SEISMIC RESPONSE OF LONG R/C BRIDGES: EFFECT OF COUPLED GROUND MOTION VARIABITY AND SOIL-FOUNDATION INTERACTION

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1 INTRODUCTION

Although bridge structures might seem at a first sight as rather linear and simple structural systems, their actual performance under earthquake loading is much more complicated than that of buildings, since bridges have typically an order of magnitude larger dimensions, cross non-uniform soil profiles whereas the contribution of higher modes of vibration is more important. In fact, design projects become more and more complex because the current socio-economic demands stretch the limits of the modern technology in order to prioritise time saving instead of cost, thus imposing the necessity of overcoming unfavourable topographic, geological, seismotectonic and geotechnical conditions. Bearing in mind that to date significant research effort has already shed some light to many bridge engineering problems, two of the most difficult aspects, which are also related to the highest relative uncertainty compared to the superstructure, is the definition of a 'realistic' input motion and the supporting conditions of the structure; both of them have been shown to be of paramount importance for the final dynamic response of the bridge in the time domain. To this end advanced analytical solutions and enhanced know-how is sought for dealing with the significant number of cases that are not covered by modern seismic codes, but the complexity is such that they are often strongly case-dependent and sometimes controversial. What is left therefore, is the performance of the design using significant simplifying assumptions in terms of spatial and temporal variation of ground excitation among the pier supports, the characterization of the underlying soil profile, as well as the interaction of the overall soil-foundation system with the structure. It is the scope of this paper to investigate the degree of detrimental influence, if any, of the aforementioned approximations by attempting to apply a comprehensive methodology that considers spatial variability of ground motion, site effects and soil-structure interaction to three 600m bridge structures.

2 CODE TREATMENT OF THE PROBLEM

During the last years, significant research has been carried out with respect to the identification of bridge sensitivity to multiple support excitation, the variation of soil profile along the bridge axis and the effect of soil-structure-foundation interaction. However, due to the inherent complexity of wave propagation issues and the multi-parametric nature of the foundation-soil influence to the overall structural response, it is often deemed more efficient and reliable to study the dynamic behaviour of the bridge by making 'reasonable' approximations with respect to particular features of the coupled seismic wave, 2D soil structure-foundation and structural system. Moreover, not all derived observations provide a widely accepted perspective of the role played by the aforementioned issues, hence highlighting the significant difficulty to propose general rules and even more, to quantify and parameterise the problem within the provisions of a seismic code. As a result, existing seismic codes provide rough guidelines often in an informative form and always treat the three phenomena separately.

As far as spatial variability is concerned, with the exception of Eurocode 8, Part 2, for bridges [1] that provides an expression for the relative displacement of adjacent piers and an informative annex for spatial variability analysis together with a threshold value of overall length for considering the effect of asynchronous motion, other modern codes deal with the problem on the basis of seating length provisions, such as the US Standard Specifications for Highways and Transportation Bridges [2] and