}{h} = -P_z \left(\frac{1}{h} + \frac{d}{2A_o}\right)$ Eq. 8.2.7

With the skin and web thickness known, the shear stresses are:

Shear stress in nose skin: $f_{s,n} = \frac{q_n}{t_n}$

Shear stress in vertical web: $f_{s,w} = \frac{q_w}{t_w}$

ANNA UNIVERSITY, CHENNAI 25

MODEL QUESTION PAPER

B.E. AERONAUTICAL ENGINEERING, VI SEMESTER

AE341 - AIRCRAFT STRUCTURES - II

TIME - 3 Hours

MAXIMUM : 100 Marks

PART A

(10 X 2 = 20 Marks)

ANSWER ALL QUESTIONS

1. Define shear centre
2. Give a sketch of a thin-walled angle section and mark the shear centre location for the same.
3. State S.I. Units for (a) shear flow, (b) shear modulus
4. State the Bredt - Batho formula and list the assumptions involved.
5. A thin - walled single - cell tube is subject to torsion. Derive an expression for shear flow in the walls of the tube.
6. Briefly write about the concept of lumping of cross - sections.
7. For a structure which carries primarily bending loads? why are I - sections preferred over other cross-sections?
8. What is a wagner beam?
9. What are monocoque structures?
10. List 2 functions of an aircraft rib.

PART B

(5 X 16 = 80 Marks)

11. (i) Bring out the differences between Symmetrical and unsymmetrical bending 4
- (ii) What are principal axes of inertia? 2
- (iii) A bending moment of 3000 Nm is applied to the cross - section shown in Figure 1 at an angle of 30 to the vertical y-axis such that M_x and M_y both produce tension in the positive x-y quadrant. Obtain the expression for bending stress. 10

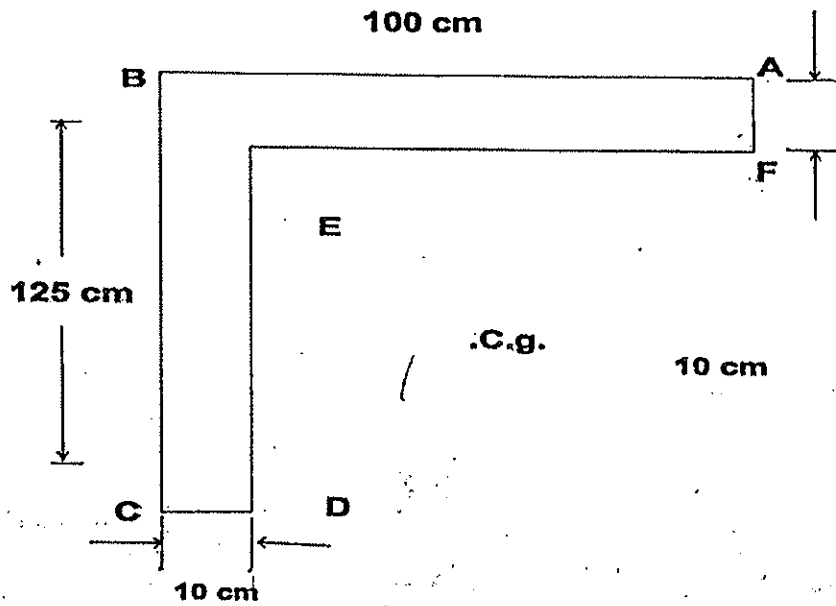


Figure 1

12(a) For the section shown in Figure 2(a), determine the shear centre location.

16

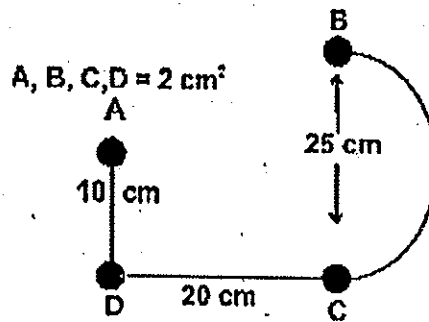


Figure 2(a)

12(b) A vertical load of 1000N is applied to the Section indicated in Figure 2(b) in the positive - y direction. Plot the shear flow distribution.

16

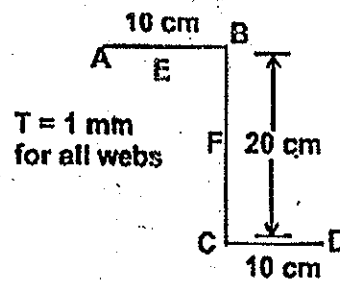


Figure 2(b)

9) Neutral axis :-

The beam bends about same axis in its cross section about which first moment of area of beam is zero and it will not be subjected to any strain known as neutral axis (or) axis of zero stress.

No compression (or) tension

$$\int \sigma z \, dA = 0$$

$$\int \frac{1}{R} E \, dA \Rightarrow \frac{E}{R} \int u \, dA = 0$$

$$\boxed{\int u \, dA = 0}$$

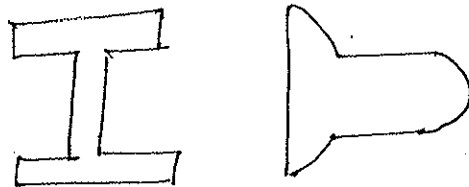
10) Define shear centre :-

Shear centre is a point in the cross section of slender uniform beam at which applying shear load produces no twist only produces bending deflection.

Shear centre for thinwalled \Rightarrow equal angle section
 \Rightarrow T section

L T

Sketch shear stress variation across I section



H 265

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2004

Sixth Semester

Aeronautical Engineering

AE 341 — AIRCRAFT STRUCTURES — II

Time : Three hours

Maximum (100) marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Differentiate between symmetric and unsymmetric bending.
2. Define Principal axes and give an expression to determine them.
3. Define Neutral axis and give an expression to determine it.
4. Define Shear center.
5. Mark shear center for thin walled (a) equal angle section (b) T-section.
6. Sketch shear stress variation across depth for an I-section.
7. Give any one moment of inertia for a thin walled I-section with thickness t and flange width = web height = h .
8. Sketch Buckling modes of a plate in (a) Compression (b) Shear.
9. What is effective width?
10. Sketch a semi-monocoque structure and name the parts.

