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COMPUTING A 'REASONABLE' SPATIALLY VARIABLE EARTHQUAKE INPUT FOR EXTENDED BRIDGE STRUCTURES

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SUMMARY

During strong ground motion, it is expected that a bridge will be subjected to excitation that is non-uniform along the structure, in terms of amplitude, frequency content and arrival time, a fact primarily attributed to the wave arrival delay, the loss of coherency, and the effect of local site conditions. Although considerable research has been carried out over the last twenty years in all the aforementioned directions, the knowledge gained has only partially been reflected on modern seismic code provisions. Currently, it is only Eurocode 8 - Part 2 that has adopted quantitative provisions for tackling this complex phenomenon of asynchronous motion. As a result, the goal of this paper is to assess these current provisions by focusing on some typical bridge structures. Using a special purpose computer program, the simplified approach proposed by EC8 is evaluated against the results of more refined analysis; the latter involves multiple support excitation of the bridges using pier-dependent artificial accelerograms that account for the aforementioned three main sources of spatial variability of ground motion. The results indicate that the new EC8 provisions are easy to apply and provide a good qualitative prediction of the asynchronous motion effects on the bridge. However, as expected, their application is subject to limitations and has to be performed by exercising engineering judgement.

1. INTRODUCTION

In current practice it is customary to assume that, during an earthquake event all of the bridge supports experience identical ground motion time histories, even in the case of multi-span bridges of considerable overall and/or span length. This assumption of identical support ground motion is also implicitly made when performing an equivalent static or a response spectrum analysis. However, reality is far more complex, since extensive scientific research has shown that earthquake ground motion may significantly differ among the support points, especially for long bridges, in terms of amplitude, frequency content and arrival time, thus inducing, under certain circumstances, significant forces and deformations. These spatial and temporal variations of seismic motion can be primarily attributed to: travelling of the waves at a finite velocity, loss of their coherency in terms of statistical dependence (due to multiple reflections, refractions and superposition of the incident seismic waves propagation), effect of local soil conditions, as well as attenuation of motion due to geometrical spreading of the wave front and loss of kinetic energy. In addition to the above, seismic motion is further modified by the foundation, depending on its relative flexibility with respect to the soil, since the foundation is not always able to vibrate according to the displacement field that is imposed to it by the incoming waves. The first pioneering studies on the effect of non-synchronism of ground motion on bridge response date back to the ’60s, though it is only since the ’90s that this phenomenon has been seen from a more practical perspective. Having set up the fundamental constitutive framework of the spatially variable ground motion, the effort was gradually extended to applications on simple structures, while analytically derived solutions for identifying loss of coherency patterns [Luco and Wong, 1986, and Zendagui et al., 1999, among others] and generating spatially variable seismic motions were developed [Deodatis, 1996, Hao, 1989, Harichandran et al, 1990, Zerva, 1990].

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