Seismic assessment of a major bridge using pushover analysis

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Summary

This study focuses on the earthquake-resistant design and assessment of the Krystallopigi bridge, which is currently under construction as part of the EGNATIA highway in northern Greece. This long and curved, twelve span bridge structure is designed according to current seismic codes and then assessed for motions up to twice the design earthquake intensity. The behavior is found to be satisfactory, yet dependent to a significant degree on geometry, earthquake and modeling assumptions.

Introduction

Although elastic analysis provides an overview of the expected dynamic response of a bridge, it is clear that it cannot predict the failure mechanisms or the redistribution of forces that follow the plastic hinge development and the potential progressive collapse of the structure. Non-linear pushover analysis on the other hand, is a widely used assessment tool that allows for the evaluation of the structural behavior in the inelastic range and the identification of the failure mechanisms, while it highlights the critical points of structural weaknesses. Although a substantial amount of work has been done on pushover analysis of buildings, corresponding work on bridges has been much more limited; the main reason for this should be the fact that fundamental mode analysis (a key characteristic of the standard pushover method) is often not appropriate for describing the behavior of bridges [1].

The present study focuses on the assessment of the expected non-linear behavior of bridges designed according to modern seismic code provisions. An effort was made to (a) identify the actual dissipation mechanisms of a 'real' structure with respect to the behavior factor assumed (b) investigate whether modern code capacity design concepts ensure failure hierarchy and prevent structural collapse (c) focus on the effect of bridge irregularity (i.e. curvature) on the structural response in the inelastic range (d) investigate the role played by the soil-foundation-superstructure interaction in terms of action effects and (e) study the sensitivity of the aforementioned issues on the modeling assumptions made during the analysis stage. Along these lines, the long, curved and irregular Krystallopigi bridge is selected as the focus of the present study.

Overview of the bridge studied

The Krystallopigi bridge is a twelve span structure of 638m total length (Fig. 1) that crosses a valley, as a part of the 680 km EGNATIA highway in northern Greece. The curvature radius is equal to 488m while its deck width is 13m. The slope and the pier height vary along the length. According to the initial design, the deck is a prestressed at its top flange concrete box girder section; concrete grade is B45 (characteristic cylinder strength f_{ck}=35 MPa) and prestressing steel grade 1570/1770 (f_y=1570 MPa). Piers are in reinforced concrete, concrete grade is B35 (f_{ck}=27.5MPa), steel grade Bst500s (f_y=500 MPa). For abutments and foundations B25 (f_{ck}=20 MPa) and Bst500s are used.

The structure is supported on piers (M1-M11 in Fig. 1) of height that varies between 11 and 27m, For the end piers M1, M2, M3, M9, M10, M11 a bearing type pier-to-deck connection is adopted (see

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