PART B — (5 × 16 = 80 marks)

11. Derive an expression for shear flow in an open tube subjected to shear loads S_x , S_y and modify this expression for a closed tube. (16)
12. (a) An equal angle section with side 20 cm thickness 2 cm is subjected to moments $M_x = 20 \text{ kN-m}$ and $M_y = 15 \text{ kN-m}$. Find the maximum tensile and compressive stresses.

Or

- (b) Determine the direct stress distribution in a thin-walled Z-section produced by a positive bending moment M_x . Height of the section = h and flange width = $h/2$.

13. (a) Determine the shear flow and shear center for the section shown in Fig. 1. Section is subjected to a vertical shear load of 5 kN.

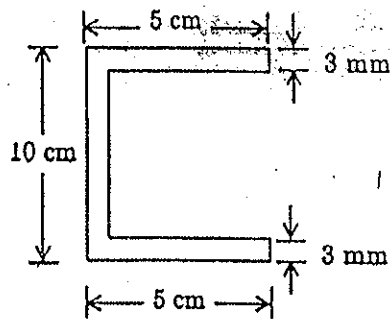


Fig. 1

Or

- (b) Determine the shear flow and shear center for the section shown in Fig. 2.

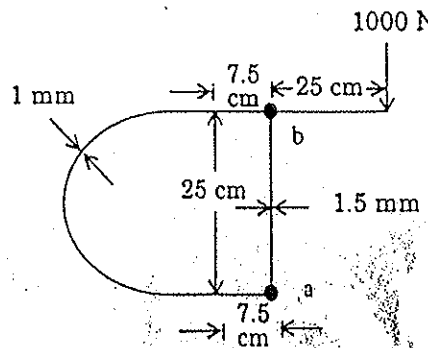


Fig. 2

14. (a) (i) Differentiate between Buckling and Crippling and explain how will you calculate Buckling stress in compression and shear. (8)
- (ii) Explain any one method to calculate Crippling strength. (8)

42

Or

- (b) Check whether the box beam shown in Fig. 3 will withstand the load without buckling and also find the Margin of Safety. Given : $P_1 = P_2 = 5000$ N, Uniform skin thickness = 1.5 mm. Area of each stringer = 2 cm^2 . Assume skin is effective in bending. For $a/b = 2$, $K_c = 5$, $K_s = 6.5$.

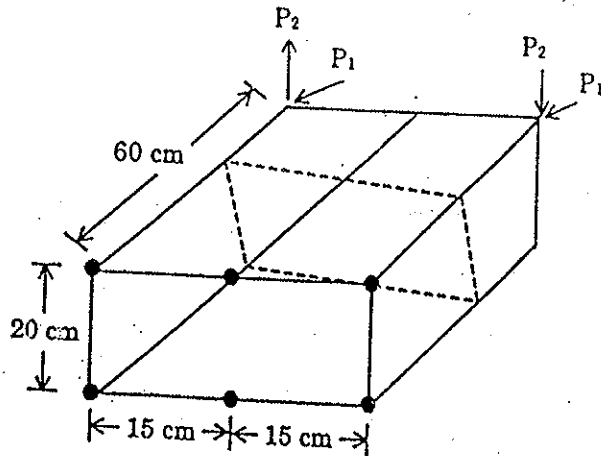


Fig. 3

15. (a) Explain the principle of Semi-Tension field beam and find an expression for
- Web stiffener load.
 - Flange axial load

Or

- (b) Find the shear flow and twist per unit length of the two cell structure shown in Fig. 4. The material used is Aluminium with $E = 70$ GPa and Poisson's ratio = 0.3.

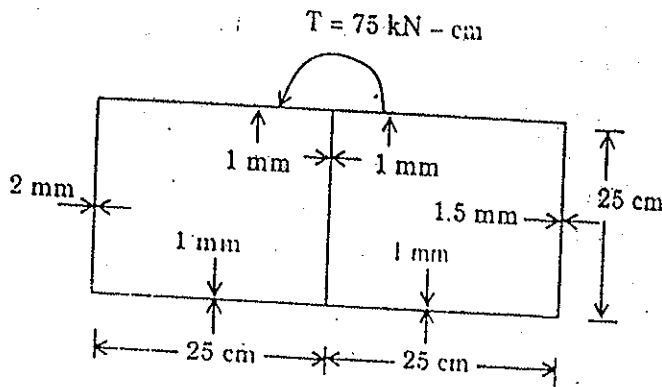


Fig. 4

N 1002

B.E./B.TECH. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2004.

Sixth Semester

Aeronautical Engineering

AIR-201 - AIRCRAFT STRUCTURES - II

Maximum : 100 marks

Time : Three hours

Answer ALL questions.

PART A - (10 x 2 = 20 marks)

(16)

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level

(12)

(4)

(8)

(8)

ory and
(16)

aircraft
(16)

ee plan
(10)

Circle
(6)

ersonic
(16)

ferences
(16)

1. Define 'redundancy' in a structure. How do you determine the order of redundancy?
2. What do you understand by unsymmetrical bending? Explain a method to find the stresses in an unsymmetrical section.
3. Explain the principle of virtual work and its application in solving structural problems.
4. How do you determine the shear flow and angle of twist for a closed single cell under torsion?
5. Indicate how Von Karman's effective width is computed knowing the stress distribution on the sheet-stiffener panel.
6. What is a lip? How does it affect the strength of a section?
7. Explain clearly the distinction between the strength and stiffness problems in structures.
8. Explain how a thin beam subjected to shear resists the load.
9. What is a semi tension field beam?
10. What do you understand by monocoque and semi monocoque type of aircraft construction?

11. Obtain the shear flow around a three cell box beam (Fig. 1) when it is subjected to a torque of $T = 100 \text{ kNm}$. The thickness of vertical members, horizontal members and semicircle are 1.25, 0.75 and 0.6 cm respectively.

