Soil Dynamics and Earthquake Engineering 31 (2011) 334–350

Contents lists available at ScienceDirect

Soil Dynamics and Earthquake Engineering

journal homepage: www.elsevier.com/locate/soildyn

Example of application of response history analysis for seismically isolated curved bridges on drilled shaft with springs representing soil

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ARTICLE INFO

Article history:
Received 2 July 2010
Received in revised form
3 September 2010
Accepted 7 September 2010

ABSTRACT

The main objective of this study is to perform a parametrical study associated with the effects of the earthquake ground motions on the seismic response of isolated curved bridges including soil–structure interaction.

For the isolated bridge system, double concave friction pendulum bearings are placed between the deck and the piers, the abutments as isolation devices. A curved bridge is selected to exhibit the application for seismic isolation. The bridge is to be modeled and analyzed in a seismic zone with an acceleration coefficient of 0.7*g*. The configuration of the bridge is a three-span, cast-in-place concrete box girder superstructure supported on reinforced concrete columns found on drilled shafts and on integral abutments founded on steel pipe piles. The bridge is located on site underlain by a deep deposit of cohesionless material. The drilled shaft–soil system is modeled by equivalent soil springs method, and is included in the finite element model. The soil is modeled as a series of springs connected to the drilled shaft at even intervals.

The reduction of the internal forces on the deck for the isolated curved bridge is observed, if the forces are compared with those obtained for the non-isolated curved bridge.

1. Introduction

Curved bridges have been frequently constructed in multi-level junctions, and to cross an obstacle such as a river, a canal or a railway on which if there need a curve shape connection to join two of the roads. The bridge type is picked over others as an example to show the effect of earthquake ground motions on the curved bridges due to the fact that torsional stresses of the girders are the most challenging and interesting part of the design process. In the design of curved girder bridges, the engineer is faced with a complex stress situation, since these types of bridges are subjected to both bending and torsional forces. In general, the torsional forces consist of two parts such as St. Venant's and warping. Thus, the procedure is significantly difficult to determine the induced stresses of a curved girder.

A curved bridge, the reason for the selection is mentioned above, is modeled and analyzed with and without isolators according to seismic design of bridges procedures obtaining from Federal Highway Administration Seismic Design Course, Design Example no. 6.

The use of horizontally curved bridges has been increased to meet the demand of highway construction. When an alignment requires for a horizontal curve, engineers design a series of simple-span straight chords. A comparison of straight-chorded sections to curved sections showed that curved members are more economical than straight-chorded members [1,2]. Mwafy and Elnashai [3] carried out a detailed seismic performance assessment of a multi-span curved bridge including soil–structure interaction effects.

It has been, recently, reported in the Wenchuan earthquake of China in 2008 that the four curved spans of the Baihau bridge in Yigxiu township collapsed, whereas the other parts of the mentioned bridge that are straight span are safely remained on foot [4].

The seismic design of bridges relies on the dissipation of earthquake-induced energy through nonlinear response in selected components of the structural frame. Such response is associated with structural damage that produces direct loss repair cost, indirect loss such as possible closure, rerouting, business interruption and perhaps casualties such as injuries and loss of life. Importantly, traditional seismic analysis and design procedures do not permit the accurate estimation of structural deformations and damage, making it impossible to predict the likelihood of direct and indirect losses and casualties.

Seismic protective systems, herein assumed to include seismic isolators and energy dissipation devices, were developed to

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doi:10.1016/j.soildyn.2010.09.002