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New beam-to-beam joint with concrete embedding for composite bridges Experimental study and finite element modelling

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ABSTRACT

This paper deals with a new type of beam-to-beam joint used to connect continuously composite beams in small and medium span bridges. This new joint is realized by encasing totally the two composite beam ends into a massive composite reinforced concrete block. A direct contact between the ends of the bottom flanges of the steel girders over the support ensures the transfer of the compression forces. A half-scale joint specimen has been designed and fabricated. The specimen was first tested at the Structural Laboratory of INSA-Rennes under fatigue loading. Next, the load was monotonically increased up to the specimen failure. The main results of this experimental study are firstly presented. To allow an accurate interpretation of the test results and get a better insight into the joint behaviour, a numerical F.E. model has been developed. The numerical results are presented and compared against experimental ones. Besides, a parametric study has been carried out in order to investigate the influence of key parameters governing the joint behaviour. The influence of the behaviour of this type of joint on the global analysis of a continuous composite beam has then been studied. Finally, a worked example of a two-span continuous railway bridge is presented and effects of intermediate beam-to-beam joint characteristics on the bridge behaviour are discussed.

1. Introduction

Bridges with span lengths of 15 m to 30 m are common in practice and they have been mostly built in the past adopting concrete or prestressed concrete solutions. In order to promote composite solutions, research programs have been developed, with the main objective to find innovative solutions to make composite bridge superstructures cost competitive, as much as possible, with ordinary prefabricated elements easily assembled on site by the same builder with a minimum of construction operations and without any sophisticated technology (such as outdoor welding for example).

Early investigations on this topic were developed in Australia between 1974 and 1991 (see [1–6]) upon request of the Department of Main Roads of Western Australia. In the same period several composite bridges were also built in the United States. Some years later, in Europe, research was carried out by J. Wang, R. Baus and A. Bruls (1997) [7], J. Haensel (2001) [8] and through the RWTH-CTICM-PROFILARBED research project (2000–2003) [9]. New joint solutions were proposed considering aspects such as strength and fatigue of hybrid girders, use of dismountable shear anchors, use of prefabricated elements…More recently, the nonlinear response of similar composite joint typologies to those presented above has been investigated in Trento by T. Zordan and B. Briseghella (2009) [10].

Within this context, under the impulse of the French Research Project MIKTI [11], several research actions have been undertaken. The Structure Laboratory of INSA Rennes was involved in this research project to investigate innovative solutions for the design and the fabrication of beam-to-beam joints ensuring the continuity of bridge composite beams [12]. Three continuous joint solutions have been selected and then studied. The aim of this paper deals with the third selected solution. It consists in embedding the steel span girder ends of the composite slab in a massive reinforced concrete transverse beam resting on the top of the pier heads.

The steelwork parts of the composite beams are prepared in factory and equipped with steel elements for connections (plates, holes, welded studs…). Then, the steel girders are transported on the construction site to be placed on their supports. Without any proping, the steel span girders, simply supported at their ends on the head of the piers, operate like isostatic beams. The joint components (contact, studs…) and the reinforcement are installed. The slab is concreted and the continuity of the composite beam is completed by concreting the beam joints and the transverse beams over the pier. Possibly, separate supports can be considered between the transversal beam and the pier to limit the shear transfer through the joint. This novel joint appears comparable to some hybrid joints used in USA and in Japan to connect composite beam to concrete column [13]. Such hybrid joints were also studied in Europe at the Budapest university (Hungary) by L. Dunai (2004) [14] and in Japan at Osaka and Kobe universities [15].

Regarding the transmission of internal forces, different parts of the joint contribute to the transfer of the bending moments, normal

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