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

SOFT COMPUTING APPROACHES FOR PROBABILISTIC DESIGN OPTIMIZATION OF STRUCTURES

*** Nikos D. Lagaros[1], Anargyri Th. Garavelas[2] and Manolis Papadrakakis[3]**

[1] Lecturer
Institute of Structural Analysis and Seismic Research,
School of Civil Engineering,
National Technical University of Athens,
Zografou Campus, Athens, 15771, Greece
nlagaros@central.ntua.gr

[2] Civil Engineer
Institute of Structural Analysis and Seismic Research,
School of Civil Engineering,
National Technical University of Athens,
Zografou Campus, Athens, 15771, Greece
anniegaravelas@yahoo.gr

[3] Professor
Institute of Structural Analysis and Seismic Research,
School of Civil Engineering,
National Technical University of Athens,
Zografou Campus, Athens, 15771, Greece
mpapadra@central.ntua.gr

Key Words: *Performance-based design, reliability-based optimization, response surface, Monte Carlo, neural networks.*

ABSTRACT

Performance-based design (PBD) is the current trend in designing better and more economic earthquake-resistant structures. The main objective of PBD is to achieve more predictable and reliable levels of safety and operability against natural hazards. According to the PBD procedures, the structures should be able to resist earthquakes in a quantifiable manner and to present target performance levels of possible damages. PBD procedures are multi-level design approaches where various levels of structural performance are considered. Furthermore, due to the significant improvements achieved in the optimization methods and the advancements in computer resources have made structural optimization an important ingredient in the design of structures.

In this work the concept of PBD is incorporated in the framework of Reliability-Based Design Optimization (RBDO) for the design of real world 3D steel buildings, where the initial construction cost is considered as the objective functions to be minimized. In this study three performance objectives are considered corresponding to the hazard levels with 50, 10 and 2 percent probabilities of exceedance in 50 years. Two types of random variables are considered in this work, random variables that influence the level of seismic demand and random variables that affect the structural capacity. The optimum design achieved with the RBDO formulation is compared with the one obtained through a deterministic-based formulation of the optimization problem.

Although a number of variance reduction techniques have been proposed in the past for reducing the computational cost of the Monte Carlo Simulation method, its implementation remains computationally inefficient especially in real world structural reliability problems where earthquake loading conditions are taken into account. For

this reason in this study the probabilistic problem is solved with the Response Surface (RS) method. The limit state function in structural problems cannot be explicitly expressed. In these cases the RS method is often adopted where the limit state function is fitted using quadratic polynomials. In this study a new method based on RS with BP neural networks is used instead. On the other hand an evolutionary algorithm is used for solving the structural optimization problem at hand.

REFERENCES

[1] Y. Tsompanakis, N.D. Lagaros and M. Papadrakakis (Eds.), Structural Design Optimization Considering Uncertainties (Structures and Infrastructures), Taylor & Francis (December 2007), ISBN: 9780415452601.

[2] M. Papadrakakis and N.D. Lagaros, “Reliability-based structural optimization using neural networks and Monte Carlo simulation”, Comput. Methods Appl. Mech. Engrg., Vol. 191(32), 3491-3507, 2002.

[3] N.D. Lagaros, A.Th. Garavelas and M. Papadrakakis, Innovative seismic design optimization with reliability constraints, Comput. Methods Appl. Mech. Engrg., (to appear), 2008.