EXPERIMENTAL TESTING AND NUMERICAL ANALYSIS OF THE CONNECTIONS IN TIMBER STRUCTURES

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Timber structures are constituted by members (one dimensional ore two dimensional elements) dissipating energy during earthquake only in mechanical connections, located in few specific zones and responsible of assuring the ductile behaviour. Therefore, the comprehension of their structural behaviour and their correct design are of crucial importance, especially in seismic conditions. Many studies have been carried out within this topic during the last decade in Europe, North America and Japan, in order to define monotonic and cyclic behaviours of most used connections when only one direction (i.e. tension and shear) is prescribed.
Nevertheless, some questions are still unanswered. In particular, during earthquakes, connections are subjected simultaneously both to shear and tension. The interaction between shear and tension forces may affect connector's capacity in terms of strength, stiffness, ductility and dissipation capacity.
Moreover, the possibility of brittle failure of connections subjected to combined tension and shear forces must be taken into account.

In order to define the tension- shear interaction in typical connections used in timber structures, the following research activities have been scheduled and partially carried out by the research group:
a) literature review about timber connection systems;
b) experimental tests on typical connection elements to investigate the tension-shear interaction;
c) analyses of results and develop of analytical model and design guideline;
d) develop of innovative numerical model capable of reproducing the tension-shear interaction in the connection elements.

A brief description of each research activity is reported below.

a) Literature review has allowed to define the state of about the timber connection especially with regard to the problem of the tension-shear interaction.

b) Experimental tests have provided a complete definition of the mechanical behaviour of the timber connection when subjected to combined tension-shear actions.
Tests have been performed using a specifically developed test setup suitable to apply both tension and shear actions on the connections, simultaneously.

Fig. 1. View of the developed tests setup (Pozza).

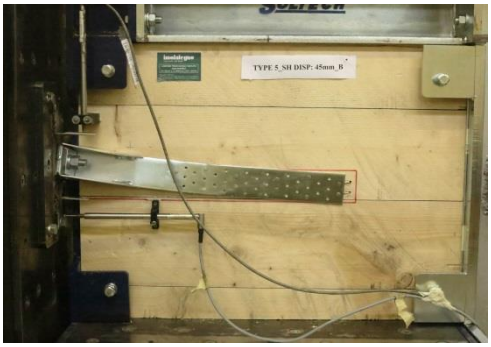

Fig. 2. View of a specimens tested with combined tension-shear forces (Pozza).

Results from experimental test allow to demonstrate the relevance of the tension shear interaction in terms of connection load bearing capacity, stiffness, ductility and dissipative behaviour.

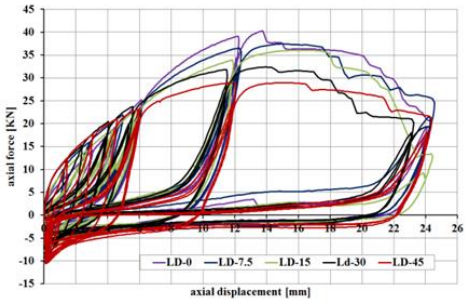

Fig. 3. Cyclic behaviour of steel to timber connection with different level of tension-shear interaction (Pozza).

In addition the developed test setup is adequate for loading simultaneously in tension and shear the connection elements providing the definition of the experimental strength domain.

c) Analyses of experimental results provide the definition of the connection behaviour. Comparison with strength and stiffness values computed using currents design provisions, has demonstrated that current design codes disregard the effects of the tension-shear interaction in the connection elements. An analytical model, capable of reproducing the tension shear interaction in hold-down load bearing capacity will be developed for an accurate and safe design of the timber connections. The model will be calibrated on the results of uniaxial tests (without tension-shear coupling) and then validated on the results form coupled tests.

d) A new numerical model able to account for the interaction between tension and shear forces on typical timber connections will be developed, starting from experimental results specifically analysed by means of appropriate method for evaluating the main strength and stiffness parameters. In order to numerically reproduce the behaviour of connections, a coupled zero-length element will be developed and implemented in OpenSees frame-work. The model will be calibrated referring to experimental results of specimens loaded only in tension. Then the model will be validated referring to tests with increasing level of tension-shear interaction.

MAIN PUBLICATIONS

Pozza, L., Massari, M., Savoia, M. and Ferracuti, B. (2016), Experimental campaign of mechanical CLT connections subjected to a combination of shear and tension forces, accepted for publication in 'Proceedings of the 3nd International Conference on Structures and Architecture ICSA2016', Guimaraes, Portugal.

Talledo, D., Pozza, L., Savoia, M., Saetta A. (2016), Analysis of CLT panels with coupled shear-tension numerical model for connections, accepted for publication in Proceedings of World Conference on Timber Engineering (WCTE), Vienna, Austria.

RESEARCH PROJECTS

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LINKS AND CONTACTS

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