Construction and Testing of a CFRP-prestressed Railway Bridge Prototype

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Abstract

This paper presents a new single-span railway bridge system, currently under development by the authors in cooperation with the Swiss Federal Railways and further partners, combining high-performance concrete, stainless reinforcing steel and CFRP prestressing for maximum durability. A significant milestone in the project was the successful construction and testing of a 6,5 x 1,7 m^2 prototype consisting of four pretensioned longitudinal girders; each prestressed with 12 Ø8,2 mm sand-coated CFRP rods. The paper discusses selected aspects of the sustainability of the novel material combination and the construction of the prototype. Furthermore, the structural behaviour of the prototype is analysed, focusing on its response under shear forces.

Keywords: sustainability; bridge engineering; precasting; CFRP-prestressing; pretensioning; stainless steel

1 Introduction

1.1 Motivation and Aim

If replacing existing rail infrastructure becomes necessary, (i) fast construction, (ii) durability and (iii) the ecological footprint of the new structure during its service life are critical. To advance in the first of these key aspects – aiming at minimising track closures to ensure efficient operation – the authors are currently developing a system for precast CFRP-prestressed concrete T-beam bridges in the span range of 2–10 m. The project is carried out in cooperation with several industrial and research partners (see acknowledgements). The basic concept is depicted in Figure 1 (a) and (b) [1, 2]. Together with non-corrosive and fatigue-resistant sand-coated CFRP rods (pretensioned and anchored via bond in the C80/95 high-performance concrete), stainless reinforcing steel ensures high durability and structural safety by providing sufficient deformation capacity. This study shows the construction and testing of a prototype of the proposed system.

1.2 Sustainability

In order to ensure that the system's benefits are not outweighed by a disproportionate environmental impact, a brief comparative life cycle analysis (LCA) between the proposed and an established design, looking only at the global warming potential (GWP), was conducted. The functional unit of the LCA is a bridge girder with 6 m span and 4,5 m width accommodating one railway track without edge girders. Both designs (see Figure 1 (b) and (c)) fulfil all serviceability, fatigue and ultimate limit state requirements; the prestressed system remains uncracked under service loads. The life cycle inventory [3] of both

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