OPTIMIZATION OF STRUCTURES WITH UNCERTAINTY USING NON-PROBABILISTIC UNCERTAINTY MODELS
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The purpose of this project is to investigate the application of a new theory for modeling uncertainties, the theory of convex models, in the optimization of structural systems. The convex model is a relatively new theory for dealing with uncertainties, and is very useful when lack of information makes the implementation of probabilistic methods difficult. Both the uniform bound and the ellipsoidal convex models are considered in this project. The convex model is applied to different types of uncertainties, including gravity, live, wind, and earthquake loads, as well as structural resistance variables such as the modulus of elasticity. Fractional uncertainty of static loads is examined, with respect to the optimization of the volume of a steel truss, which results in the truss with the minimum cost. The convex model is implemented for structural systems subjected to uncertain loads both in magnitude and direction. The effect of uncertainties, modeled using convex models, on structural displacements is found in closed-form for certain well-posed problems. Three methods are defined for determining the parameters of an ellipsoidal convex model, i.e., the dimensions of the convex domain. A linear superposition method for implementing the uniform bound or “box” convex model, for optimal structural design, has been achieved. The method is based on convex model superposition of linear systems and it does not require deviation of closed-form expressions. The ellipsoidal and uniform bound convex models were used for the study of combined uncertainty in the applied loads and structural resistance. Finally, the convex model is implemented in the seismic design of reinforced concrete frames considering that the period of the structure and the magnitude of the earthquake are uncertain. The design spectrum is modeled as a convex domain and the maximum structural response is obtained. Performance-based design concepts and design constraints are used in the structural optimization. This study has shown that convex model theory can be used to account for uncertainties in structural systems. Moreover, convex models can be used effectively in the optimal design of structures.