Review of Finite Element Analysis (FEA) of Concrete Reinforced Materials

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Abstract

As a heterogeneous and generally anisotropic material with both brittle and ductile failure modes, concrete is a difficult material to simulate using finite element models. Coupled with discrete reinforcement interactions and different material properties depending on strain degradation, many different numerical models are available for accurately representing concrete with varying tradeoffs. This study provides a review of general Finite Element Analysis (FEA) techniques and methodologies, how concrete and reinforced concrete are unique, and examples of accurate modeling to assist in further understanding this subject. Finite element modeling of concrete and reinforced concrete structures offers considerable complexity due to concrete's composite structure and a large difference in its compressive and tensile strengths. The two preeminent methods of solving concrete systems are the Smeared Crack Method (SCM) and the Concrete-Damaged Plasticity (CDP) model. The powerful program Abaqus, used in this study, is capable in utilizing these models in the concrete analysis. The SCM and the CDP model both offer a method of simulating concrete complex behavior in finite element analysis software packages, each with their own advantages and disadvantages. While the SCM is well suited to non-cyclic loading and is less computationally intensive, it is often unstable without careful consideration of reinforcement. The CDP model is more computationally intensive and requires a larger amount of test data to yield accurate results, but it models the behavior of concrete under repeated load cycles and is well suited to simulating seismic loads and fatigue-like behavior, as well as accurate crack prediction. Overall, the field of concrete finite element analysis is still developing, and future advancements in the form of existing model refinements or entirely new models may still be possible.

Keywords: Concrete, Finite Element Analysis (FEA), Abaqus, Structures, Fatigue, Crack