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QUICK REVISION

FORMULA SHEET

for

GATE-AE AIRCRAFT STRUCTURES

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PEC, CHANDIGARH
AIR - 6

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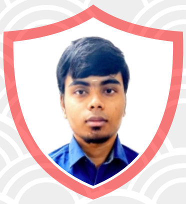
IIEST, SHIBPUR
AIR - 8



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RVCE, BANGALORE
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- ***Mr. Abhilash K*** *(Amrita Univ Coimbatore)*
- ***Ms. Ajitha Nishma V*** *(IIST Trivendrum)*
- ***Mr. Dheeraj Sappa*** *(IIEST Shibpur)*
- ***Ms. F Jahangir*** *(MIT Chennai)*
- ***Mr. Goutham*** *(KCG College Chennai)*
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- ***Mr. Niladhari Pahari*** *(IIEST Shibpur)*
- ***Mr. Nitesh Singh*** *(Sandip Univ Nashik)*
- ***Mr. Ramanathan A*** *(Amrita Univ Coimbatore)*
- ***Ms. Shruti S Rajpara*** *(IIEST Shibpur)*

HAL DT ENGINEER

Job Position for Recruitment **(2023)**

- ***Mr. Anantha Krishan A.G*** *(Amrita Univ Coimbatore)*
- ***Mr. S.S Sanjay*** *(Amrita Univ Coimbatore)*
- ***Mr. Shashi Kanth M*** *(Sastra Univ Tanjore)*
- ***Mr. Vagicharla Dinesh*** *(Lovely Professional Univ Panjab)*

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(MIT, CHENNAI)
HAL DT ENGINEER 2022

MOHAN KUMAR .H
(MVJCE, BANGALORE)
HAL DT ENGINEER 2022

ARATHY ANILKUMAR NAIR
(AMRITA UNIV, COIMBATORE)
HAL DT ENGINEER 2021

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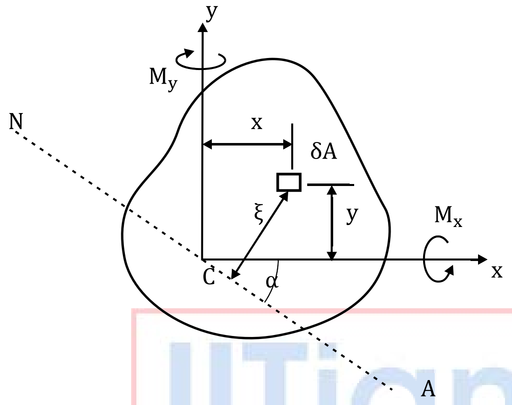
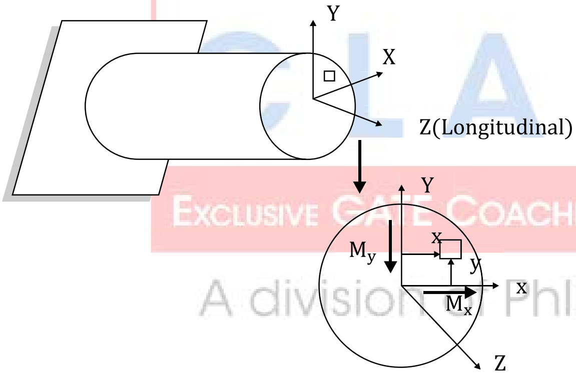
UNSYMMETRICAL BENDING

For an unsymmetrical cross section under complex bending



Sign Convention



To produce to same effect or same kind of stress (compressive or tension), moment need to follow each other.

Moments in Inclined Plane

- The moment in YZ plane is always about X- axis.
- The moment in XZ plane is always about Y- axis.

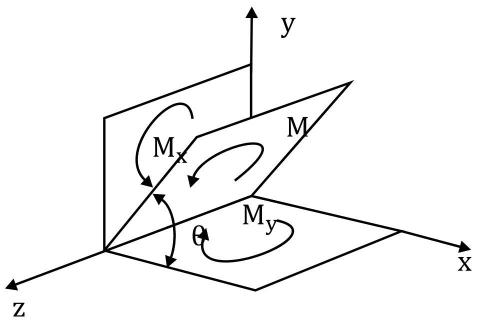


fig (a)

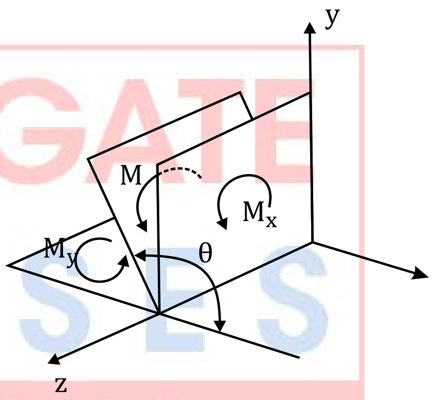


fig (b)

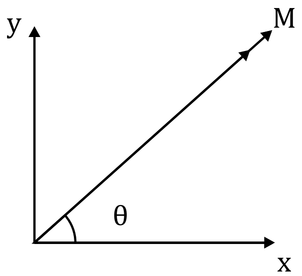
Resolution of bending moments sign depending on the size of θ. In both cases, for the sense of M shown

- $M_x = M\sin\theta$
- $M_y = M\cos\theta$

  This gives,

- For $\theta < \frac{\pi}{2}, M_x$ and M_y positive (fig (a)) and for $\theta > \frac{\pi}{2}, M_x$ positive and M_y negative (fig (b)).

