Design, construction and structural response of a lightweight FRP footbridge

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Abstract

This paper presents the design, construction and structural response of a laboratory FRP footbridge. Pultruded elements, Glass-FRP profiles and Carbon-FRP strips, comprise the 10 m long simply supported structure, which linear mass is only 80 kg/m approximately. A value of $L/200$ (L being the length of the span) was the limit adopted for the long-term deflection at mid-span, and verifications at Ultimate Limit State were carried out according to the recommendations of the FRP manufacturer and the European Guideline to design FRP Structures. To construct the bridge, the following phases were completed: (i) bonding CFRP strips to the GFRP stringers, (ii) connecting the FRP elements, (iii) casting concrete at the support regions, and (iv) installing the deck. Once the construction finished, an experimental static and dynamic campaign was performed to assess the bridge structural behavior. As expected from the design stage, excessive vertical vibrations under different pedestrian actions (walking and bouncing) were measured.

Keywords: FRP footbridge; design; construction; static behaviour; dynamic response.

1 Introduction

Structural applications using fibre-reinforced polymers (FRPs) have increased over last years in bridge engineering due to several benefits, such as low maintenance cost, dead load reduction, high corrosion resistance, and fast installation. In addition, these novel materials, also known as composites, have proved to lead to sustainable and environmentally-friendly footbridge projects [1].

Different types of footbridges can be found nowadays, in which most of the structural elements were manufactured with FRPs [2–4]. High strength-to-weight ratio and low moduli of elasticity are characteristics of composites, so the design of FRP structures is usually driven by serviceability limit states, either deflections [5] or excessive human-induced vibrations [6].

However, applying conventional deflection requirements of codes and guidelines to composite bridges may be uneconomical and restrictive in most cases [7]. Regarding vibration issues, a suitable solution may be the use of inertial controllers (passive, semi-active or active inertial controllers), which also may help to avoid oversizing structural elements.

Therefore, a motion-based design approach may be adopted to design FRP footbridges. In this strategy, static and dynamic problems are tackled separately. Once static requirements are met, a desired degree of vibration comfort is intended to be accomplished by installing inertial vibration control devices on the structure.

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