AN INNOVATIVE CONNECTION SYSTEM FOR CLT STRUCTURES: EXPERIMENTAL – NUMERICAL ANALYSIS

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ABSTRACT: The paper describes experimental and numerical analyses on a completely new connection system developed for CLT (Cross Laminated Timber) constructions. The innovative solution herein proposed, named X-RAD, consists of a point-to-point mechanical connection system, fixed to the corners of the CLT panels. This connection, that is designed to be prefabricated, is made of a metal wrapping and an inner hard wood element which are fastened to the panel by means of all-threaded self-tapping screws. Such system permits to reduce significantly the number of bolts/fasteners required to assemble two or more panels together or to connect them to the foundation. This results in the enhancement of the installation process in terms of speed, quality and safety. One of the reasons that fuelled the development of the presented system, is the desire of offering a solution to those issues (e.g. to satisfy ductility and energetic dissipation requirements) commonly related to the seismic safety of timber structures. In other words there was the will of defining a system able to guarantee an adequate level of ductility and energetic dissipation.

KEYWORDS: innovative connection system, CLT constructions, experimental tests

1 INTRODUCTION

The development of new connection systems explicitly designed to enhance the performance of the buildings made with the CLT technology, has become a necessity so as to comply with the most recent standards and to satisfy an international market that is getting more and more interested in such topic. According to the proposed system, the new connection-elements form the panel joints and are connected by means of metal plates and steel bolts. The screws can be installed at two different angles of inclination, so as to maximize the withdrawal strength by crossing more board layers. In addition, the presence of the hardwood element guarantees the possibility of distributing the internal actions in all directions, since the force transferring mechanism relies on contact forces rather than on direct interaction between the screw head and the metal plate as it happens in the traditional connection systems. Moreover, in case of a seismic event, the presence of a steel-to-steel link at the top/bottom of each panel provides to the CLT building a sufficient ductility level and an adequate dissipating capability, thanks to the plastic deformation under cyclic loading of the steel elements.

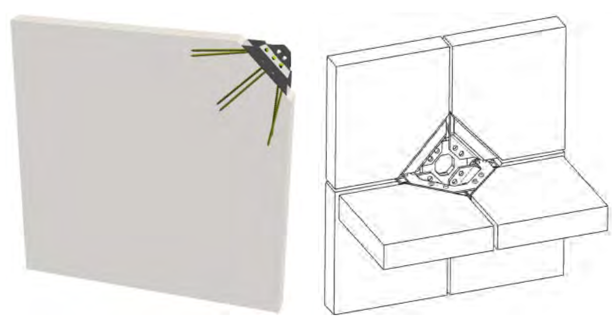

Figure 1: *The new connection system X-RAD fixed at a corner of a CLT panel, schematic view (left), different CLT panels connected by the use of X-RAD (right)*

The system, named X-RAD, is made of a metal wrapping which hosts inside a pre-drilled hardwood element (or a polymeric element) which allows the insertion of the screws required to fix the system to the CLT panels.

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Once on site, the panels are assembled simply by joining together the CLT elements placed at the corners of adjacent panels, through apposite metal plates and steel bolts. In the X-RAD system, the all-threaded screws can be installed at two different angles of inclination, so as to maximize the withdrawal strength. Because the screws are subjected to a tension force, the resulting joints are stronger and stiffer than the traditional ones where shear is the predominant action. The proposed system exploits the high performance (capacity and stiffness) provided by the usage of all-threaded screws inserted in a crossed disposition. The X-RAD system is symmetrically positioned with respect to the main stress plane and thanks to the peculiar geometrical disposition of the fasteners, it is able to make the CLT panels and the all-threaded screws develop their full capacity.

2 EXPERIMENTAL ANALYSIS

A preliminary test campaign was designed to determine the behaviour of full-threaded self-tapping screws when drilled in a wood element which inserted into a steel tube profile as in the X-RAD configuration. Following has been carried out a series of tests aimed at characterizing the mechanical behavior of the innovative connection system X-RAD. At the laboratory of CNR – IVALSA at San Michele all'Adige, Trento were tested 14 specimens characterized by two different version of the prototype and different load configurations.

