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Response of Steel Moment and Braced Frames Subjected to Near-Source Pulse-Like Ground Motions by Including Soil-Structure Interaction Effects

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Abstract

Most seismic regulations are usually associated with fixed-base structures, assuming that elimination of this phenomenon leads to conservative results and engineers are not obliged to use near-fault earthquakes. This study investigates the effect of soil–structure interaction on the inelastic response of MDOF steel structures by using well known Cone method. In order to achieve this, three dimensional multi-storey steel structures with moment and braced frame are analysed using non-linear time history method under the action of 40 near-fault records. Seismic response parameters, such as base shear, performance of structures, ductility demand and displacement demand ratios of structures subjected to different frequency-contents of near-fault records including pulse type and high-frequency components are investigated. The results elucidate that the flexibility of soil strongly affects the seismic response of steel frames. Soil–structure interaction can increase seismic demands of structures. Also, soil has approximately increasing and mitigating effects on structural responses subjected to the pulse type and high frequency components. A threshold period exists below which can highly change the ductility demand for short period structures subjected to near-fault records.

Keywords: Near-Fault Earthquakes; Soil-Structure Interaction; Cone Model; Steel Structure; Ductility Demand.

1. Introduction

Ground shaking near an active fault has some distinctive characteristics. Short–duration impulsive motion is one of them. This pulse is clearly evident in velocity time history where the fault rupture propagates towards the site at a velocity close to shear wave velocity. In addition, Near-fault records are rich in high frequencies. In other words, both short and high frequency contents of near-fault records are strong as opposed to ordinary ground motions that only have strong low frequency content [1, 2].

A plenty number of studies on both linear and nonlinear behaviour of structures subjected to pulse type motion of near-fault earthquakes were done. However, the effect of soil flexibility on response of structures subjected to near-fault records was ignored. In addition, high-frequency part of near-fault earthquakes was overlooked. As a consequence, all research process and computer simulation models may be doomed to provide unrealistic or at least questionable results. Somerville et al studied on the particular effects of forward directivity (1997) [3]. Among the years 2002 and 2003, an equation was introduced in order to create pulse type motion of near-fault earthquakes by Papageorgiou and Mavroeidis [5, 6]. The effect of pulse type motions on response spectrum was studied by Mavroeidis et al. in 2007. They clarified that pulses are able to strongly influence on response spectrum [7]. A new method was proposed to identify pulse-type component of near-fault ground motions by Tang and Zhang (2011) [8]. Iervolino et al. (2012) studied on inelastic displacement factors under near-fault ground motions and expressed a formulation for estimating inelastic displacement of structures subjected to near-fault earthquakes [9]. In 2004, the response of multi-story framed structures subjected to far-field earthquakes and simulated pulse type motions were

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