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The dynamic evaluation of composite materials footbridges

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Abstract

The dynamic analyses of two examples of composite footbridges are presented in this paper. The investigation focussed on the comparison of dynamic responses to different types of dynamic load – specifically, pedestrian movement, traffic loads and rail loads. For dynamic analyses, a set of 3D models of the footbridges was prepared using the ABAQUS software program. The first step of the analysis was to determine the dynamic characteristics of the structure, i.e. its mode shapes and natural frequencies. Modal analyses revealed that the lowest natural frequency of one footbridge coincides with the frequency of pedestrian steps while walking or running; therefore, an evaluation of the dynamic response to these types of human actions was performed in order to identify the possible resonance phenomena. In the next stage, the authors assessed the dynamic response of the footbridges to typical traffic loads; these types of load are transmitted to the structure through the ground and foundations. Such an assessment appears to be necessary due to potential increases in the number of vibration sources arising from changes in the types and volume of traffic over time. It should be noted that traffic loads, which are a source of vibration for footbridges that are located over highways or railways, constitute an interesting yet still under-recognised problem concerning footbridges. For the analyses, representative time histories relating to the passage of a heavy goods vehicle and a train were used. The results of the analyses were compared with acceptability limits, with regard to levels of acceleration, in order to assess levels of vibration serviceability. The analyses revealed that the dynamic responses to both road traffic and rail loads are of a lower magnitude than the responses to the movements of human users.

Keywords: footbridges; dynamic analysis; vibration comfort criteria assessment; advanced composite material; fibre-reinforced plastic (FRP); glass-fibre-reinforced polymer (GFRP); ABAQUS

1 Introduction

Over recent decades, the use of fibre-reinforced plastic (FRP) materials in general, and of glass-fibre-reinforced polymers (GFRP) in particular in civil engineering projects has undergone significant development. Because of their properties e.g. high strength, chemical resistance, low weight, electromagnetic transparency and ease of installation, these materials have the potential for use in civil engineering infrastructure. One of the most significant applications is in the realisation of

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