Progressive Cable Yielding of a Cable-Stayed Bridge Considering Geometric Nonlinearities and Uncertainties of Loads

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Abstract

In this paper, a numerical study to assess the vehicle carrying safety of a cable-stayed bridge considering the cables plasticity propagation within the cable net is conducted. A simplified 2D finite-element cable-stayed bridge model is analysed under its dead weight and the in-service live loads. All types of geometric nonlinearity, namely the cable sag effect, the axial force-bending moment interaction within the deck and pylons, and finally the change of geometry due to large displacements, are considered in the analysis. Vehicle load multipliers are computed based on the load incremental analysis until the bridge get to the considered state that four cables have reached their plastic behaviour, which represents the initial progressive plasticity occurring in the cable net system. The probability distributions of load multipliers considering progressive cables plasticity are computed using the Monte Carlo simulation concerning uncertainties of loads.

Keywords: cable stayed bridge, load uncertainties, safety, progressive cables yielding, geometrical nonlinearities

1 Introduction

Cable-stayed bridges are still in a fast development, and have been already in use for several decades. While 30 years ago about 150 major cable-stayed bridges were known, the number has increased to more than a thousand today, with updated new span length records. As the economic range for suspension bridges is limited for very long spans, cable-stayed bridges are an efficient solution for a wide range of long span crossing and are in that way a continuous interest and focus of bridge engineers [1-2].

Long span cable-stayed bridges have the particularity to exhibit a remarkable nonlinear behaviour under dead and live loads. In this study, all kind of geometric nonlinearities that may arise from different sources are considered. The three main sources are known as the cable sag effect, the beam-column effect and the large displacements effect. Other nonlinear effects may be related to the constitutive behaviour of materials [3-4] and won't be considered in this paper beside a perfectly-plastic behaviour for the stay cables beyond their elastic state.