Seismic assessment of a major bridge using modal pushover analysis and dynamic time-history analysis

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Summary

Modal Pushover Analysis has been shown to be a significant improvement compared to the pushover analysis procedures currently used for buildings. This work investigates the extension, applicability and accuracy of the method for a different case of structures, namely bridges. The structure analysed to illustrate the above is a long and curved, twelve span bridge structure, currently under construction in Greece. The bridge is designed according to current seismic codes and then assessed for motions up to twice the design earthquake intensity. Its performance in the transverse direction is herein evaluated through 'standard' and modal pushover, as well as non-linear time history, analysis. The behaviour is found to be satisfactory regardless of analysis method, but the estimated performance slightly varies depending on the analysis approach adopted.

Introduction

Non-linear static (pushover) analysis, is a widely used assessment tool that allows the evaluation of the structural behaviour in the inelastic range and the identification of failure mechanisms, while it highlights the critical points of structural weaknesses. Nevertheless, the inherent assumption is made that structural performance is controlled by the fundamental mode. In particular, the structure is subjected to monotonically increasing lateral forces having a constant pattern until a predetermined target displacement is reached. As a result, both the invariant force distributions and the target displacement, do not account for higher mode contribution, or for potential redistribution of inertia forces due to structural yielding, thus limiting the application of the approach to cases where the fundamental mode is dominant. To overcome the aforementioned limitations, a Modal Pushover Analysis (MPA) procedure has been developed ([1], [2]) wherein the higher mode effect is taken into account (in an approximate way) but despite the substantial amount of work that has been performed for buildings, the corresponding work on bridges is relatively limited ([3], [4]). It is therefore still open to research whether the non-linear performance of a bridge can be accurately assessed using 'standard' or a more refined (modal) pushover analyses, or whether a complete non-linear dynamic analysis in the time domain is required.

The present study describes the general framework of modal pushover analysis and its application to a bridge of complex configuration, in order to highlight potential differences between the three possible types of non-linear analysis, hence shed some light on the feasibility of MPA for bridges.

Overview of the adopted methology

Modal Pushover Analysis is considered as an extension of the 'standard' (single-mode) pushover analysis. According to this procedure, standard pushover analysis is performed for each mode independently, wherein invariant seismic load patterns are defined according to the elastic mode shape amplitudes. Modal pushover curves are then plotted and can be converted

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