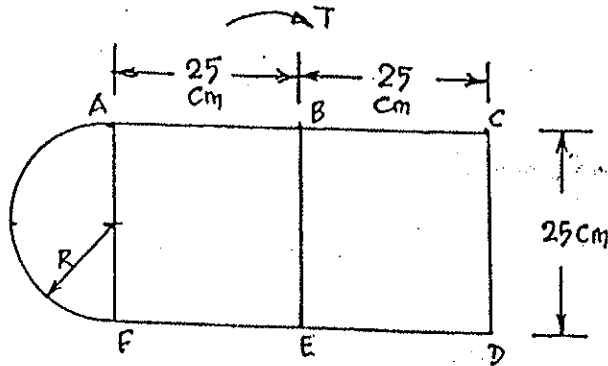


Fig. 1

12. (a) (i) Does the shear center always lie outside for the open section? Explain.
- (ii) Obtain the shear flow and shear center location for the channel section subjected to a vertical shear load of 5 kN. The height of the vertical web is 50 mm and width of flanges is 25 mm. Thickness of the flanges and the web is 1.5 mm.

Or

- (b) Obtain the shear flow distribution for the closed section shown in Fig. 2. Each stringer area is 6.5 cm^2 .

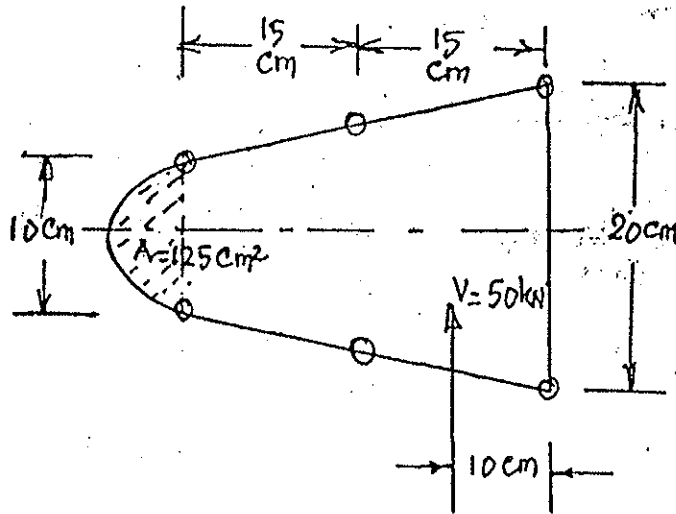


Fig. 2.

13. (a) (i) What is a rib? How does it transfer the load?
 (ii) Determine the load distribution in all the members of the rib shown over in Fig. 3.

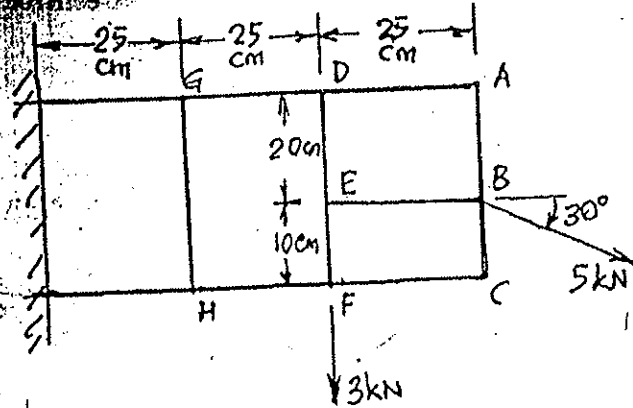


Fig. 3

Or

- (b) A fuselage bulkhead of 1 m radius, has 12 stringers equally placed around the section starting from top point. Each stringer area is 6.25 cm^2 . The bulk head is subjected to a symmetrical vertical shear load of 10 kN. Find the shear flow around the bulk head.
14. (a) (i) Show that the sum of the moment of inertia about any two orthogonal axes is invariant with respect to any other two orthogonal axes. (6)
- (ii) Obtain the shear flow distribution and shear center location for the section shown in Fig. 4. When it is subjected to a shear load of 5 kN. (10)

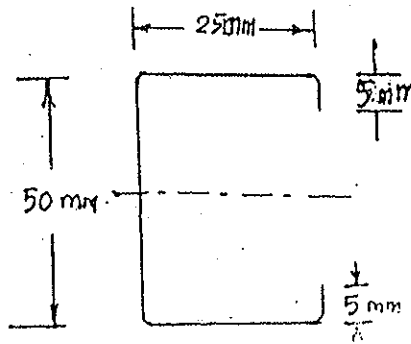


Fig. 4

Or

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- (b) A beam section shown in Fig. 5 has four stringers. The area of the stringers A, B, C and D are 6.25, 3.125, 4.5 and 6 sq.cm. respectively. Find the stresses in all the four stringers of the section due to $M_x = 50$ kNm and $M_y = -20$ kNm where x and y are the centroidal axes. Assume that webs and walls are ineffective in bending.

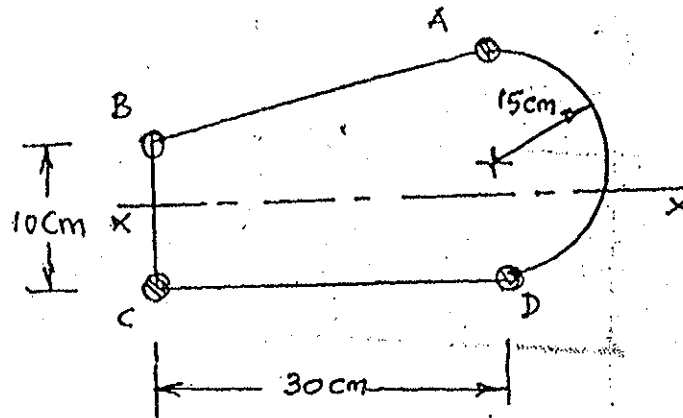


Fig. 5

15. (a) (i) Clearly bring out the difference between shear resistance beams and tension field beams. (6)
- (ii) Find the crippling load for an angle section of aluminium alloy, 50 mm \times 25 mm \times 1 mm. (10)

Or

- (b) Write short notes on :

- (i) Formed and extruded section
- (ii) Gerard method of finding crippling stress
- (iii) Energy theorems in structural analysis.

