RELIABILTY BASED TOPOLOGY OPTIMIZATION FOR THE SEISMIC DESIGN OF TRUSS-LIKE STRUCTURES

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ABSTRACT

In this paper, reliability based design methodology is applied towards optimization of truss structures excited by earthquake ground motions. The total weight of structure is optimized under constraints related to minimum target reliabilities specified for each element and different performance requirements. To achieve this goal, the redundant materials slightly move from strong spots to the weak segments of the structure until a state of uniform deformation and confidence prevails. Probabilistic seismic performance assessment adopted by PEER is applied to calculate the expected mean annual exceedance frequency of demand parameter of a given truss system considering seven seismic excitations. The efficiency of the applied method is illustrated by case study. The algorithm has the capability of considering desired reliability constraints for each element resulting in a balanced distribution of weight.

INTRODUCTION

Direct guidance for reducing the potential for damage to the structural systems during a building's service life cannot be provided by conventional building codes (Rojas, Foley, & Pezeshk, 2011). Some procedures to overcome this restriction in the context of performance-based seismic design are posed,((FEMA356, 2000);(ATC40, 1996)). In addition, Pacific Earthquake Engineering Center (PEER) puts forward a performance-based design procedure in a reliability format evolved for evaluation of structures. Four sources of uncertainties due to seismic hazard, structural demand, structural capacity, and seismic induced consequences are combined aiming to estimate mean annual frequency of decision variables in terms of direct financial loss and number of casualties. To achieve this very end, four steps entitled as seismic hazard analysis, structural analysis, damage analysis, and loss analysis are considered. The PEER approach which is formulated based on the application of the total probability theorem, is presented in equation (1):

$$\lambda(DV) = \iiint G(DV \mid DM).dG(DM \mid EDP).dG(EDP \mid IM).d\lambda(IM) \tag{1}$$

In the formula above, λ (DV) represents the probabilistic description of the decision variables, DM shows the damage measure, EDP represents the engineering demand parameter, and IM is the intensity measure. The main goal of the PEER methodology is to merge all significant sources of uncertainty that appear up in specification of the ground motion, the material properties, and the modeling and evaluation process.