An Investigation on the Seismic Behavior of Braced Steel Frames under Vertical Component of Ground Motion

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Abstract

In this research the effect of combined horizontal and vertical component of earthquakes on the seismic behavior of braced steel frames was investigated. Seismic behavior has been verified by conduction nonlinear dynamic analysis under the vertical and horizontal earthquakes and horizontal component alone. Three structures with 4, 8 and 12 stories representing low, medium and high braced steel structures selected. The analysis subjected to 3 strong motion records. Results from the analytical study indicated that the inclusion of the vertical component has greatly influence the axial forces in the columns but little effect on the shears and bending moment in the beam.

Keywords: Braced Frame, Vertical and Horizontal Accelerations, Nonlinear Analysis, Seismic Behavior

1. INTRODUCTION

Evidence indicates that the vertical component of ground motion is more significant than previously thought, especially for near fault events. However, many design codes do not reflect the importance of the vertical component of ground motion. Iyengar and Shinozuka [1] investigated the effect of self weight and vertical accelerations on the behavior of tall structures. The structures have been idealized as cantilevers and the ground motion as a random process. Their main conclusions are; the consideration of self weight and vertical accelerations might increase or decrease the peak responses. However, the difference either way seems to be considerable in most cases. The effect of vertical accelerations could be more pronounced particularly in beam response, if a frame structure is considered. Iyengar and Sahia [2] investigated the effect of vertical ground motion on the response of cantilever structures using the mode superposition method; their main conclusion is that the consideration of the vertical component is essential in analyzing towers. The non inclusion of this makes the design err on the unsafe side at some sections. Anderson and Bertero [3] evaluated using numerical methods the inelastic response of a ten story unbraced steel frame subjected to a horizontal component of earthquake and to combinations of this component with the vertical one, they deduced the following points; the inclusion of the vertical motion on one hand does not increase the displacements but on the other hand increases the girder ductility requirement by 50% and induces plastic deformations in columns. Mostghel and Ahmadi [4-6] studied the effect of vertical motion on columns and tall buildings which have been idealised as cantilevers, using the mathematical theory of stability of Liapunov. Their main conclusion is : in the elastic range, for an initially straight column, if the total maximum loading during an earthquake is less than the Euler buckling load, then the column will be always be stable irrespective of the time history of the earthquake to which it is subjected. But this is unlikely to be the case for reinforced concrete columns because of the crushing of concrete in compression and the buckling of the yielded reinforcement [7, 8].

In this study, a number of 3D dynamic analyses of braced steel buildings were performed in order to investigate the correct procedures of the structural analysis under the vertical component of earthquakes. Moreover, the relationships of extreme column axial forces and beam moments between vertical earthquake were investigated.