Moments About Inclined Axis



Resolving Bending Moment along x and y axis

- $M_x = M\cos\theta$
- $M_y = -M\sin\theta$
- For all values of θ

Direct stress due to Unsymmetrical Bending:

$$\sigma_z = \left(\frac{I_{xx}M_y - I_{xy}M_x}{I_{xx}I_{yy} - I_{xy}^2}\right)x + \left(\frac{I_{yy}M_x - I_{xy}M_y}{I_{xx}I_{yy} - I_{xy}^2}\right)y$$

$$\sigma_z = k_1 x + k_2 y$$

here

$$k_1 = \frac{(I_{xx}M_y - I_{xy}M_x)}{(I_{xx}I_{yy} - I_{xy}{}^2)}$$

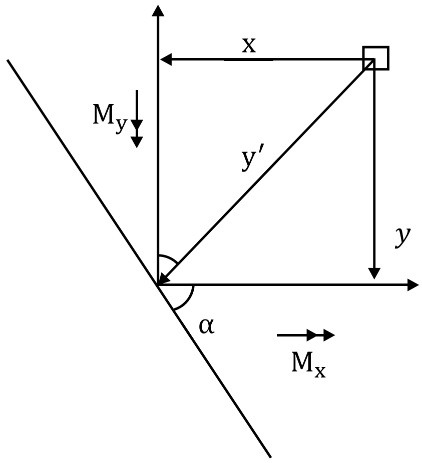
$$k_2 = \frac{(I_{yy}M_x - I_{xy}M_y)}{(I_{xx}I_{yy} - I_{xy}{}^2)}$$

For Symmetric C/S

$I_{xy} = 0$

$$\sigma_z = \frac{M_{xy}}{I_{yy}}x + \frac{M_x}{I_{xx}}y$$

Position of Neutral axis:



At neutral axis

$$\sigma_z = k_1 x + k_2 y = 0$$

$$\Rightarrow k_1 x_{NA} + k_2\, y_{NA} = 0$$

$$\Rightarrow \frac{-y_{NA}}{x_{NA}} = \tan\alpha = \frac{k_1}{k_2}$$

Where α is inclination of neutral axis

α is measure in x-axis in clockwise direction

FLEXURAL-SHEAR FLOW

For thin-walled Open Section

Change of shear flow along section

$$\frac{\partial q}{\partial s} = -t\left[\frac{I_{xx}\frac{\partial M_y}{\partial z} - I_{xy}\frac{\partial M_x}{\partial z}}{I_{xx}I_{yy} - I_{xy}{}^2}\right]x$$

$$-t\left[\frac{I_{yy}\frac{\partial M_x}{\partial z} - I_{xy}\frac{\partial M_y}{\partial z}}{I_{xx}I_{yy} - I_{xy}{}^2}\right]y$$

$$V_x = \frac{\partial M_y}{\partial z} \text{ and } V_y = \frac{\partial M_x}{\partial z}$$

$$\frac{\partial q}{\partial s} = -t\frac{(I_{xx}V_x - I_{xy}V_y)}{(I_{xx}I_{yy} - I_{xy}{}^2)}x$$

$$-t\frac{(I_{yy}V_y - I_{xy}V_x)}{(I_{xx}I_{yy} - I_{xy}{}^2)}y$$

$$q_{s2} - q_{s1} = \int_{s_1}^{s_2}\frac{\partial q}{\partial s}ds$$

Note: For thin-walled section at the free end (open end) shear flow is considered as zero (Boundary condition)

For thin walled idealized (boom) section

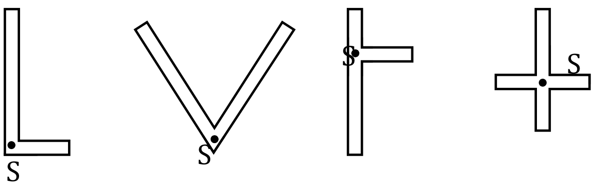
$$q_s = -\frac{(I_{xx}V_n - I_{xy}V_y)}{(I_{xx}I_{yy} - I_{xy}^2)}\Sigma Ax - \frac{(I_{xx}V_y - I_{xy}V_y)}{(I_{xx} - I_{yy} - I_{xy}^2)}\Sigma Ay$$

For Closed Section

$q = q_s + q_{s,0}$

Shear Centre

- Shear centre is a point, if transverse loading is applied through this point, and then there will be no twist of the section. It will be only undergoing bending.
- It is also the point of twist or centre of the twist or centre of flexure.
- Shear centre is cross section property and it is independence of loading.
- For any section, if there is a junction, the junction itself will be a shear centre.



