Connections with timber pins: the influence of dowel bearing strength

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The use of timber pins in connecting timber elements is a valid alternative to the employment of metallic devices and it could be an efficient solution in the field of restoring ancient timber structures. Authors of the present study are carrying on an extended experimental research, trying to better understand the complex mode of failure of timber joints connected by timber pins. In this report, the target is a deeper insight on dowel-bearing strength when using a timber pin.
The half-hole set up (ASTM D 5764) has been used to measure the dowel-bearing strength with a steel bolt as well as with a timber (ash) pin. Three different essences have been used, with a strong difference in density values: durmast, fir and pawlonia. Therefore the behaviour of the ash pin has been characterized in free and confined compression also to study the applicability of the springs-in-series model proposed by Schmidt (Schmidt 2006). In Figure 1, are quoted, for each essence, the load-displacement curves for the dowel-bearing tests with steel bolt and with timber pin, for the confined compression test on the timber pin, and that obtained summing the first one and the last one. It's quite evident that the last one, that is the diagram of the springs-in-series model, doesn't reproduce the rheological behavior experimentally obtained, as, for all the essences, this one is characterized by a well marked yielding phase, which is not visible in the springs-in-series diagram. Besides this diagram overestimates deformation in the first part, and then underestimates it in the second one, and therefore can't give a reliable yielding limit value of the dowel-bearing strength. Comparison between the load-displacement curves for the dowel-bearing tests with steel bolt and with timber pin, and for the confined compression test on the timber pin, evidences that when density of boards' timber is larger than that of the pin, (durmast), the first part of the diagram quite reproduces that of the pin confined compression; moreover, second part slope, always less than the slope of the first part, is only determined by the nature of the boards' timber. It can be inferred that the yielding phase constitutes a transition phase in between two subsequent ones: in the first phase, the timber pin, carrying the larger amount of the applied load, behaves like a damper in transferring the load to the boards' timber. Consequently, this last one, shows a stiffer behavior; when the timber pin yields, load transfers to the boards' timber, which instantaneously presents a deformation proportional to the applied load; in the second phase, deformation corresponding to the applied load is quite the sum of the deformation corresponding to that level of load in the load-displacement curve for dowel-bearing test with steel bolt, deformation of the timber pin, and the deformation of boards' timber in the transition phase.

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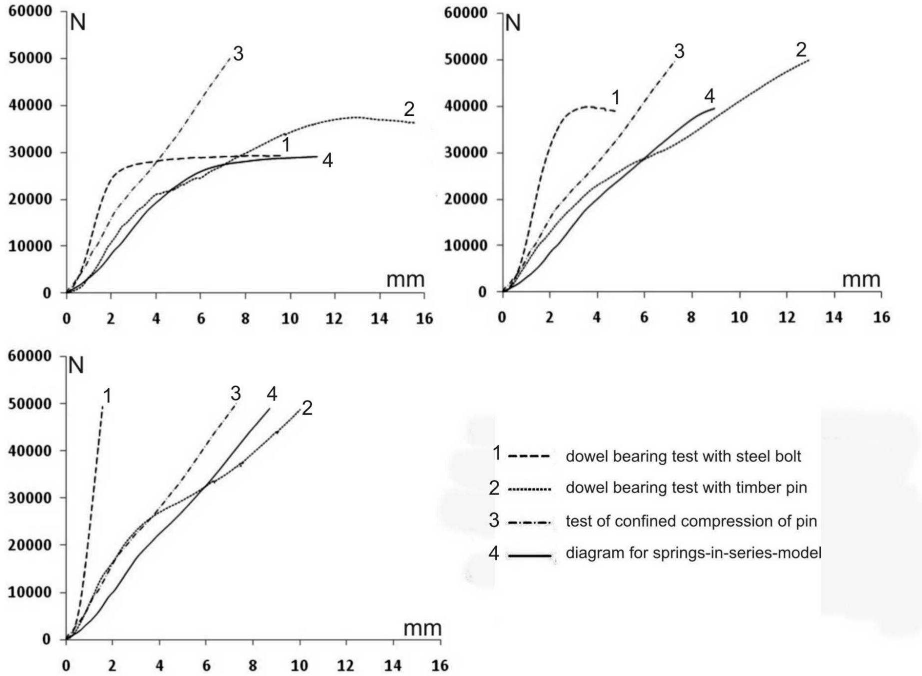

Figure 1 – Load-displacement curves for each used wood essence

The dowel-bearing behavior just described can be schematized like in Figure 2, where point A corresponds to the load value F_c for which yielding of the pin occurs, as OA line has the slope K_1 of the diagram of the pin confined compression test; point B has deformation equal to the sum of that corresponding to point A plus that corresponding to the value F_c of the applied load in the diagram of dowel-bearing test with steel bolt; BC line has the slope K_2 of the diagram of the springs-in-series-model.

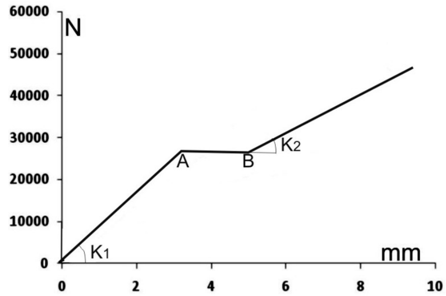

Figure 2 – Model of the dowel-bearing behavior with timber pin.

Adopting the proposed model implies indentifying the yield limit for dowel-bearing with timber pin with the yielding load value F_c obtained in confined compression tests on timber pin, to which corresponds a stress value always smaller than the experimental values. This circumstance, if on one hand let working always in safe, on the other hand underestimates the dowel-bearing strength of the joint. Underestimating increases with the strength of the beards' timber and is quite penalizing when density of the boards' timber is larger than that of the pin. On the other hand, dowel-bearing strength is only one of the parameter needed in defining the global behavior of the joint, for which usually is more convenient the employment for the pin of a timber with density larger than that of which the jointing structural elements are made. So, in spite of those inaccuracies which using the proposed simplified model implies, the adopted schematization has the great vantage that the few parameters needed for its identification are easily obtained. In fact, the only tests needed are: confined radial compression tests on the timber pin which give K_1 and F_c parameters, and dowel-bearing tests with steel bolt, which give, for each essence, point B, and, using the springs-in-series model, K_2 parameter.