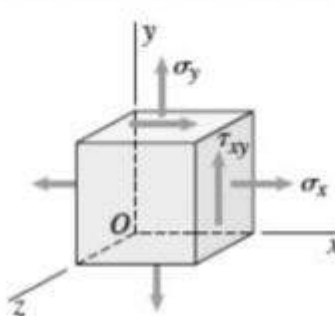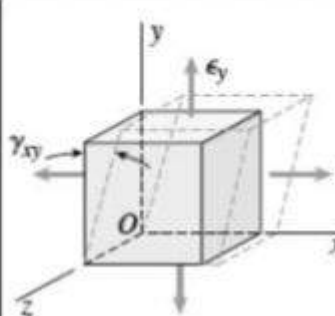# Plane Stress vs Plane Strain

Plane stress is an approximation, but the plane strain is an accurate solution. Plane strain is a specific solution to the entire three-dimensional elasticity equations, whereas plane stress occurs only when the thickness of the laden body approaches zero. Stress, or the force applied to a material, is defined as the force divided by the substance's cross-sectional area. Both Plane Stress and Plane Strain are important as per the GATE exam. Strain is a material's deformation or displacement induced by applied stress.

Difference Between Plane Stress and Plane Strain

Plane strain is a precise solution, whereas plane stress is an approximation. In contrast to plane stress, which only manifests when the thickness of the laden body approaches zero, plane strain is a specific solution to the whole set of three-dimensional elasticity equations.

	Plane stress	Plane strain
Stresses	$\sigma_z = 0 \qquad \tau_{xz} = 0 \qquad \tau_{yz} = 0$ $\sigma_x, \sigma_y,$ and τ_{xy} may have nonzero values	$\tau_{xz} = 0 \qquad \tau_{yz} = 0$ $\sigma_x, \sigma_y, \sigma_z,$ and τ_{xy} may have nonzero values
Strains	$\gamma_{xz} = 0 \qquad \gamma_{yz} = 0$ $\epsilon_x, \epsilon_y, \epsilon_z,$ and γ_{xy} may have nonzero values	$\epsilon_z = 0 \qquad \gamma_{xz} = 0 \qquad \gamma_{yz} = 0$ $\epsilon_x, \epsilon_y,$ and γ_{xy} may have nonzero values

Plane Stress

Plane stress is a state where the normal stress remains zero, and the shear stress in the direction perpendicular to the applied load is assumed to be zero. In planar stress, one of the object's dimensions is insignificant compared to the other two dimensions. Plane stress is widely used in formulating questions in the GATE ME

question paper. In basic terms, a uniform load is given to the object's thickness, which is substantially smaller than the object's other two dimensions.

Furthermore, the shear stress caused by the load can be minor since it causes negligible deformations in the object's thickness. There is insufficient limit material to maintain constant thickness stress:

$$\sigma_Z = \sigma_{XZ} = \sigma_{YZ} = 0$$

Plane Strain

In simple strain, the object's thickness is significantly greater than its other two dimensions. Plane strain distorts an object's dimension in the plane's perpendicular directions. Plane strain assumptions are useful for modelling real-world components. MSQ-based questions are formulated using the plane strain concept in the GATE question paper. In-plane stresses are created in the same way that they are in a full 3D model, but out-of-plane or z-direction strains are set to zero. It occurs in an object with strong z-direction walls. The formulation only allows for stress reduction in the plane, hence the plane strain:

$$ZZ = XZ = YZ = 0$$

Hooke's Law

The interaction of the three normal stresses and strains is the primary influence of plane stress and strain assumptions. Hooke's law is a very important part of the GATE ME syllabus. To see this, you must be familiar with Hooke's Law, but only for regular stresses and strains, not shears. Remember that Hooke's Law can be summed up in a single tensor equation.

$$\epsilon_{ij} = \frac{1}{E}\left[(1+\nu)\sigma_{ij} - \nu\,\delta_{ij}\,\sigma_{kk}\right]$$

$$\sigma_{ij} = \frac{E}{(1+\nu)}\left[\epsilon_{ij} + \frac{\nu}{(1-2\nu)}\delta_{ij}\epsilon_{kk}\right]$$