Faculty Name	:	**Dr.M.Subramanian, Prof & Head/ Aerospace**	Academic Year	:	**2024-2025 (Odd)**
Year & Branch	:	**III Aerospace**	Semester	:	**V**
Course	:	**19ASB302 – Finite Element Method for Aerospace**			

Unit:1

Plane stress, plane strain

Plane Stress:

- Plane stress occurs when a material is subjected to loads that act within a single plane, and the stress in the direction perpendicular to this plane is assumed to be negligible. In other words, the stress components acting in the thickness direction are considered to be zero.
- This simplification is often used for thin structures like plates, shells, and beams where the thickness is much smaller compared to the other dimensions.
- Plane stress analysis is commonly used in engineering applications such as the design of pressure vessels, aircraft structures, and electronic components.

Plane Strain:

- Plane strain occurs when a material is subjected to loads that cause deformation only in two dimensions while the material is constrained from deforming in the third dimension. In plane strain conditions, the strain in the direction perpendicular to the loaded plane is assumed to be zero.
- This simplification is useful for analyzing problems like the stretching of a thin sheet of material where the thickness remains constant during deformation.
- Plane strain analysis is commonly used in geotechnical engineering, metal forming processes, and other applications involving thin structures.

Differences from Normal Stress and Normal Strain:

1. Normal Stress:

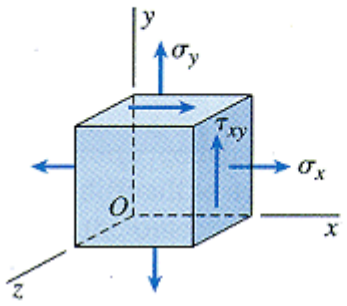
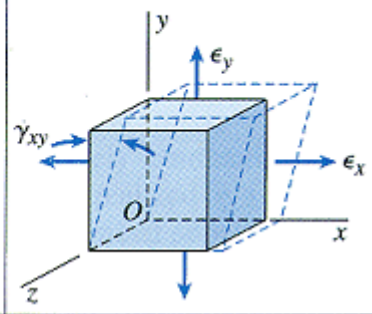
- Normal stress refers to the stress that acts perpendicular to a given plane or surface within a material.
- In the context of plane stress and plane strain, normal stress is the stress acting in the direction perpendicular to the plane of interest.
- Normal stress can cause a material to deform or change shape in the direction perpendicular to the surface on which it acts.

Normal Strain:

- Normal strain refers to the deformation that occurs in a material in the direction perpendicular to a given plane or surface.
- In the context of plane stress and plane strain, normal strain is the strain that occurs in the direction perpendicular to the plane of interest.
- Normal strain is a measure of how much a material elongates or contracts in the direction perpendicular to the applied load.

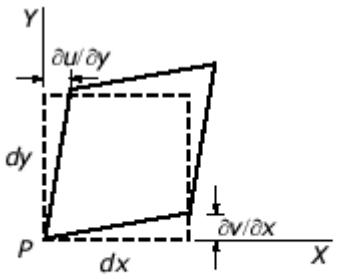
In summary, plane stress and plane strain are simplifications that assume negligible stress or strain in the direction perpendicular to a specific plane of interest. This

simplification allows for easier analysis of certain types of problems in solid mechanics, particularly in cases where the thickness of a structure is much smaller compared to the other dimensions. Normal stress and normal strain, on the other hand, refer to stress and strain acting in the direction perpendicular to a given plane or surface within a material.

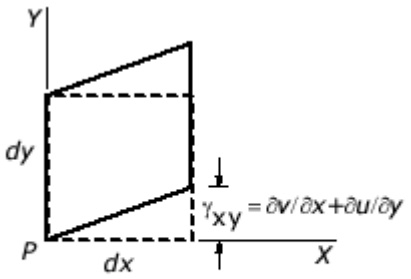
	Plane stress	Plane strain
		
Stresses	$\sigma_z = 0 \quad \tau_{xz} = 0 \quad \tau_{yz} = 0$ σ_x, σ_y, and τ_{xy} may have nonzero values	$\tau_{xz} = 0 \quad \tau_{yz} = 0$ σ_x, σ_y, σ_z, and τ_{xy} may have nonzero values
Strains	$\gamma_{xz} = 0 \quad \gamma_{yz} = 0$ ϵ_x, ϵ_y, ϵ_z, and γ_{xy} may have nonzero values	$\epsilon_z = 0 \quad \gamma_{xz} = 0 \quad \gamma_{yz} = 0$ ϵ_x, ϵ_y, and γ_{xy} may have nonzero values

Stress and strain are related to each other. Being linear relation for solids. On the other hand for fluids, if this relation is linear the fluid is called Newtonian and if it's non-linear the fluid is called non-Newtonian.

Depending upon the matter/material on which the strain (due to deformation) is acting and knowing the relation, we can get the stresses.

