ABSTRACT: Timber-steel hybrid elements are structurally reliable, clean and fast to assemble and disassemble, light, ecologic and economic. Design criteria and a calculation model for beams were developed and a series of real scale tests were carried out in order to check their performance. The results proved to be satisfactory and promising for the final objective of building structural frames for different types of multi-storey buildings.

KEYWORDS: Timber-steel, hybrid, beam, test, multi-storey

1 INTRODUCTION

The application of timber-steel hybrid elements for multi-storey buildings will be one objective in the future. First ideas, details, economical calculations, static analyses and tests were presented by the authors at the WCTE 2010 Trento [1] and WCTE 2012 Auckland [2]

Structural frames built with timber-steel hybrid elements could achieve an optimum mechanical performance, easiness for assembling and disassembling, supply enough self-fire protection thanks to their use of wood and a very good performance regarding ecological parameters. Moreover they make the building of rigid and semi-rigid steel-steel joints between beams and pillars simple, and the combined use of steel with timber counteracts the creeping behaviour effects of the last one.

2 DESIGN CRITERIA

The idea is to optimize the cross section of the timber-steel hybrid beam regarding cost effectiveness, load bearing capacity and fire protection. The steel is placed inside the wood in such a way that is protected against fire and both materials, under a common deformation, can reach at the same time its performance limit value, i.e. elastic limit for steel and bending characteristic strength for timber.

Three different types of timber-steel hybrid beams (Types B,C,D) were designed using glulam GL28c. A fourth type (Type E) was designed using cross laminated timber (CLT) made from C24 planks.

Figure 1: Cross section and strain and stress diagrams

Figure 2: Cross section of hybrid beams tested.
Steel S355 was used in all cases, in welded sections (Types B,C) or doubled-folded U sections made from 3 mm thick steel plates (Types D,E). For 6 metres span beams the total structural depth was 36 cm and the width was 16 cm in all cases. The beams type B,C and D present a theoretically equivalent value of global bending stiffness.

Figure 3: Type D hybrid beam being assembled.

3 CALCULATION AND TESTS

Calculations were carried out using a simplified matrix-based model of connected bars as shown in Figure 3. Each material is modelled by a different bar and are connected for sharing the load and having the same deformation.

Figure 4: Calculation model.

Objectives of the tests were the checking of the calculation model used comparing it with the real beams performance, the verification that no buckling problems because of slender steel web or flanges appear and the proofing of efficiency of the double-folded U steel design comparing it with the other welded sections. The procedure followed was a four point bending loading test for 6 metres span.

4 RESULTS

As expected there weren’t buckling problems neither in web nor in steel flanges. The buckling of flanges only happened under very high loads after the rupture of the timber pieces. There were no relevant differences among beams regarding rupture values, meanwhile regarding stiffness the welded types proved to be 8% stiffer than the glulam-steel folded ones, and (as expected) 19% stiffer than the CLT option.

Figure 5: Disassembled type D hybrid beam after test.

The calculation model used proved to be overall valid, although on average 5% stiffer than the real welded-hybrid beams (Types B/C) and 13% stiffer than the real folded-hybrid beams (Types D/E), and it needs to be corrected.

Figure 6: Load-deformation diagram for Type D beams.

5 CONCLUSIONS

Analysis of the testing data reflected that the hybrid beams types B,C and D have a good performance regarding both Ultimate and Serviceability Limit States. The designs tested could be used in Housing/Office buildings (Total load 7 kN/m²) or Public buildings (Total load 10 kN/m²) allowing spacings of more than 6 or 4 m respectively.

REFERENCES
