Spatially variable seismic ground motions and their effect on cable-stayed bridges: The role of the tower.

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Abstract

This paper focuses on the effect of the spatial variability of the ground motion on the towers of cable-stayed bridges with typical span lengths equal to 200, 400 and 600m. For this work, seismic analysis of the considered bridges is performed, accounting for the different components of the spatial variability namely: incoherence effect and wave passage effect. The response of the towers is examined under various wave propagation velocities. Finally, the discussion is extended to the effect of the angle of incidence of the seismic waves with respect to the axis of the bridge, presenting an extensive study on the seismic demand of the towers.

Keywords: cable-stayed bridges; finite element models; seismic action; spatial variability; incidence angle

1. Introduction

Cable-stayed bridges are landmark structures that represent key parts of transportation networks, capable of spanning distances that other types of bridges fail to. These structures present large flexibility, reduced weight and lower damping[1] than other types of bridges, making them susceptible to dynamic loads such as earthquake and wind loads.

Another key characteristic of cable-stayed bridges is that they are affected by the spatial variability of the ground motion (SVGM), in other words, their supports are excited asynchronously. Eurocode 8[2] defines SVGM as a "*situation in which the ground motion at different supports of the bridge differs and, hence, the seismic action cannot be based on the characterisation of the motion at a single point*". According to Abdel-Ghaffar[3], asynchronous motion begins when the bridge is long with respect to the wavelengths of the input motion in the frequency range of importance to its earthquake response, and consequently different supports may be subjected to different excitations.

SVGM has been extensively studied by many researchers, [3-8] among others. The phenomenon started being examined more closely as soon as the first dense instrument arrays were installed and started recording[8]. The non-uniform earthquake ground motion is the outcome of the combination of three important components [6, 10] namely:

- *Wave passage effect* which refers to the difference in arrival times of the seismic waves to different stations.
- *Incoherence effect* referring mainly to the loss of coherence of the ground motion due to several reflections and refractions of the seismic waves in heterogeneous soil media.
- *Local soil effect* which is due to the local soil conditions and the effect that these soil conditions have on the amplitude and the frequency content of the ground motion.

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