



The effect of ductile connectors on the behaviour of timber–concrete composite beams

Alfredo M.P.G. Dias^{a,*}, Luís F.C. Jorge^b

^a CIEC, Department of Civil Engineering, University of Coimbra, FCTUC – Polo II 3030-290 Coimbra, Portugal

^b Polytechnic Institute of Castelo Branco, Avenida do Empresário 6000-767, Castelo Branco, Portugal

ARTICLE INFO

Article history:

Available online 22 June 2011

Keywords:

Timber–concrete structures
Timber–concrete connections
Ductility of connections

ABSTRACT

The load-carrying capacity and ultimate deformation capacity of timber–concrete composite systems can be significantly influenced by the ductility of the connection between the two materials. The use of more ductile connections can increase the load-carrying capacity of the composite system as well as its ultimate deformation capacity. In this work, the potential increase that might be expected for these two parameters due to the use of ductile connections will be assessed through numerical simulations, taking the non-linear behaviour of the connections into account.

Furthermore, the connection ductility required to achieve the maximum load capacity depends on the mechanical properties of the connection as well as on the geometric and mechanical properties of the composite system. There are certain types of connections, such as notched connections, with a very brittle behaviour, for which the failure of the composite structure might be significantly influenced by connection failure, unless very small spacing between the fasteners is used. On the other hand, ductile connections such as dowel-type fasteners can be used with large spacing since their high ultimate deformation capacity is unlikely to be reached before the failure of either the concrete or the timber member. With the aim of identifying the maximum spacing that should be allowed for each specific connector type, numerical analyses were performed with the aim of identifying the maximum spacing that should be allowed for each specific connector type so as to maximize the load-carrying capacity and possibly increase the ultimate deformation capacity.

© 2011 Elsevier Ltd. All rights reserved.

1. Introduction

Timber–concrete composite systems are a well-known solution for the rehabilitation and strengthening of old timber structures as well as for the laying of new floors. This composite system combines a relatively high compression strength and stiffness of concrete with a relatively high tension strength of timber. The system relies on a connection system that transfers the stresses between the two materials leading to an effective composite behaviour [1,2]. The mechanical behaviour of the connections has a direct influence on the most important mechanical properties of the composite system, namely load-carrying capacity, stiffness and ultimate deformation capacity. Among the properties of the connection, the ones with the greatest influence on the mechanical behaviour of the composite system are the load-carrying capacity, stiffness and ductility [3–5]. In most cases, the calculation method used in the analysis and design of this type of composite structure is the one indicated in annex B of EC5 [6], from now on referred to

in this document as the γ method. The use of this method requires that the connection stiffness and load-carrying capacity is known, so that the composite system's load-carrying capacity and stiffness can be determined. Therefore, it is essential to take into account the influence that these two connection properties have on the design of the composite system. On the other hand, the ductility of the connections is not considered in this calculation method, either directly or indirectly. Regardless of this factor, this property might have a significant influence on the mechanical behaviour of the system.

Due to the mechanical properties of the two materials, such composite systems usually show a low deformation capacity, always strongly dependent on the deformation capacity of the connections. Moreover, in most cases, the greatest deformations will take place in the fasteners next to the beam ends. Consequently, the failure of the first connector will result in an additional load in the remaining fasteners that might lead to a more brittle failure of the whole composite system. The risk of this can be significantly reduced by using ductile connections, namely connections with an ultimate deformation capacity higher than the maximum slip demand between timber and concrete in the composite system, allowing load redistribution among the connections. In practice, however, this might be difficult to calculate and achieve with

* Corresponding author.

E-mail addresses: alfgdias@dec.uc.pt (A.M.P.G. Dias), luisfc@ipcb.pt (L.F.C. Jorge).