- For doubly symmetric section, shear centre and centroid is same.
- For single symmetric section, shear centre lies on axis of symmetry.

TORSION OF THIN-WALLED STRUCTURES

For Solid shaft

$\tau \propto r$ (radial distance)

$\theta \propto l$ (Longitudnal length)

Torsional Formula

$\frac{\tau}{r} = \frac{T}{J} = \frac{G\theta}{L}$ $\quad \tau_{\text{solid shaft}} = \frac{16T}{\pi d^3}$

For Thin-Walled single cell closed section:

Shear Flow $q = \tau t$

Bredth -Batho Theory:

$T = 2Aq$

$\tau = \frac{q}{t} = \frac{T}{2At}$

Angle of twist per unit length:

$$\frac{d\theta}{dx} = \frac{T}{4A^2G}\oint\frac{ds}{dt} = \frac{q}{2AG}\oint\frac{ds}{t}$$

$$T = GJ\frac{d\theta}{dx}$$

Torsional Constant:

$$J = \frac{4A^2}{\int\frac{ds}{t}}$$

Torsional Rigidity

$$GJ = \frac{4A^2}{\int\frac{ds}{Gt}} \rightarrow \text{torstonal Rigidity}$$

$J = I_P \rightarrow$ for circular crossection $= 2\pi r^3 t$

Thin-Walled single cell Open section:

Torsional formula

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

Torsion constant $J = \sum \frac{bt^3}{3}$ or $\int \frac{t^3 ds}{3}$

Max shear stress

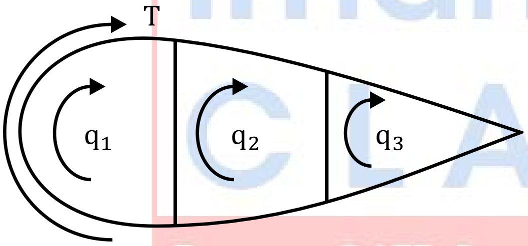
$$\tau_{max} = \frac{T}{J} t$$

Here t is thickness

Angle of twist per unit length

$$\frac{\theta}{L} = \frac{T}{GJ}$$

Thin-Walled multi cell closed section



Bredt Batho Equation

$T = 2A_1q_1 + 2A_2q_2 + 2A_3q_3$ .... (1)

Compatibility equation

$\theta'_1 = \theta'_2 = \theta'_3$ .... (2)

Note: - For multi shell there is less twist than single shell.

AIRCRAFT STRUCTURAL COMPONENT

Functions of Skin or Cover

1. It transmits the aerodynamic farces to the longitudinal and transverse supporting members by plate and membrane action
2. It develops shearing stresses which react to the applied torsional moments and shear forces.
3. It acts with the longitudinal members in resisting the applied bending and axial loads.
4. It acts with longitudinal members in resisting the hoop or circumferential load when the structure is pressurized.
5. In addition to theses, it provides an aerodynamic surface and cover for the contents of the vehicle.
   - Spar webs play a role that is like function 2 of the skin.

Functions of Longitudinal, Stringers or Stiffeners (Longerons)

1. They resist bending and axial loads along with the skin.
2. They divide the skin into small panels and thereby increase its buckling and failure stresses.
3. They act with the skin in resisting axial loads caused by pressurization.
   - The spar caps in an aerodynamic surface perform functions 1 and 2

Functions of Frames, Ribs and Rings (Bulkheads)

1. Maintain cross section shape
2. Distribute concentrated loads into the structure and redistribute stresses around structural discontinuities.
3. Establish the column length and provide end restraint for the longitudinal to increase their column buckling stress.
4. Provide edge restraint for the skin panels and thereby increase the plate buckling stress of these elements.
5. Act with the skin in resisting the circumferential loads due to pressurization.

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OUR COURSES

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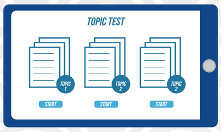
Course Features



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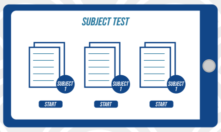

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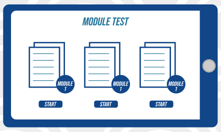

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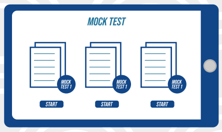

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