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Effects of earthquake characteristics and soil on the performance of seismic isolation of bridges

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Abstract

Due to the destructive effects of near-fault earthquakes and soil effects, the aim of this study is to investigate the effect of these parameters on isolated bridges. Real earthquake records with different distances of fault are chosen and investigated. Results in terms of deck acceleration, base shear, displacement and the performance of isolator are studied and compared by nonlinear time history analysis in SAP2000. Results demonstrate that for NF zones, considering the soil effect, is imperative. In soft soils, seismic responses are amplified. Designing isolator without taking this fact into account will cause inappropriate design with lower capacity.

Keywords: Near-Fault records, Soil effect, Isolation system, seismic responses.

1. INTRODUCTION

Seismic isolation technology which has an inordinate potential at improving the seismic performance over the conventional design philosophy, attempts to reduce the seismic forces to or near the elastic capacity of the structural members, thereby eliminate or drastically reduce inelastic deformations. The main concept of seismic isolation is to diminish the lateral fundamental frequency of vibration to a value lower than the predominant energy-containing frequencies of earthquake ground motions and to control seismic displacement demand by added damping [1-3]. In the case of bridge, its application is through the use of special bearings between the super-structure and the top of piers/abutments.

In order to have reliable installations to confront damaging earthquakes, it is necessary to consider, at the design stage, all effective parameters on the performance of the isolated structures. According to experimental and analytical studies and based on the evidences of the past earthquakes, NF records and Soil-Structure Interaction (SSI) are two of the most important parameters in this context [4, 5].

Ground motion records obtained in major earthquakes have shown that the characteristics of NF are particularly different from far-field (FF) records. FF records are characterized by low Peak Ground Acceleration (PGA) and high frequency, whereas NF records often contain a strong and long period velocity pulses that could cause severe structural damages [6, 7].

Wen-I Liao et al. (2000) and Jerry Shen et al. (2004) studied the effect of NF records on the isolated bridges. They showed that in NF record PGV/ PGA ratio, velocity pulse, and input energy are higher than FF record and it causes higher ductility demand and larger base shear [8]. NF records amplify the seismic responses of the isolated bridge when the pulse period is close to the effective period of the isolation system and the ratio of dissipated energy by the isolation system to the total input energy is slightly influenced by the NF effect [9].

Several important factors have been pointed out in previous studies and they show that NF records cause severe damages to conventional and isolated bridges. They cause high values of story drifts forcing the structure to behave in the inelastic range and consequently leading to severe damages [10-12].