R 162

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2005.

Sixth Semester

AE 341 — AIRCRAFT STRUCTURES — II

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. Show a typical stress distribution for a open/closed section undergoing unsymmetrical bending.
2. Define principal axes of a section.
3. Define shear flow. How shear stress is obtained from shear flow?
4. Indicate the position of shear center for a channel section and angle section.
5. List down various structural components in an aircraft wing.
6. List down various structural components in the fuselage.
7. Explain how torque is realized by an aircraft wing.
8. Is it convenient to have engine fitted to the aircraft wing from the structural design point of view? Justify the answer.
9. Briefly explain the effective width theory.
10. What is the difference between tension field beam semi tension field beam?

PART B — (5 × 16 = 80 marks)

11. (i) Derive the expression for the shear flow in thin walled single cell subjected to torque load. (4)
(ii) Obtain the shear flow for the thin walled structure shown in the Fig. 1. (12)

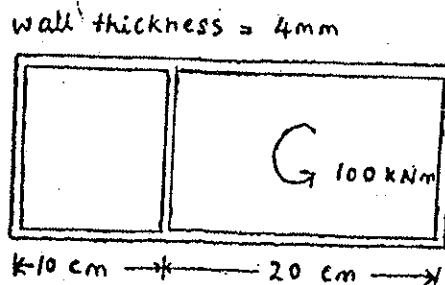
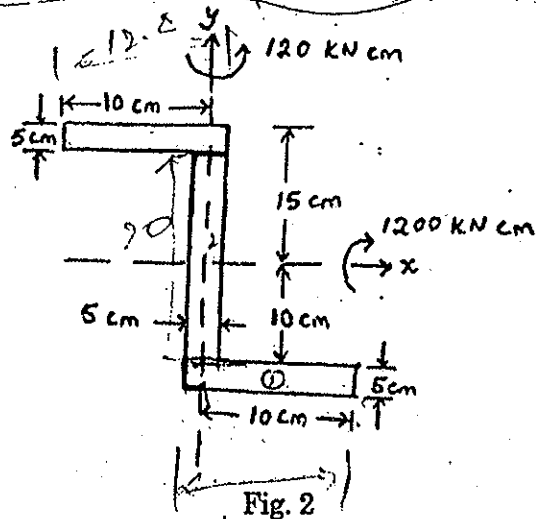


Fig. 1

12. (a) Obtain the bending stress values at the points A, B, C and D for the section shown in Fig. 2. Compute the stresses using moment values with respect to x and y axes and principal axes.



- (b) Compute the load on the lumped flanges due to bending of the section shown in Fig. 3. Assume the webs do not take part in bending. Compute the loads using moment values with respect to x and y axes and principal axes.

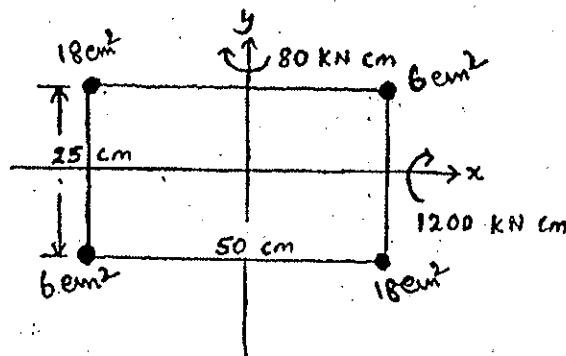


Fig. 3

13. (a) Find the shear flow distribution and locate the shear center for the section shown in Fig. 4. Each of the stringers has an area of 4 cm^2 and the section is subjected vertical shear of 50 kN .

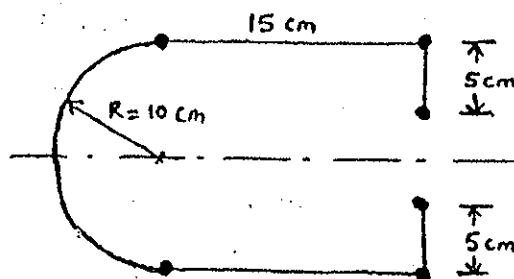


Fig. 4

Or

- (b) The section shown in Fig. 5 is subjected to vertical shear of 60 kN applied through shear center. Obtain the shear flow for the section. Areas of all the stringers are same and is equal to 7 cm^2 .

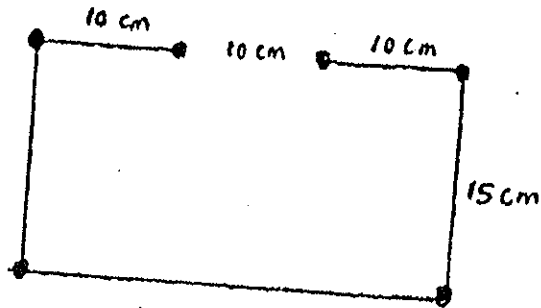


Fig. 5

14. (a) Obtain the shear flow for the box beam shown in Fig. 6. $A_1 = A_5 = 25 \text{ cm}^2$, $A_2 = A_3 = A_6 = A_7 = 7 \text{ cm}^2$ and $A_4 = A_8 = 12 \text{ cm}^2$.

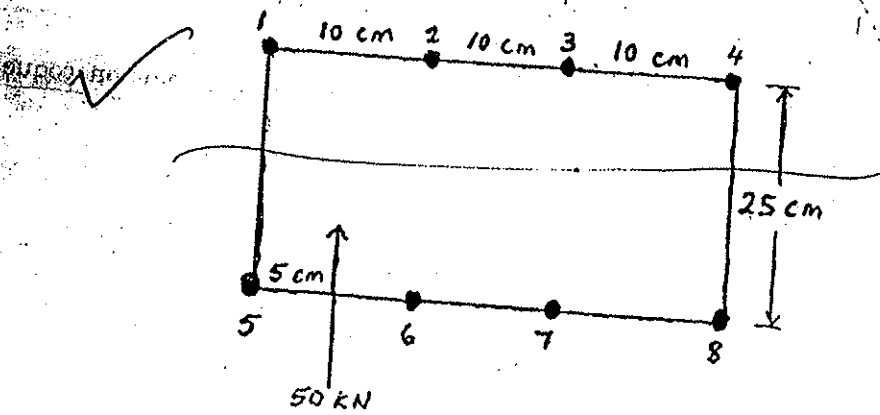


Fig. 6

Or

- (b) A multicell structure shown in Fig. 7 is subjected to a clockwise torque of 1000 N-m. Compute the shear flow in the cell structure and the associated twist.

