Stress analysis of a doubly reinforced concrete beam with uncertain structural parameters

M.V.Rama Rao
Department of Civil Engineering
Vasavi College of Engineering, Ibrahimbagh
Hyderabad-500 031 INDIA
dr.mvrr@gmail.com

Andrzej Pownuk
Department of Mathematical Sciences
University of Texas at El Paso
500 W. University Ave.
El Paso, Texas 79968, USA
ampownuk@math.utep.edu

David Moens
Department of Mechanical Engineering
Katholieke Universiteit Leuven
Kasteelpark Arenberg 41
3001 Heverlee Belgium
david.moens@mech.kuleuven.be

Abstract

In this paper, the cross-section of a doubly reinforced concrete beam with interval values of structural parameters and subjected to an interval bending moment is taken up for analysis. The uncertainties in loading, areas of reinforcement in tension and compression and the corresponding Young's modulus of steel are defined by fuzzy membership functions. The interval values of the structural parameters at a specified level of uncertainty are extracted from these membership functions using the α-cut approach. The internal moment of resistance of the beam is expressed as a function of interval values of stresses in concrete and steel. The stress distribution model for the cross section of the beam given by IS 456-2000 (Indian Standard Code of Practice for Plain and Reinforced Concrete) is modified for this purpose. The internal moment of resistance is then equated to the external bending moment due to interval loads acting on the beam.

The stresses in concrete and steel are obtained as interval values for

various combinations of interval structural parameters. The stress analysis is performed by three principal approaches viz. a search based algorithm, sensitivity analysis and a combinatorial approach. Also, approximate search based solution schemes are applied on the same problem. The reduced optimization performs the search on a subset of the uncertainty space by first identifying the uncertain parameters that have substantial impact on the output of interest. A response surface based method further reduces the computational burden of the global optimization problem. Reference results with guaranteed accuracy are calculated using global optimization.

The methods are compared to the reference results for accuracy as well as numerical efficiency. Combined membership functions are plotted for neutral axis depth and stresses in concrete and steel and are found to be triangular. Interval stresses and strains are also calculated. It is observed that the results obtained are in excellent agreement. These approaches allow the designer to have a detailed knowledge about the effect of uncertainty on the stress distribution of the beam. Thus modelling with intervals provides a link between design and analysis where uncertainty may be represented by bounded sets of parameters.

References:

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