Reliability response surfaces for a nonlinear deflection problem under geometric uncertainty

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This work presents a reliability-based analysis of a nonlinear deflection problem under geometric uncertainty. The investigated system is a cantilever column subjected to an axial compressive force and a transverse distributed load. The deterministic response is described by an Euler-Bernoulli beam formulation including the P-Delta effect, where the axial force acting on the laterally deflected configuration increases the final displacement. The column length is modelled as a normally distributed random variable, and its coefficient of variation defines the level of geometric uncertainty. A deflection-based limit state function is defined as the difference between the allowable deflection and the nonlinear P-Delta deflection response.

The reliability index is evaluated as a function of the coefficient of variation of the column length and the axial load multiplier. Three approaches are compared: Monte Carlo simulation, an analytical approximation based on a truncated series expansion, and the tenth-order stochastic perturbation method. The calculated reliability indices are then approximated by bivariate polynomial response surfaces using the least-squares method. These surfaces are used to interpret reliability degradation and to draw reference reliability contours.

The results show that increasing geometric uncertainty and axial load level reduce reliability. The response surface representation provides a compact framework for interpreting the analysed nonlinear reliability problem.

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