8th International Conference on Seismology & Earthquake Engineering
11-13 Nov. 2019, Tehran, Iran

DAMAGE CONTROLLED-PERFORMANCE-BASED-OPTIMUM DESIGN OF STEEL MOMENT FRAMES, CONSIDERING LIFE-CYCLE COST

Hashem DADASHI
Ph.D. Student, IIEES, Tehran, Iran
hashem.dadashi@stu.iiees.ac.ir
Majid MOHAMMADI
Associate Professor, IIEES, Tehran, Iran
mohammadi@iiees.ac.ir

Keywords: Performance-based seismic design of structures, Optimization, Structural and non-structural element, Life-cycle cost

Major earthquakes of recent decades indicate the devastating power of earthquakes to destruct structures and cause severe economic losses. They display the need to enhance structural performance by introducing a new design methods e.g. performance-based design. This design method expresses the expected performance of a structure for a considered hazard level.

According to FEMA302, structures are categorized in three design groups. These groups determine the expected performance for a given hazard level based on the type of usage of a building and the extent of its importance. The supposed hazard levels are earthquakes with %2 probability of occurrence in 50 years (MCE) and (2/3 of MCE) and %50 in 50 years. Each building is categorized based on its type and level of occupancy. Most commercial, residential and industrial buildings are in the Seismic Use Group-I, Buildings with high occupancy or hazardous materials are in the Seismic Use Group-II and finally buildings that need to maintain their operation after earthquakes belong to Seismic UseGroup-III. The performance of the buildings in these group are different; for example residential, commercial and industrial buildings which are in Group-I, should satisfy IO and CP performance levels for earthquakes with %50 and %2 probability of occurrence in 50 years, respectively.

In regular design procedure of structures, determination of dimensions of structural elements consists of a repetitive procedure of structural analysis with continual changes in dimensions of structural elements. Especially the trial and error cycle in nonlinear analysis leads to a large volume of calculations thus the design of structures would be practically a hard and tough process. To resolve this problem, a reliable and efficient automatic method for the analysis and design of a structure would be useful. Therefore one can assign optimization methods for designing in order to reduce the design process; in other words, one can consider the optimization as a minimization or maximization process of the objective function incorporating the constraints of the problem. There are different optimization methods and in this paper, the improved PSO method, named as Rupso, will be used.

Up to now, the optimization process focused on minimizing the structural cost. However, it is clear that non-structural elements of a building should also be considered. They are mostly more valuable than the building structure and they are divided into two groups of drift-sensitive and acceleration sensitive (HAZUS-AEBM).

In other words, total damage cost of a building should be considered in the optimization process, which includes initial cost of construction and the cost of damage of structural and non-structural members during the useful life of the structure. Based on FEMA356, the constraints of the problem are the inter-story drift ratio and the rotation capacity of plastic hinges.

Therefore the mathematical presentation of the problem would be as follows:

Minimize $f(x)= I_c+L_{cc}$

subject to: $g_1(x) = \frac{StoryDrift}{allowableStoryDrift} - 1 \leq 0$

$$g_2(x) = \frac{PlasticDeformation}{allowablePlasticDeformation} - 1 \leq 0$$

In this paper, in the first step, the optimum performance-based design of steel moment frames is achieved then the damage cost of structural and non-structural members is evaluated performing a nonlinear Incremental Dynamic Analysis (IDA). Afterwards an optimal design is introduced to minimize the total cost.

In this research, the design of the structure will be based only on minimizing the cost over the useful life of the structure. The resulting structure will then be compared with the structure that is typically obtained by minimizing the initial cost of construction.

REFERENCES

Federal Emergency Management Agency (2000). *Recommended Seismic Design Criteria for New Steel Moment-Frame Buildings*. FEMA-350.

Federal Emergency Management Agency (2000). *Prestandard and Commentary for the Seismic Rehabilitation of Buildings*. FEMA-356

Federal Emergency Management Agency (1997). *Nehrp Recommended Provisions for Seismic Regulations for New Buildings and Other Structures*. FEMA-302.

Fragiadakis, M., Lagaros, N.D., and Papadrakakis, M. (2006). Performance-based multi objective optimum design of steel structures considering life-cycle cost. *Structural and Multidisciplinary Optimization*, 32, 1-11.

Gholizadeh, S., Kamyab, R., and Dadashi, H. (2013). Performance-based design optimization of Steel moment frames. *International Journal of Optimization in Civil Engineering*, 3, 327-343.

HAZUS-MH 2.1. 1992-2002. Multi-Hazard Loss Estimation Methodology, Technical Manual. Federal Emergency Management Agency.

Kaveh, A., Bakhshpoori, T., and Azimi, M. (2014). Seismic optimal design of 3D steel frames using cuckoo search algorithm. *The Structural Design of Tall and Special Buildings*, 24, 210-227.

Qiang Xue and Cheng-Chung Chen (2003). Performance-based Seismic Design of Structures: a direct displacement-based approach. *Engineering Structures*, *25*, 1803-1813.