Seismic Performance of Steel Hollow Box Column under Combined Effect of Fire and Cyclic loading: Thermo-Mechanical Numerical Approach

Y.P.K.M.W.N. Kanakarathna[1], J.A.R.D. Jayasooriya[1], J.A.S.C Jayasinghe[1]*, S. Bandara[1]

[1]University of Peradeniya, Peradeniya, 20400, Sri Lanka
**supunj@eng.pdn.ac.lk*

Steel structural elements are becoming more common in modern structures due to their multiple benefits. These steel structures may be damaged by the combined impact of fires, earthquakes, and other dynamic loads during their service life. The deformation and bucking of steel structures are more complicated when multiple disasters are coupled, causing more damage to steel structures than single disaster. This study investigated the seismic performance of steel hollow box column exposed to simultaneously combined lateral seismic loading and non-uniform temperature distributions using a unidirectional coupling methodology. In this study, the fire scenarios were simulated using a CFD based Fire Dynamics Simulator (FDS), and the FE analyses were performed using ABAQUS software. Initially, a numerical model for fire simulation and FE analysis was developed for steel hollow box column and validated using relevant experimental data. Subsequently, a parametric analysis was carried out to assess the seismic performance of steel hollow building columns with different slenderness ratios and constant width-to-thickness ratios. In this scenario, cyclic load analysis was conducted to determine the lateral load-lateral displacement variation of the steel hollow building column in order to assess seismic performance. The effect of column slenderness ratio on seismic parameters such as, ultimate strength, ductility and energy absorption capacity under fire condition and room temperature condition (25°C) was evaluated in this study. It was observed that when the slenderness ratio varies within 0.25 – 0.45 range, maximum strength represents noteworthy reduction around 45% to 60% and energy absorption capacity represents around 50% to 65% under fire condition compared to the room temperature condition (25°C). Furthermore, ductility under fire conditions remains relatively unchanged when using columns with a slenderness ratio below 0.35. However, once the slenderness ratio exceeds 0.35, a noticeable reduction in ductility occurs.

Keywords: Finite element simulation, Fluid dynamic simulation, Seismic performance, Steel hollow box column, Thermo-mechanical modeling

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