Limit Analysis of 3D Reinforced Concrete Beam Elements

A new finite-element framework for lower-bound limit analysis of reinforced concrete beams, subjected to loading in three dimensions, is presented. The method circumvents the need for a direct formulation of a complex section-force-based yield criterion by creating a discrete representation of the internal stress-state in the beam. The yield criteria are formulated and applied on a stress-state level. The stress-state is decomposed to concrete and reinforcement stresses, and separate yield criteria are applied to each component. Simple limits are used on the reinforcement stresses, and a modified Coulomb criterion is applied to the concrete stresses. The modified Coulomb criterion is approximated using second-order cone programming for improved performance over implementations using semidefinite programming. The element is verified by comparing the numerical results with analytical solutions.

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