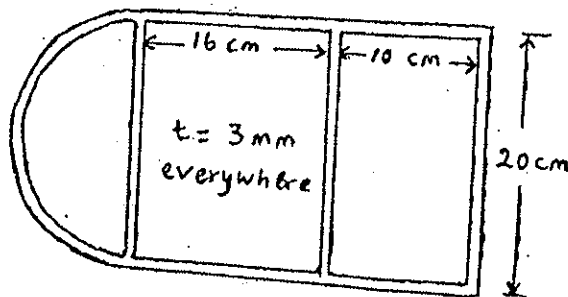


Fig. 7

15. (a) (i) Derive the expression for buckling stress for a thin plate under compression. (6)
- (ii) Obtain the critical load for the composite section shown in Fig. 8. Effective width is 150 cm. $E = 200$ GPa. (10)

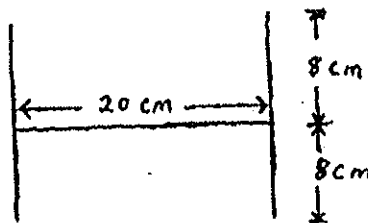


Fig. 8

Or

- (b) Write short notes on any TWO of the following :

- (i) Definition and analysis of monocoque and semimonocoque structures.
- (ii) Idealisation and analysis of aircraft wing structure ✓
- (iii) Idealisation and analysis of aircraft fuselage. ✓

B 112

APR 2004

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2005.

Sixth Semester

Aeronautical Engineering

AE 341 — AIRCRAFT STRUCTURES — II

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. State the assumptions made in the Bredt-Batho theory.
2. Explain difference between symmetric and unsymmetric bending with examples.
3. Define Neutral axis and give an expression to determine them.
4. Define Principal axes and give an expression to determine them.
5. Define Shear center and Elastic axis.
6. Show that for a curved web $T = 2Aq$.
7. Explain effective width and give an expression to determine it.
8. Explain Buckling in compression for a Plate.
9. Draw shear stress and bending stress variation across the depth for (a) rectangular section and (b) I-section.
10. Find I_{xx} and I_{yy} for a thin walled I-section with thickness t and flange width = web height = h .

PART B — (5 × 16 = 80 marks)

11. (i) Derive an expression for shear flow of an open tube of arbitrary cross-section subjected to shear loads S_x and S_y without twist. (12)
- (ii) Modify the above expression for a closed tube. (4)

52

12. (a) Find the bending stress distribution in a thin walled Z-section, whose thickness is t , height h , flange width $h/2$ and subjected to a positive bending moment M_x .

Or

- (b) Find the max. bending stress for the section shown in the fig. 1, subjected to a bending moment $M_x = 1500 \text{ N-m}$.

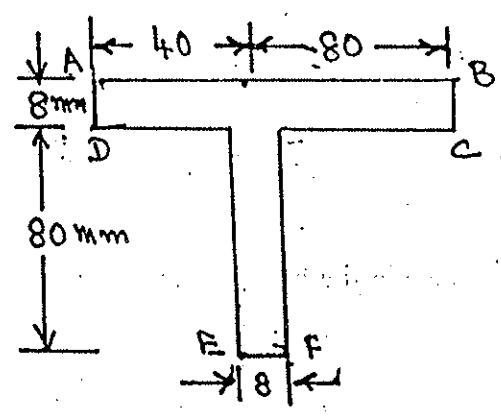


Fig. 1

13. (a) Find the shear flow distribution and shear center for a thin walled channel section of thickness 3 mm, flange width 5 cm, web height 10 cm, and subjected to a vertical load of 5 kN through the shear center.

Or

- (b) Find shear flow of the open section shown in fig. 2. Area of each stringer = 6 cm^2 . The loads are $S_x = 10 \text{ kN}$ and $S_y = 50 \text{ kN}$ acting through the shear center.

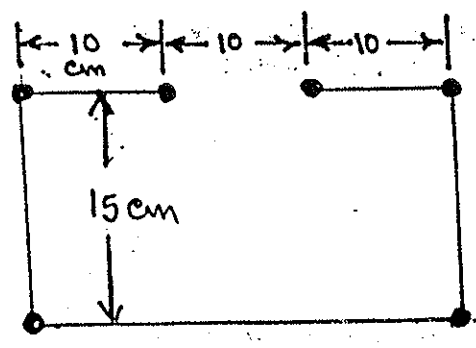


Fig. 2

14. (a) Find shear flow for the closed tube shown in the fig. 3.

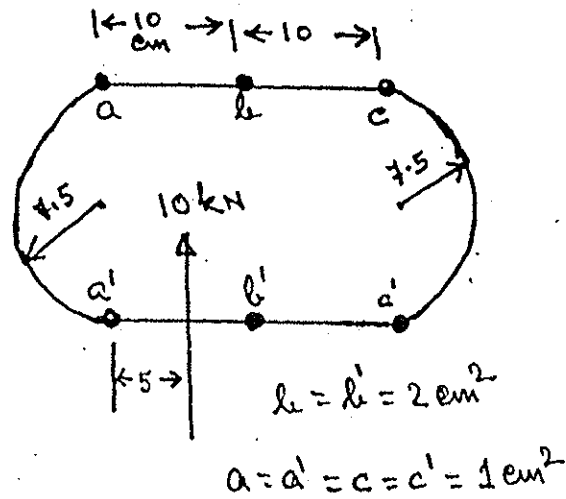


Fig. 3

Or

- (b) Find the shear flow and twist per unit length of the two cell tube made of aluminium as shown in the fig. 4 and subjected to a Torque 75000 N-cm.

