# Comparative Analysis of Material Models in Simulating Reinforced Concrete Beam Bending

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## Abstract

Characterizing the inelastic behavior of concrete presents a challenge due to its quasi-brittle nature. Concrete exhibits brittle fracture under uniaxial tension, while under compression, it demonstrates strain hardening, softening, and ultimately crushing. Throughout its load history, concrete undergoes various damage states, including compressive crushing, tensile cracking, stiffness degradation, and subsequent stiffness recovery through crack closure. To facilitate Finite Element (FE) analysis, numerous material models have been devised over time to accurately describe the nonlinear behavior of concrete. This study investigates the accuracy of these models in simulating reinforced concrete (RC) beams under four-point bending tests. A reinforced concrete beam with flexural and shear reinforcement is subjected to incremental loading until failure, with load and displacement data recorded to analyze the load-deflection response. The FE model incorporates concrete damage plasticity (CDP), Menetrey-Willam (MW), Drucker-Prager (DP), and coupled damage-plasticity micro-plane (CDPMP) models. Multiple stages of the reinforced concrete beam are simulated, such as elastic behavior, first crack, multiple crack formation, and rebar yielding. Initial simulations using the CDP model with closed-form tension equations revealed discrepancies at crack initiation. To improve accuracy, Nayal and Rasheed's tension stiffening model and a novel tension model with a steeper post-cracking stress drop are tested. The proposed model within the CDP framework closely matches experimental results across all deformation stages. This research underscores the importance of selecting appropriate material models for simulating RC behavior, demonstrating that the proposed tension model within the CDP framework and the CDPMP model offers effective and efficient solutions for accurately predicting load-deflection behavior in RC beams. This enhances the predictive capabilities of numerical simulations in concrete structure analysis.