LOAD-SLIP BEHAVIOUR OF TIMBER-TO-CONCRETE CONNECTIONS REINFORCED WITH PUNCHED METAL PLATES

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ABSTRACT: The main purpose of this paper is to present and evaluate a numerical approach, recently developed by the authors [1], to predict the behaviour of timber-to-concrete connections with reinforcements. Experimental results on unreinforced connections and on connections reinforced with punched metal plates are reported. The main current modelling techniques available in the ABAQUS software to model such reinforcements are assessed. Finally, an efficient numerical approach is proposed to capture the non-linear load-slip behaviour of reinforced connections. A good correlation between experimental and numerical results is obtained.

KEYWORDS: Timber, concrete, screws, punched metal plates, connections, FEM

1 INTRODUCTION

Composite timber-to-concrete beams have been extensively used for strength and stiffness upgrading of existing and new flooring systems. They have gained more and more interest in residential and non-residential building constructions with the development of lightweight construction and rehabilitation programs [2]. The structural performance of timber-to-concrete connections is highly depending on the shear resistance of the mechanical connector, which is a key parameter. A large range of mechanical shear connectors, with an extensive variety of stiffness and strength [3], are used to connect a timber beam to an upper concrete slab. Timber-to-concrete system is an effective means for combining the structural and non-structural benefits and eliminating some weaknesses of each material. Many experimental investigations have been carried out in the last years, to measure the characteristics of such connection systems. Tests have been made on different types of shear connectors. In general, measurements include: nonlinear load–slip relationship, slip modulus for the ultimate and serviceability limit states, load-carrying capacity as well as mode of failures.

It is well-known that high-performance connections often are carried out as reinforced connections. The reinforcement relates to the timber in the connection area, where especially tensile stresses perpendicular to the grain are transferred by the reinforcement [5]. In this study, the authors explore the reinforcement of timber-to-concrete connections using punched metal plates (Figure 1).

![Figure 1: Timber member reinforced with punched metal plate in the connection area](image)

The improvement of the yield load levels is shown based on several experimental studies comparing non-reinforced to reinforced connections. In addition to the experimental, an efficient numerical approach is proposed to capture the non-linear load-slip behaviour of connections, as an alternative to the theoretical models and the detailed 3D FE models.

2 DESCRIPTION OF THE FE APPROACH

Among the numerous existing calculation models for screws, up to now, a general and predictive theory is not yet established in this area. Generally, theoretical models require fitting parameters that should be determined by a large number of experimental trials and they are not suitable connections with reinforcements neither for large size industrial applications with large number of screws. Also, detailed numerical modelling using solid finite elements would be very expensive from a computational...
point of view. The numerical approach developed recently by the authors [1] is based only on mechanical properties of materials. The basic idea is to model the screws using a special one-dimensional beam elements and the assembled members (timber and concrete) using detailed solid elements, leading in fact to a beam-to-solid coupling (Figure 2).

Figure 2: The global flowchart of the FE approach

Several reinforced and non-reinforced timber-to-concrete connections made with SFS screws (Figure 3) have been tested according to EN 26891 requirements.

Figure 3: Push-out shear test on timber-to-concrete specimens (dimensions in mm): (a) specimen geometry, (b) test set-up, (c) top view, (d) SFS-screw VB 48-7.5-100.

3 RESULTS

With the adjustment of the mesh, a satisfying computation has been obtained. Figure 4 shows the comparison between experimental results and numerical simulation. A fairly good agreement can be observed between experimental curves and the numerically predicted one. It is worth noting that the nonlinear load–slip relationship is accurately predicted until a slip level of about 20 mm. Beyond this slip level, the accuracy is not satisfying because the progressive damage caused in both timber and concrete has not been considered in the present model. Based on Figure 4, it can be concluded that the present approach can well predict the slip modulus of connections and the load-carrying capacity at a maximum allowable slip level of 15 mm, suggested by the EN 26891.

Figure 4: Comparison between experimental and numerical load-slip curves from reinforced joints

4 CONCLUSIONS

Several push-out-shear tests on timber-to-concrete connections reinforced with punched metal plates have been carried out and the results were compared to those from unreinforced connections showing numerous performance levels. In addition to the experimental work, an efficient FE approach to model reinforced connections, which is based only on the mechanical properties of materials, is presented. A good correlation between experimental and numerical results is obtained. Finally, the main advantages of the proposed approach are discussed by comparison to the currently available models in the literature.

REFERENCES