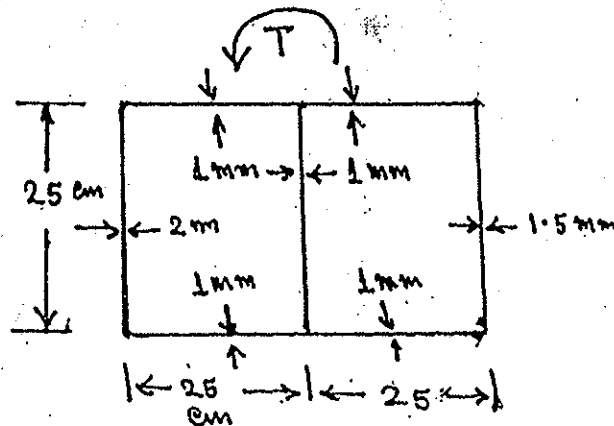


Fig. 4

15. (a) (i) Differentiate between buckling and crippling and explain any one method to determine crippling strength. (10)
 (ii) Explain Wagner beam. (6)

Or

- (b) Explain lift load distribution, structural load distribution on a cantilever wing and draw the shear force and bending moment diagrams.

B 112

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2005.

Sixth Semester

Aeronautical Engineering

AE 341 — AIRCRAFT STRUCTURES — II

Time: Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. State the assumptions made in the Bredt-Batho theory.
2. Explain difference between symmetric and unsymmetric bending with examples.
3. Define Neutral axis and give an expression to determine them.
4. Define Principal axes and give an expression to determine them.
5. Define Shear center and Elastic axis.
6. Show that for a curved web $T = 2Aq$.
7. Explain effective width and give an expression to determine it.
8. Explain Buckling in compression for a Plate.
9. Draw shear stress and bending stress variation across the depth for (a) rectangular section and (b) I-section.
10. Find I_{xx} and I_{yy} for a thin walled I-section with thickness t and flange width = web height = h .

PART B — (5 × 16 = 80 marks)

11. (i) Derive an expression for shear flow of an open tube of arbitrary cross-section subjected to shear loads S_x and S_y without twist. (12)
- (ii) Modify the above expression for a closed tube. (4)

12. (a) Find the bending stress distribution in a thin walled Z-section, whose thickness is t , height h , flange width $h/2$ and subjected to a positive bending moment M_x .

Or

- (b) Find the max. bending stress for the section shown in the fig. 1, subjected to a bending moment $M_x = 1500 \text{ N-m}$.

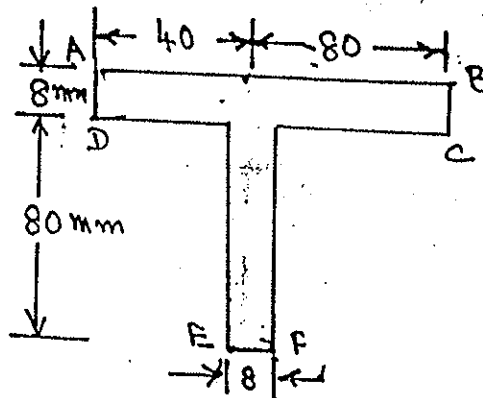


Fig. 1

13. (a) Find the shear flow distribution and shear center for a thin walled channel section of thickness 3 mm, flange width 5 cm, web height 10 cm and subjected to a vertical load of 5 kN through the shear center.

Or

- (b) Find shear flow of the open section shown in fig. 2 Area of each stringer = 6 cm². The loads are $S_x = 10 \text{ kN}$ and $S_y = 50 \text{ kN}$ acting through the shear center.

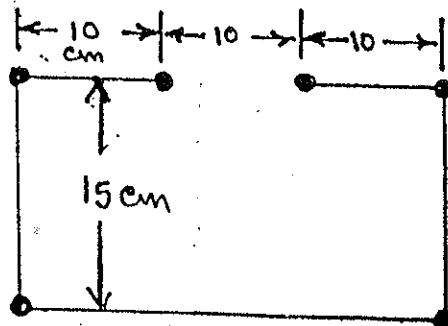


Fig. 2

14. (a) Find shear flow for the closed tube shown in the fig. 3.

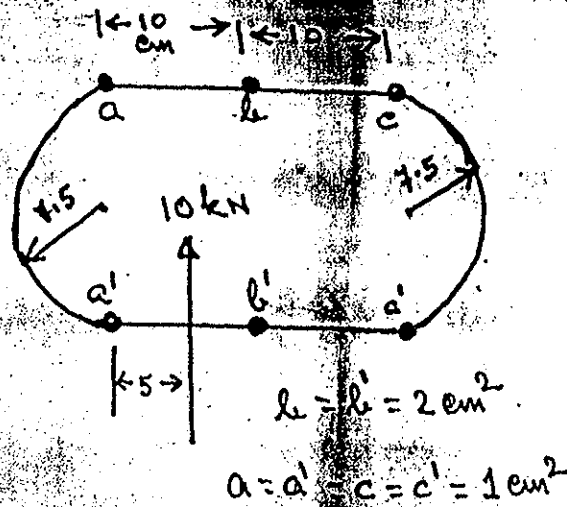


Fig. 3

Or

(b) Find the shear flow and twist per unit length of the two cell tube made of aluminium as shown in the fig. 4 and subjected to a Torque 75000 N-cm.

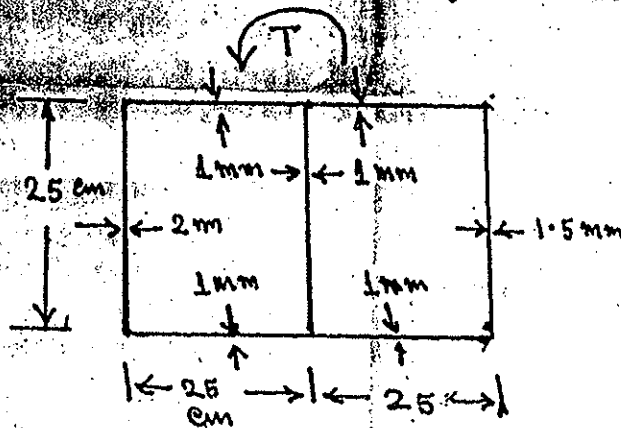


Fig. 4

15. (a) (i) Differentiate between buckling and crippling and explain any one method to determine crippling strength. (10)

(ii) Explain Wagner beam. (6)

Or

(b) Explain lift load distribution, structural load distribution on a cantilever wing and draw the shear force and bending moment diagrams.

