University of Florence – School of Agriculture

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Title of thesis: STRUCTURAL REPAIR OF TIMBER BEAMS: INVESTIGATION ON THE INTERVENTIONS CARRIED OUT WITH WOOD PROSTHESES CONNECTED WITH GLUED-IN RODS.

Supervisor: Prof. Marco TOGNI

Assistant supervisors: Ing. Benedetto PIZZO Ing. Marco Pio LAURIOLA

Candidate: Alessio SUSINI e-mail: alessio.susini@hotmail.com

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ABSTRACT

In this work, structural repairing of timber end-beams currently used in restore interventions was experimentally evaluated. The analysed method of intervention regards the replacement of the damaged part with a wood prosthesis connected to the sound part of the element with glued-in rods.
Presently in Italy this kind of intervention is realized following the Technical Document CNR DT 206/2007, that provides three different cases considering in the intervention design.
This design approach considers the minimum value among the joint strength related to the:
a) rupture or yielding of the rod
b) rupture of the wood-adhesive or reinforcement-adhesive bonding
c) tensile rupture of the wood (parallel-to-grain).
A different kind of rupture which is not described in the currently used procedure was also considered:
d) splitting of wood (orthogonal-to-grain wood rupture)
The execution of real interventions was simulated using a series of 45 new spruce (*Picea abies* Karst.) *glulam* beams. Two different size elements were used: 25 elements with 120x140 mm cross section and 20 with 200x160 mm cross section. The joint was realized using steel rods, glued-in with epoxy resin: beams were cut close to the end and then the two parts were jointed together by using the considered reinforcing technique. Steel rods were placed parallel to wood grain in appropriate slots of square section. Slots were usually closed by using appropriate wooden laths.
In this experimentally study many intervention configurations were considered. A series of 5 beams was used for each configuration, in order to evaluate:
on small beams:
- different cut inclination, making a 45°, 90° and 135° cut (using 3 different series of beams);
- reinforcement of wood (orthogonal-to-grain) with screws;
- use of a pair of thread bars with 7 mm of diameter. In this case the reinforcement section is the same to 10 mm bars, but the stiffness is higher;

on big beams:
- different size of reinforcement bar, using a 10 mm and 14 mm steel rods;
- absence of wooden laths closing lateral slots;
- increase of depth of reinforcement bars to lateral edge of beams.

Beams were subjected to a bending test. The flexural stiffness was measured on beams, before the joint realization. In addiction of flexural stiffness also the joint stiffness was measured on jointed beams. Finally, load at the collapse of repaired beams was measured.
According to results obtained from tests, stiffness measured on repaired beams was lower than sound beams. Moreover, about 70% of rupture has happened with the 4th rupture mode (d: splitting of wood) which wasn't considered in the CNR DT 206/2007. Different rupture mode was noted only on the screw-reinforcement series and the 14 mm steel rod series of beams.
Differences in collapse load values were measured on screw-reinforced beams which was higher than the other series of small beams and on the no-lath series of beams which was lower than the other similar series. This fact doesn't confirm the importance of cut inclination on joint strength. Although, it confirms the importance of wooden laths closing the lateral slots which contribute to the structural strength of joint.
Moreover, the analysis of collapse modes of repaired beams permits to observe that the use of stiffer reinforcement elements, as steel rods, could cause ruptures on the weakest part of wood (orthogonal-to-grain direction). Future developments in this study should include the use of a wooden lath directly like joint reinforcement, checking the compatibility with bonding.