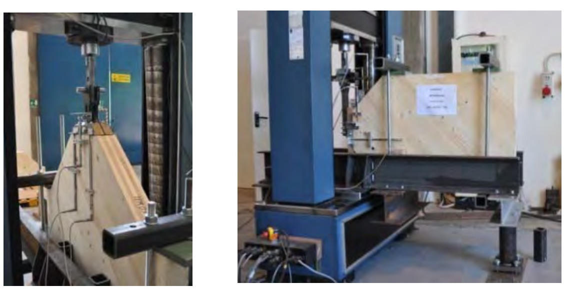

Figure 2: *Setup adopted for tension configuration and shear configuration*

Tests were conducted on a complete X-RAD connection system connected to a CLT panel by the use of 6 full-threaded self-tapping screws.

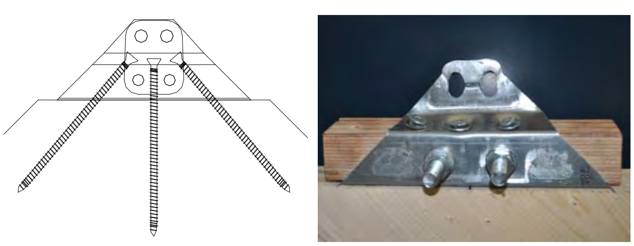

Figure 3: *The connection X-RAD fixed at a corner of a CLT panel (left), failure in tension configuration (right)*

The connection system was tested in two different load configurations called "Tension" configuration and "Shear" configuration. The adopted CLT panel was a typical 5-layer panel with a thickness equal to 100 mm. The presented tests have been performed to define a proper mechanical configuration of prototype. In tensile configuration it is possible to notice an evident bilinear behaviour due to the fact that the tensioned screws remained in the elastic field during the whole test and in the first phase also the steel box behaved elastically. After the global yielding point it is possible to notice plastic deformations both in the steel box both in the transversal bolts. In conclusion, the whole behaviour was determined by the steel components.

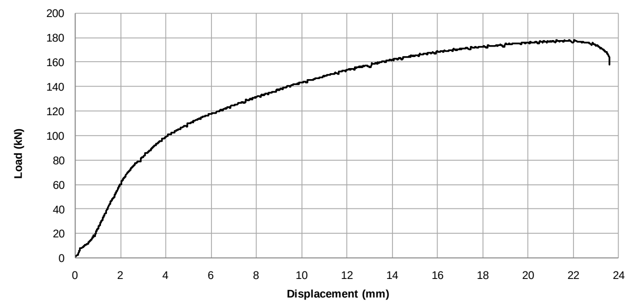

Figure 4: *Experimental load – global displacement curve*

During the testing no CLT failures in the timber area interested by the inclined screws was observed.

3 NUMERICAL ANALYSIS

In order to have a comparison with the test results and to have a more in-depth comprehension of the mechanical behavior of the different system components a 3D FE (Finite Element) model was implemented.

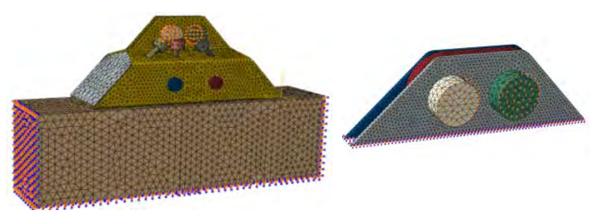

Figure 5: *View of FEM Abaqus model, The whole model and submodel use to study the block shear failure problem*

4 CONCLUSION

An innovative connection system for CLT structures was developed starting from the analysis of the main problems of "traditional" CLT assembling system. The main tests, the results of which were confirmed by an extensive numerical study, lead to the definition of the actual prototype that is characterized by strong capacity and high stiffness.