H 1014

B.E./B.Tech. DEGREE EXAMINATION, MAY/JUNE 2006.

Sixth Semester

Aeronautical Engineering

AE 341 — AIRCRAFT STRUCTURES — II

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. ✓ Sketch a semi-monocoque structure and explain its advantages.
2. Specify any one aluminium alloy used in aircraft construction and its properties.
3. Draw shear stress and bending stress variation across the depth for (a) rectangular section and (b) I-section.
4. Define principal axes and give an expression to determine them.
5. Define shear center and locate shear center for channel section and equal angle section.
6. Show that for a curved web shear center distance $e = 2 A/L$.
7. Explain effective width and give an expression to determine it.
8. Explain safe life and fail safe design with example.
9. Give expression for buckling stress (a) column (b) sheet.
10. Define load factor and classify aircraft based on load factor.

PART B — (5 × 16 = 80 marks)

11. Fig. 1 shows the section of an angle purlin. A bending moment of 3000 Nm is applied to the purlin in a plane at an angle of 30° to the vertical y axis. If the sense of the bending moment is such that its components M_x and M_y both produce tension in the positive $x y$ quadrant. Calculate the maximum direct stress in the purlin stating clearly the point at which it acts.

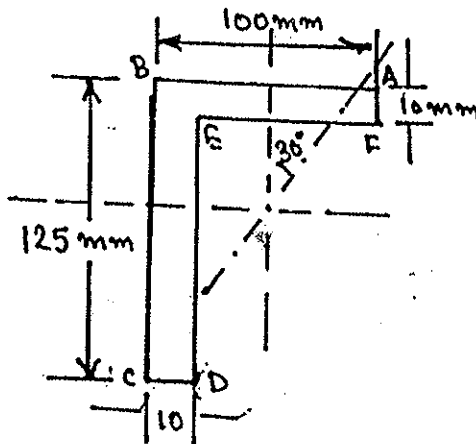


Fig. 1

12. (a) Derive an expression for bending stress in an unsymmetric section subjected to M_x and M_y and modify this expression with respect to principal axis and neutral axis.

Or

- (b) Find the shear flow distribution in a thin walled Z-section, whose thickness is t , height h , flange width $h/2$ and subjected to a vertical load through the shear center.

13. (a) Find the shear flow for the section shown in the Fig 2. The area of stringers $a = b = 4 \text{ cm}^2$, $c = d = 2 \text{ cm}^2$.

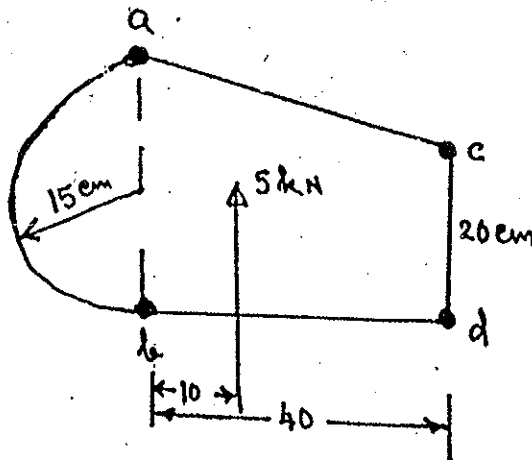


Fig. 2

Or

- (b) Find the M.S. in buckling for the box beam shown in Fig. 5. Given : $P_1 = P_2 = 10 \text{ kN}$. Area of each stringer = 2 cm^2 and the sheet thickness is 1.5 mm through out. Assume the sheets are effective in bending and made of 2024 -T₃. Aluminium alloy. For $a/b = 2$, $K_c = 5$, $K_s = 6.5$ and for $a/b = 3$, $K_c = 4$, $K_s = 5.8$.

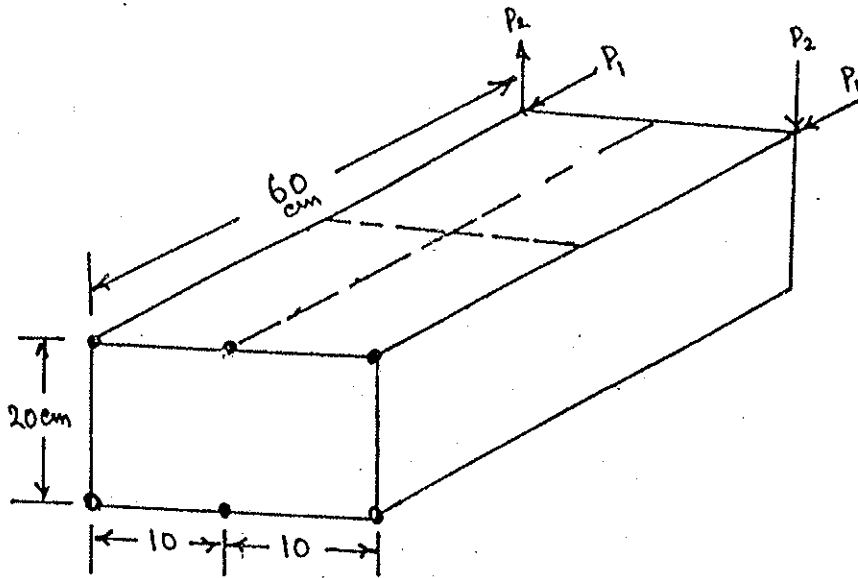


Fig. 5

15. (a) (i) Differentiate between buckling and crippling and explain any one method to determine crippling strength. (10)
- (ii) Explain Wagner beam. (6)

Or

- (b) Explain the various loads and structural load distribution on the fuselage of a passenger aircraft and assuming it as a free-free beam draw the shear force and bending moment diagrams.

