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In-plane Response of a Three-span Simply Supported Bridge to Near-fault Strong Ground Motion

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Abstract

In this paper a simple model of a three-span simply supported bridge excited by the horizontal component of fault-normal pulse with different magnitudes and time lags has been considered. In the considered model the axially rigid mass-less piers are connected at the top to the rigid decks by hinges and at the bottom to the ground by linear rotational springs and dashpots. For determination of the pounding force between decks, the linear viscoelastic model has been chosen. It is assumed that the bridge is near the fault and the excitations at all piers have the same amplitude but differ in terms of phase. The system of equations of motion has been solved by the fourth-order Runge-Kutta method because of its self-starting feature and the long-range stability. For a range of main period of the bridge, the maximum impact force between decks and the minimum gap size required to avoid collision can be determined under fault-normal pulse with different magnitudes and time lags. It could be concluded from the results that time lag plays a very important role in determining maximum impact force and it’s better to use softer piers to reduce the maximum impact force and the minimum gap size required to avoid collision between decks.

Keywords: **Pounding, near-fault ground motion, simply-supported bridge, wave-passage.**

1-Introduction

Interactions between neighboring, inadequately separated buildings or bridge segments have been repeatedly observed during earthquakes. This phenomenon is often referred to as earthquake-induced structural pounding, may result in substantial damage or even total destruction of colliding structures during severe ground motions [1,2]. Considerable damage due to pounding between parts of school buildings, including the collapse of the roof parapet, was observed after the Athens earthquake of September 7, 1999 [3]. Rosenblueth and Meli [4] reported that in the Mexico City earthquake of September 19, 1985 about 40% of the damaged structures experienced some level of pounding, 15% of them leading to structural collapse. Structural pounding between the main building of the Olive View Hospital and one of its independently standing stairway towers during the San Fernando earthquake (09.02.1971) evoked stairway tower damage resulting in its permanent tilting [5]. The most natural way to prevent structural pounding is to provide sufficiently large spacing between adjacent structures or structural members. Thus, the minimum seismic gap is specified in most recent earthquake-resistant design codes for newly constructed buildings [6]. In the near field of large earthquakes, and especially close to surface faults, the strong ground motion can be dominated by the permanent displacements (typically parallel to the fault surface) and by large pulses (often perpendicular to the fault). Traces of these large displacements and pulses may not always be obvious in the processed records of the recorded motions because of the band-pass filtering, designed to eliminate digitization and processing noise [7-9].The magnitude of the impact force, which can be expected during the time of earthquake, needs to be known in order to assess the potential damage due to collisions. For this purpose, the idea of an impact force response spectrum for earthquake-induced pounding between three adjacent decks [1,2] is applied in this paper. The spectrum shows the maximum pounding force value versus the period of each piers and the gap size between the decks, which can be expected during the earthquake.

2-Structural model and simulation of pounding force during collision

As can be seen in Fig. 1, the model we consider is a multi-span bridge which the decks are connected to the piers by hinges and the massless piers are connected to the ground by circular springs and circular dashpots to provide the stiffness and fraction of critical damping of the bridge. The linear viscoelastic model is used for simulating the impact force. Rotation of the piers is assumed not to be small, which leads us to consider the geometric non-linearity. The mass is acted upon by the acceleration of gravity, g, and is excited by differential near-fault ground motions. The deformed shape and all forces which act on the bridge segments, including the D’Alembert’s forces, are shown in Fig. 2 (a) and Fig. 2 (b). We define the parameters of the model as coming: