

# Experimental and Numerical Study on the Anchoring Mechanism of an Anchor Bolt Considering its Lateral Restraint Effect

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**Abstract:** Anchoring is a highly effective means to reinforce jointed rock masses. In addition to the axial force from the anchor bolt, the effect of its transverse force in constraining the displacement of the structural plane cannot be ignored. Thus, this paper studies the combined action of the axial and shear forces of an anchor bolt on enhancing the shear strength of the anchored joint. In this work, first, laboratory direct shear tests are conducted to study the evolution of the peak shear strength of the anchored joint with increasing angle between the shear direction and bolt inclination. Second, to further verify this trend, numerical simulation with the finite difference method is used to simulate the same direct shear tests to reveal the lateral and axial stresses and deformations of the bolt. Finally, according to classical beam theory, the mechanical analysis model of a bolt subjected to the combined action of axial tension and lateral shear is established, which takes the realistic stress and deformation patterns of the bolt from the numerical simulation into account. The results show that the lateral restraint of the bolt plays a significant role in the shear strength of the anchored joint, its enhancing effect first increases and then decreases with increasing installation angle, and the optimal installation angle providing the maximum shear strength is approximately 60°. In addition, it is concluded that the shear resistance of the bolt is mainly due to its axial force when the installation angle is relatively small; conversely, the shear resistance of the bolt is mainly due to its shear force when the installation angle is relatively large.

**Keywords:** Rock bolt; Anchoring mechanism; Shear strength; Direct shear test; Lateral restraint