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- (b) The idealized single cell thin-walled tube shown in Fig. 3 has a horizontal axis of symmetry. Direct stresses are carried by the booms B_1 to B_8 while the walls are effective only in carrying shear stress. Calculate the distribution of shear flow around the section. Given : $B_1 = B_8 = 2 \text{ cm}^2$, $B_2 = B_7 = 2.5 \text{ cm}^2$, $B_3 = B_6 = 4 \text{ cm}^2$, and $B_4 = B_5 = 1 \text{ cm}^2$.

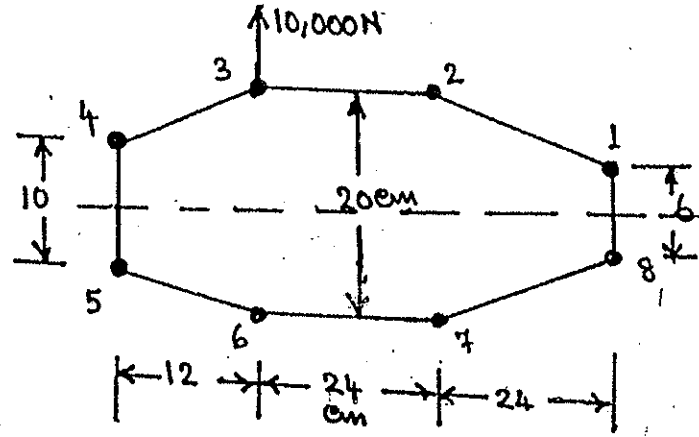
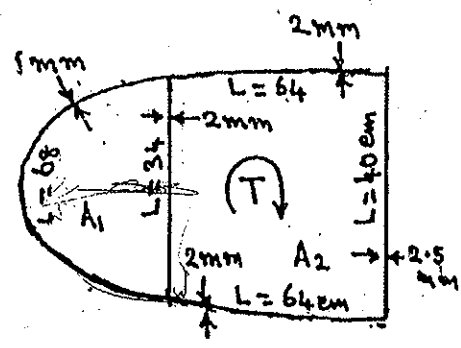


Fig. 3

14. (a) Find the shear flow and twist per unit length of the two cell tube made of aluminium as shown in the Fig. 4 and subjected to a Torque 90000 N-cm.



$A_1 = 677 \text{ cm}^2, A_2 = 2500 \text{ cm}^2$

Fig. 4
Or

16
32
2
34

23
16
39

3
60

H 1014

15(a) (i) Discuss the analysis of a semi-cantilever type of aircraft wing

(ii) List out the different structural elements contained in an aircraft wing. What are their functions?

or

15(b) The tapered beam shown in figure 4(a) is subject to a vertical load V

(i) Derive an expression for shear flow at any point in the web of the beam.

(ii) Obtain the shear flow distribution when $V = 10,000 \text{ N}$

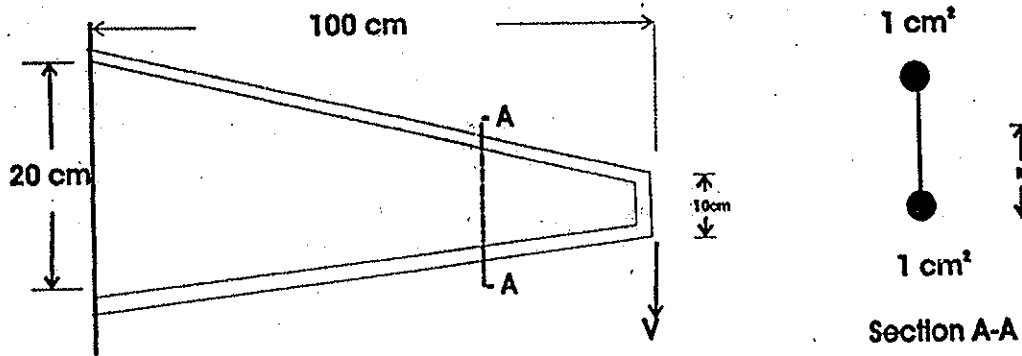


Figure 4 (a)

- 13(a) The section shown in Figure 3(a) is subject to forces $F_x = -1600 \text{ N}$ and $F_y = 6000 \text{ N}$. Determine the bending stresses at the stringer locations A, B, C, D. Assume that the webs are ineffective in bending. 16

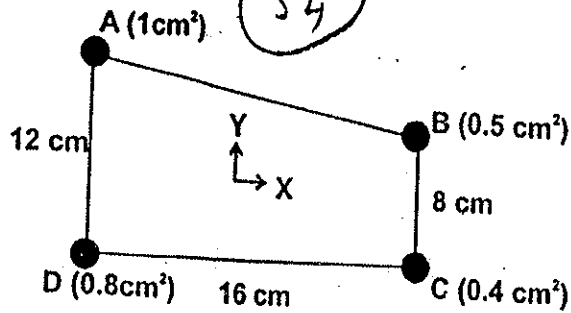
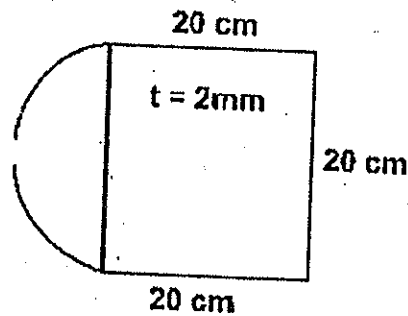


Figure 3 (a)

- 13(b) (i) A thin-walled tube having a cross-sectional area 'A' and wall thickness 't', is subject to twisting moment M_o . Derive and obtain the expression for cell twist. 8
- (ii) The 2-cell tube indicated in Figure 3(b) is subject to a clockwise twisting moment of 1000 Ncm . Determine the shear flows in the walls of the tube. 8



All other wall thickness = 1 mm

Figure 3(b)

- 14(a) Write notes on the following 6
- (i) the strength of thin-walled columns, 6
 - (ii) the concept of 'EFFECTIVE SHEET WIDTH', 4
 - (iii) inter-rivet and sheet wrinkling failures
- 14(b) (i) Derive the buckling equation for a thin plate 10
- (ii) Explain the interaction relationship and state its uses 6