Improvements in the design of timber structures joined with metal dowel-type fasteners

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Abstract Dowel-type joints are one of the wood-steel connections most widely used in timber structures. The present work is intended to study these joint technologies when the dowel works in double shear, especially when it is threaded, because of the increasing interest in this technique from industrial companies. Other possibilities were also studied, just like the use of threaded and glued dowels, and dowels with washer and nuts. The aim of this work was to compare the performance of the joints with all these different configurations. The study determines their load capacity in two different ways. First, using the analytical equations of the official standards that apply to them and, secondly, making empiric tests of the same proposed designs. The results have allowed to evaluate the performance improvement of the joints when using threaded dowels, adhesive threaded dowels and dowels with washer and nuts at their ends, depending on the different geometric dimensions of the joint parts.

Keywords timber, connections, dowel, rope effect

1. EXTENDED ABSTRACT

The EC-5 (EN 1995-1-1 2004) is the European Structural Standard which develops the design of timber structures. One of its principal aims is to give the engineers the rules to design the connections that are used in these kinds of structures. Dowel-type fasteners are one of the most extended kinds of joints that can appear in timber structures, and they work in single or in double shear. The focus of this research was to study the design stresses and the overall behaviour of the joints in double shear for different sizes and joint designs (Rodd and Leijten 2003).

The work has been developed through experimental tests carried out in timber joints of real size made in the laboratories of Mechanical Engineering of the University of Salamanca using a test machine MTS Alliance RF200 with a 200kN cell load and special equipment specifically designed for these tests. Also some of the proposed techniques have been used in the rehabilitation of the warehouses at the dock of the Canal de Castilla in Alar del Rey (Palencia, Spain), in a timber building dating from the eighteenth century with historic interest. Because the combinations of materials, constraints, geometries and loads that can appear in these kinds of structural joints are infinite, some representative

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cases were proposed with realistic values for some variables in order to carry out the study. The analyzed variables were: thickness of the lateral pieces (t1), thickness of the central piece, (t2); diameter of the bolt (d). The tests were replicated using threaded dowels, glued dowels and dowels with washer and nuts at their ends (Bainbridge et al. 2002) to study the effect of these different configurations.

The study objectives were to analyze the behavior of specimens for the different configurations and to compare the results with those given by the EC-5 European Standard and by the Johansen's equations (Johansen 1949) in which are based the equations of the Eurocode. The difference betwen the Johansen's equations, the equations of the Eurocode and those used in the different European States is owed to slight modifications in the multiplying constants which appear in these equations.

From the results of this research, several conclusions could be drawn. First, the studies made for verifying the load of collapse given by the different standards equations when some geometrical variables are modified, confirm the correct formulation of these equations. In the cases that were studied, the greater moments that appeared in the dowels corresponded to the first hinge, and in all the cases the maximum moments supported by the dowels were between the elastic and the plastic values. Consequently, the maximum values of the loads indicated by the Johansen equations are within the safe range in respect to the plastic failure of the joint, but above the elastic yields, which would cause the existence of irreversible plastic deformations, whereas the bearing moment for the second and third hinge are always below the elastic moment.

Second, the new methodologies of joints proposed in this study, using threaded dowels, glued dowels and dowels with washer and nuts at their ends, in spite of implying some disadvantages, as the increase of the construction costs and manufacturing time or others just like those of aesthetic type, improve significantly the performance of the joint (Larsen and Jensen 2000). Anyway, the analysis of the results can allow the designer to decide if the improvements are sufficient to compensate the disadvantages.

In conclusion, the tests have allowed to evaluate the possibilities of improvement of joints in double shear and how the used of new methodologies as threaded dowels, glued dowels and dowels with washer and nuts at their ends, can optimize the resistance of this kind of joints.

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