Numerical and experimental evaluation of concrete cracking in timber concrete composite bridge beams

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Summary

TCC bridges are a more durable alternative to the very high number of conventional timber bridges en Chile´s road network. In a research project, numerical analyses and laboratory tests were conducted in order to obtain the influence of concrete cracking in TCC beams. The results from the FEM simulations and from the shear tests indicate that the influence of the concrete cracking is not limited to a stiffness reduction of the concrete slab, but it the stiffness of the shear connectors is reduced, too. No other parameter was found to significantly improve the correlation between simulations and real tests. Laboratory tests validate that small concrete cracks can cause significant connector stiffness reductions. Good correlations on the safe side between numeric simulation and test results is obtained, if the connectors' slip modulus is reduced by 60%, in addition to the theoretic concrete cracking.

Keywords: composites; concrete; timber; bridges; testing; computational methods; serviceability.

1. Introduction

Timber bridges are an important element of the Chilean road network, constituting about a 19% of all highway bridges. However, due to durability problems in the conventional construction types, i.e. uncovered and not protected by design, timber bridges are considered of inferior quality.

An attractive technology that extends substantially the service life of timber bridges are the timber concrete-composite (TCC) beams, whereby the timber beams are protected by the impermeable concrete slab. During the development of the scientific basis for the design of TCC bridges, the influence of the concrete cracking on the deformation and forces distribution has not been specifically addressed. On the one hand, it is recognized that concrete cracking can increase deformation by up to 30% and timber stresses by up to 20% [1]. But, on the other hand, the design recommendations for taking into account such an important effect vary from neglecting it completely [2] to a reduction of the concrete stiffness down to 40% [3]!

At Universidad Austral de Chile, a numerical and experimental evaluation of the concrete cracking influence on the deformation and force distribution in TCC beams was conducted. The project is divided into 4 main parts, that is, the development of a parameterized numerical analysis model, the calibration of the model with test data from the literature and own laboratory test, the execution of a parametric study and, finally, an engineering adequate consideration of concrete cracking effects shall be proposed.

2. General methodology

The timber concrete composite idea is used in many different countries for bridge construction. The systems, and especially the shear connectors, used vary from country to country and even from engineer to engineer. Therefore, in a first step the construction system was chosen and implemented in the design of an example bridge under Chilean design and construction rules. The example

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