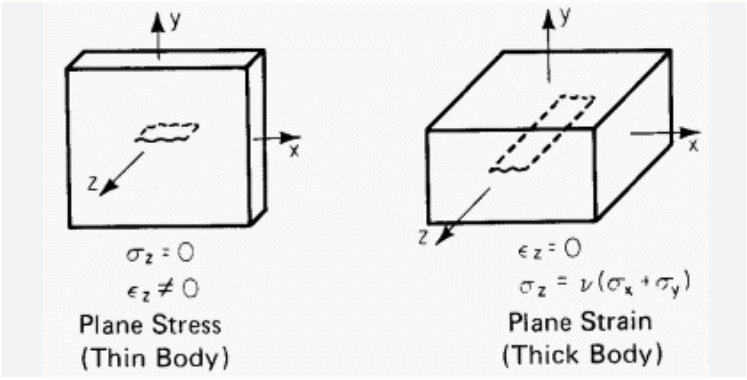


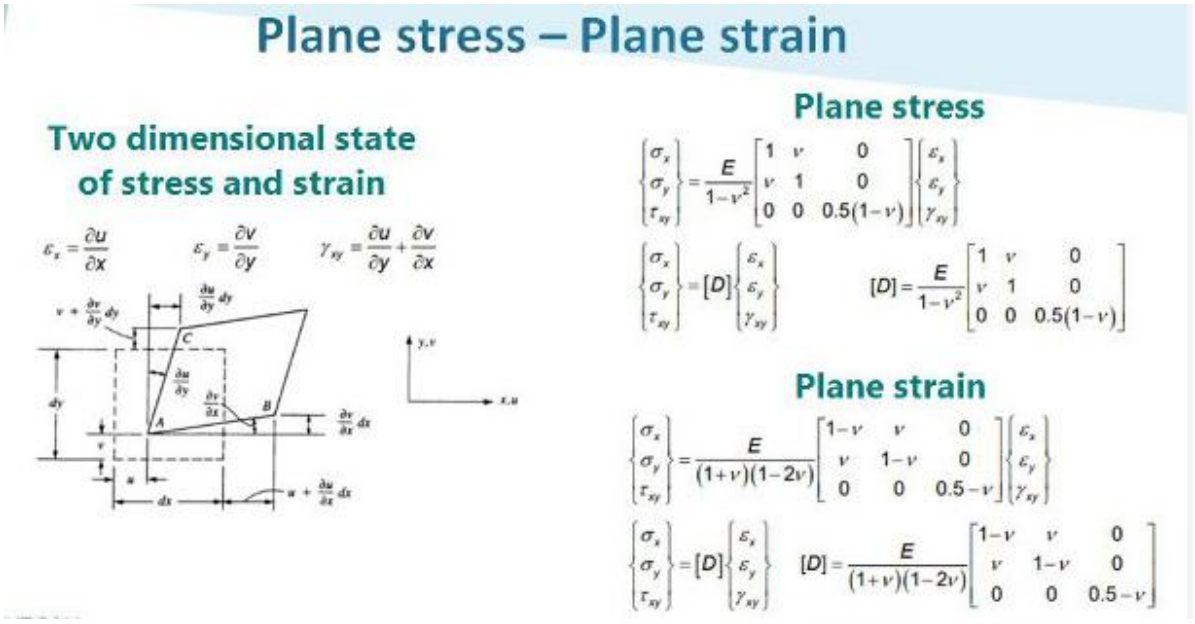
Shear strain tensor is the ***average*** of two strains, i.e.,
$\varepsilon_{xy} = (\partial v/\partial x + \partial u/\partial y)/2 = \varepsilon_{yx}$

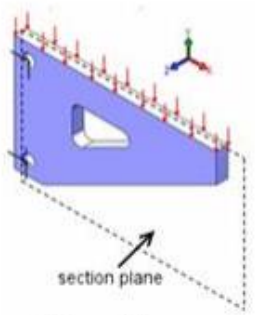


Engineer shear strain is the ***total*** shear strain, i.e.,
$\gamma_{xy} = \partial v/\partial x + \partial u/\partial y$

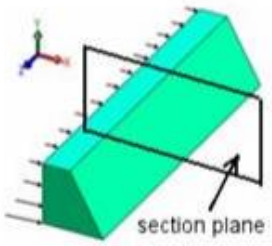
Plane stresses are those which act along/tangential to the plane, also known as shear stresses. Similarly plane strain are those which act along/tangential to the plane, also known as shear strains.



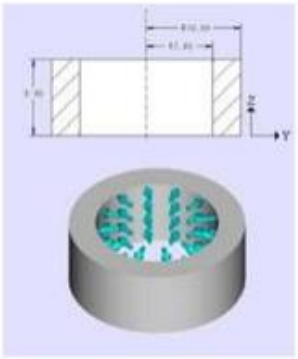




Plane Stress



Plane Strain



Axisymmetric

Prepared: Dr. M. Subramanian/Professor & Head Aerospace Engineering