Formula Home

- **Plate Theory**
  - Classical Plate
    - Kinematics
    - Constitutive
    - Resultants
    - Equilibrium
  - Sign Convention
- **Plate Calculators**
  - Calculator List
- **Material Data**
  - Elastic Moduli
- **Resources**
  - Bibliography

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Materials | Design | Processes | Units | Formulas | Math

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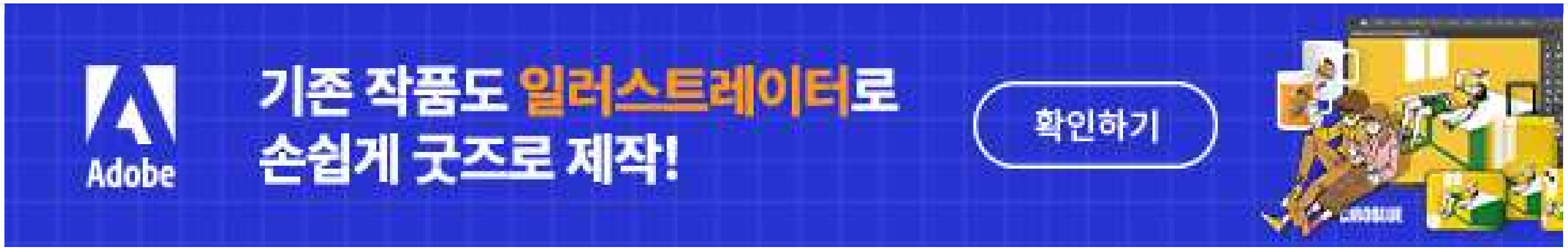

To enforce equilibrium, consider the balance of forces and moments acting on a small section of plate. There are six (6) equilibrium equations, three for the forces and three for the moments, that need to be satisfied.

The equations of force equilibrium are

$$x \text{ direction: } \frac{\partial N_x}{\partial x} + \frac{\partial N_{yx}}{\partial y} + p_x = 0$$

$$y \text{ direction: } \frac{\partial N_{xy}}{\partial x} + \frac{\partial N_y}{\partial y} + p_y = 0$$

$$z \text{ direction: } \frac{\partial Q_{xz}}{\partial x} + \frac{\partial Q_{yz}}{\partial y} + p_z = 0$$

where N_x, N_y, N_{xy}, N_{yx}, Q_{xz}, and Q_{yz} are force resultants; p_x, p_y, and p_z are distributed external forces applied on the plate.

The equations of moment equilibrium are

$$x \text{ direction: } -\frac{\partial M_{xy}}{\partial x} - \frac{\partial M_y}{\partial y} + Q_{yz} + m_x = 0$$

$$y \text{ direction: } \frac{\partial M_x}{\partial x} + \frac{\partial M_{yx}}{\partial y} - Q_{xz} + m_y = 0$$

$$z \text{ direction: } N_{xy} - N_{yx} + m_z = 0$$

where M_x, M_y, M_{xy}, M_{yx}, N_{xy}, and N_{yx} are moment resultants; and m_x, m_y, and m_z are distributed external

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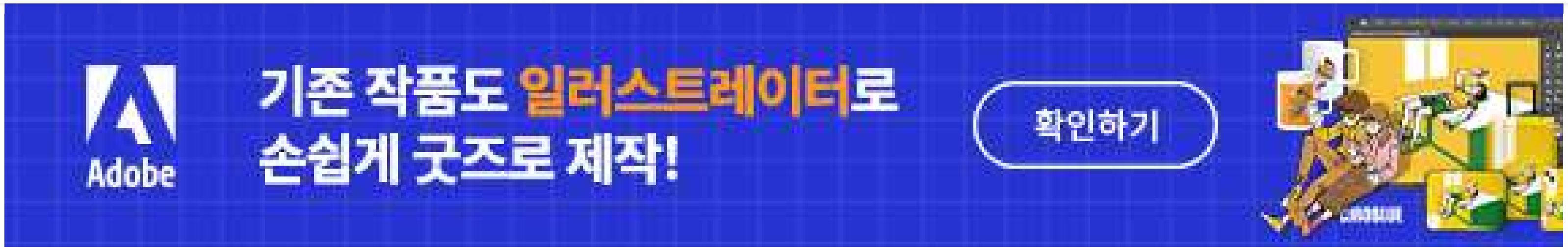

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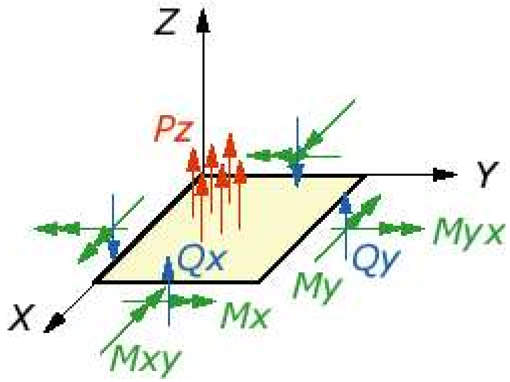
Further Simplicification



To further simplify the problem, consider a plate subjected to transverse loads. In other words, only p_z is the non-zero external force. All forces and moments in other directions are zero: $p_x=p_y=m_x=m_y=m_z=0$

The above six equations of equilibrium become

$$\frac{\partial N_x}{\partial x}+\frac{\partial N_{yx}}{\partial y}=0$$

$$\frac{\partial N_{xy}}{\partial x}+\frac{\partial N_y}{\partial y}=0$$

$$\frac{\partial Q_{xz}}{\partial x}+\frac{\partial Q_{yz}}{\partial y}=-p_z$$

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$$N_{xy} = N_{yx}$$

Due to the lack of external force components other than p_z, the shear stresses at any given point are paired as follows:

$$\sigma_{xy} = \sigma_{yx}$$
$$\sigma_{yx} = \sigma_{xy}$$
$$\sigma_{zx} = \sigma_{xz}$$

This yields

$$N_{xy} = N_{yx}$$

$$M_{xy} = M_{yx}$$

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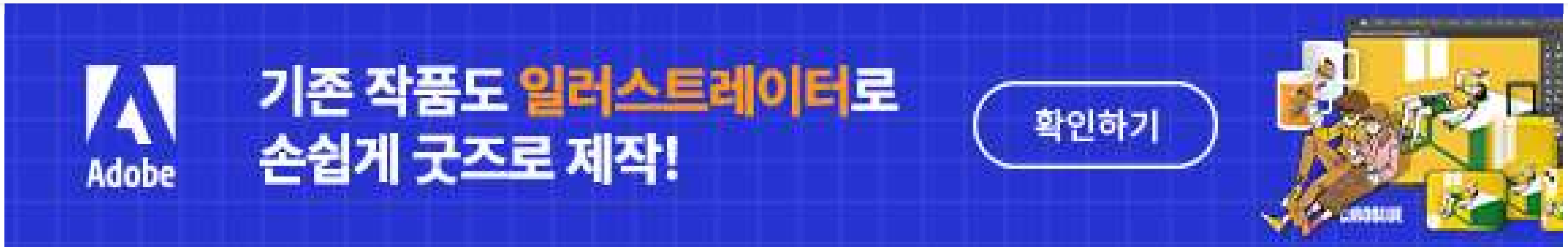

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