Stress

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Synonyms

Pressure

Definition

Stress acting on a rock or soil mass can cause the mass to experience a change in volume, a change in shape, or a change in both volume and shape. Stress is a tensor quantity, having a magnitude and direction, like a vector quantity, but also requiring reference to a plane across which it acts (Eberhardt 2009). A rock or soil mass represented as a cube with dimensions approaching zero can be oriented such that its faces are parallel to Cartesian coordinate system axes x , y , and z . Considering the area of each face of the reference cube to approach zero demonstrates that stress is a point property. The stress field σ acting on the faces of the reference cube can be resolved into one component that is perpendicular or normal to each face of the cube (normal stresses σ_{xx} , σ_{yy} , and σ_{zz}) and two components that are in the plane of each face of the cube, parallel with its edges, and perpendicular to each other (shear stresses τ_{xy} , τ_{xz} , τ_{yx} , τ_{yz} , τ_{zx} , and τ_{zy}); the subscripts denote the axis perpendicular to the plane on which each component acts and the direction in which the component acts. Opposite sides of the cube have normal stress components that are of equal magnitude and opposite direction. Shear stresses on adjacent planes that act in perpendicular directions have the same magnitude ($\tau_{xy} = \tau_{yx}$, $\tau_{xz} = \tau_{zx}$, and $\tau_{yz} = \tau_{zy}$). Consequently, the stress tensor σ has nine components, three that are normal stresses and six that are shear stresses (Rock Mechanics for Engineers 2016).

$$\sigma = \begin{bmatrix} \sigma_{xx} & \tau_{yx} & \tau_{zx} \\ \tau_{xy} & \sigma_{yy} & \tau_{zy} \\ \tau_{xz} & \tau_{yz} & \sigma_{zz} \end{bmatrix} \quad (1)$$

Stress that causes a change in volume without a change in shape results from hydrostatic pressure, which is a scalar quantity because it acts equally in all directions and has the same units as stress (force per unit area). Liquid and gas cannot sustain or transmit shear stress; thus, hydrostatic stress is a scalar quantity referred to as pressure. The reference cube can be rotated to a position such that the shear stresses in the planes of the faces have zero magnitude, which coincides with the normal stresses being principal stresses. The stresses applied to a rock or soil mass include the hydrostatic stress and other stress produced by tectonic forces, external loads, and excavations that may remove earth materials which provide support for adjacent earth material (Pariseau 2012).

Cross-References

- Deviatoric Stress
- Geostatic Stress
- Pressure

References

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- Pariseau WG (2012) Design analysis in rock mechanics, 2nd edn. CRC Press, London
- Rock Mechanics for Engineers (2016) Principal stresses and stress invariants. <http://www.rockmechs.com/stress-strain/stress/principal-stresses-and-invariants/>. Accessed April 2016