8th. World Congress on Computational Mechanics (WCCM8)
5th. European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 – July 5, 2008
Venice, Italy

ROBUST DESIGN OF SHELLS WITH STOCHASTIC PROPERTIES

*** Vissarion Papadopoulos[1], Nikos D. Lagaros[2] and Manolis Papadrakakis[3]**

[1] National Technical University of Athens
Athens, GR-15780, Greece
vpapado@central.ntua.gr

[2] National Technical University of Athens
Athens, GR-15780, Greece
nlagaros@central.ntua.gr

[3] National Technical University of Athens
Athens, GR-15780, Greece
mpapadra@central.ntua.gr

Key Words: *Robust design optimization*, *Nonlinear shell finite element, Stability analysis, Stochastic imperfections.*

ABSTRACT

In the present study an efficient RDO formulation is proposed for the combined probabilistic sizing and shape optimization of shell-type structures possessing random initial geometric material and thickness imperfections. In particular, the effect of combined geometric, material and thickness imperfections on the buckling load of cylindrical shells is investigated. For this purpose, the concept of an initial “imperfect” structure is introduced involving not only geometric deviations of the shell structure from its perfect geometry but also a spatial variability of the modulus of elasticity as well as of the thickness of the shell. These combined “imperfections” are incorporated in an efficient and cost effective non-linear stochastic finite element formulation of the TRIC shell element [13-16] using the mid point method for the derivation of the stochastic stiffness matrix, while the variability of the limit loads is obtained by means of a brute-force Monte Carlo Simulation (MCS) procedure. All types of imperfections are modeled as two dimensional univariate homogeneous stochastic fields (2D-1V) using the spectral representation method.

Two objective functions, the material volume of the structure and the coefficient of variation of the buckling load of the shell, are used for the description of the RDO problem, while deterministic constraints imposedby Eurocode 3 are taken into account. Numerical results are presented for a cylindrical panel, demonstrating the efficiency as well as the applicability of the proposed methodology in obtaining rational optimum designs of imperfect shell-type structures. The solution of the two-objective optimization problem at hand is performed with the Nondomination Sort Evolution Strategies II (NSES-II) algorithm, which has been proved very efficient.

REFERENCES

[1] C.A. Schenk and G.I. Schuëller, “Buckling analysis of cylindrical shells with random geometric imperfections”, *Int. J. of Non-Linear Mechanics*, Vol. **38**, pp. 1119-1132, (2003).

[2] V. Papadopoulos and M. Papadrakakis, "Finite element analysis of cylindrical panels with random initial imperfections", *J. of Engineering Mechanics (ASCE)*, Vol. **130**, pp. 867-876, (2004).

[3] Lagaros ND, Papadopoulos V. Optimum design of shell structures with random geometric, material and thickness imperfections, *International Journal of Solids and Structures*, 43(22-23): 6948-6964, (2006).