Feasibility of timber-concrete composite road bridges with under-deck stay cables

Zhan Lyu, Christian Málaga-Chuquitaype, and Ana M. Ruiz-Teran
Imperial College London, London, UK

Contact: z.lyu15@imperial.ac.uk

Abstract

Timber-concrete composite (TCC) bridges represent an attractive structural system due to the synergistic use of wood and reinforced-concrete. However, the benefits of TCC bridges can be hampered by their relatively large flexibility that limits their application to long spans. This paper presents an alternative solution for TCC bridges that incorporates post-tensioned under-deck tendons. These steel tendons are deviated by two struts and anchored to the diaphragms at the support section, effectively subdividing the total span of the TCC bridge into three sub-spans. The advantages of the newly proposed system are evaluated for 60 m span TCC bridges. This paper shows that the incorporation of under-deck post-tensioning effectively changes the critical limit states governing the design of TCC bridges. In addition, the application of post-tensioned tendons leads to a significant increase in the allowable slenderness and efficiency of structures.

Keywords: design, timber-concrete composite, post-tensioning, critical limit states, bridge.

1 Introduction

A timber-concrete composite (TCC) bridge combines timber beams with concrete decks by means of different connection types. Such structures exploit the best properties of both materials since bending and tensile forces are resisted mainly by the timber and compression by the concrete. The application of TCC systems in bridge construction was first studied by Seiler & Keeney [1]. This study aimed at finding a cheaper solution than reinforced concrete for the construction of bridges with a longer service life than timber bridges. With the development of Engineered Wood Products (EWPs) and improvements in construction technology, the total number of TCC bridges has now increased. The Vihantasalmi Bridge built in 1999 in Finland, a five-span king-post truss bridge (21 + 42 + 42 + 42 + 21 = 168 m) with an 11-m-wide roadway and 3-m sideways, is a prime example of TCC bridges.

Slab bridges and girder bridges with composite deck are the two main types of TCC bridges, being applied for spans of 5-15 m and 10-30 m, respectively. Although TCC slab bridges are less structural efficient than TCC girder bridges, the former might be a better option in some cases, especially when clearance constrains under the bridge are present. However, the TCC system seems to be less competitive at longer spans because of its relatively large flexibility.

An alternative potentially more efficient solution comes through the implementation of external post-tensioning tendons with high eccentricity. The benefits of this solution, in terms of strength capacity and deflection control, have been revealed in concrete and steel-concrete composite bridges. Similarly, the advantages of longitudinally post-tensioning laminated veneer lumber (LVL) timber beams have been shown through experimental and numerical investigations [2]. An innovative type of longitudinal post-tensioning,

https://doi.org/10.2749/vancouver.2017.0268