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Structural behaviour of log timber walls under lateral in-plane loads

Jorge M. Branco *, João P. Araújo

ISISE, Univ. of Minho, Dept. of Civil Engineering, Campus de Azurém, 4810-058 Guimarães, Portugal

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ABSTRACT

The present works intends to represent a further step in the knowledge of timber log-houses through an experimental approach, from which only few information is available. The main part of the experimental work is based on in-plane static tests conducted on timber log walls with distinct transversal stiffness, two vertical compression levels and different values of slenderness. Monotonic and cyclic tests were performed according to EN 12512:2001. The former were performed to define the elastic slip values and assessment of the failure mechanisms while the latter allowed for the evaluation of the impairment of strength, the measurement of the ductility and the quantification the energy dissipation. Previously to the full-scale tests of walls, an extensive characterization of the timber logs was made. Due to its importance, the connection between the first timber log and the basement was also evaluated through tests. In a second step of the research, a case study was used to develop a numeric analysis. Using FEM, the in-plane stiffness of timber logs walls was quantified, thus allowing to compare the result of distributing the horizontal loads by the walls according to their area of influence or their in-plane stiffness. Finally, improvements to the log system analyzed were suggested.

1. Introduction

The construction of timber houses using logs is an ancient practice in many regions of the globe. Overlapped logs were used, covering the gaps between logs with moss. With the emergence of other construction materials, the use of timber decreased considerably and the log system lost importance. Nevertheless, timber log constructions are still popular in many forest regions of the world, especially in North America and Scandinavia.

One of the main disadvantages of log construction is the lack of sound understanding of the structural behaviour of these structures, in particular, under seismic loads [1,2]. Log buildings rely on the walls built staking horizontal layers of logs, for resistance to both vertical and horizontal loads. The resistance to vertical loads depends mostly of the contact area between logs and on the compression strength perpendicular to the grain. While, horizontal loads are supported by transverse walls, depending strongly on the friction between slots.

Lateral loads in log shear walls depends on the (1) interlocks between logs, (2) wood or steel dowels, (3) vertical through bolts and anchor-bolts, and, (4) frictions between logs due to vertical loads [1]. However, current codes only consider the influence of dowels and vertical through bolts [3], as a result of the significant variability and inexistence of accurate models for the other resistance mechanisms.

In this paper, the resistance of a standardized log construction technology considering all mentioned mechanisms (Fig. 1) is evaluated experimentally. Wall panels under vertical and horizontal loads are tested and, lastly, a timber log house is studied under seismic loading.

2. Timber logs

The basic component of this system is the log obtained from lamellas (40 mm) glued face to face, representing an example of vertical glulam, as defined in EN 386:2001 [4]. Three thicknesses are available for the logs: 80 mm (2 lamellas), 120 mm (3 lamellas) and 160 mm (4 lamellas). Notches are made in the top and bottom surfaces of the logs. Those notches increase the interlock and the friction between horizontal layers of logs. Fig. 2 presents log cross-sections available on the Rusticasa system.

Lamellas are made of Scots pine (*Pinus sylvestris* L.), bought from the Scandinavian supplier with the minimum requirement to belong to Quality Class VI (or Class C under the new designation), according to [5]. In other words, lamellas are bought based on a visual classification for non-structural applications.

Using NP EN 1194:1999 [6] it is possible to predict the global behaviour (log) based on the mechanical properties of the lamellas. However, in this case, no reference values were known for the lamellas. Therefore, an experimental analysis of the logs under compression perpendicular to the grain and bending was

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* Corresponding author. Tel.: +351 253 510 200; fax: +351 253 510 217.
E-mail addresses: jbranco@civil.uminho.pt (J.M. Branco), jparaujo.civil@gmail.com (J.P. Araújo).

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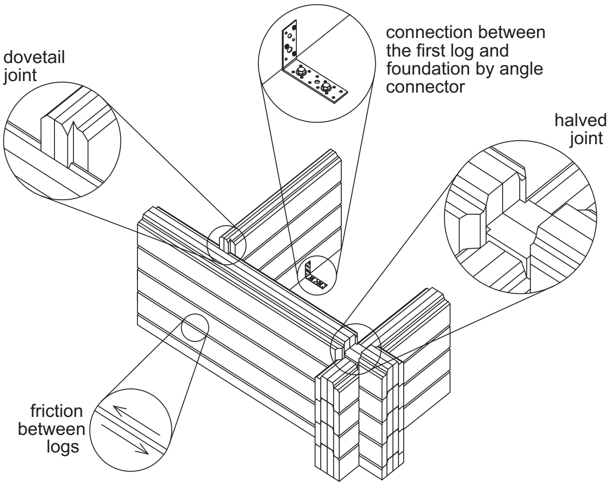

Fig. 1. Lateral resisting elements of log shear walls.

performed, following [7]. The experimental campaign undertaken, the tests results obtained and their analysis can be found in [8,9].

3. Connection between the first log and foundation

In timber log constructions, connections between the first log and the foundation are normally achieved through anchor bolts using holes, spaced 120 cm on average, using oversized to facilitate construction. Anchor bolts lose tightness as the log shrinks due to drying and anchor bolt nuts may be inaccessible, thus they cannot be tightened later in the life of the structure [10]. In the Rusticasa system, the connection between the first log and the foundation is made using an angle connector (BMF 40314), every 150 cm, with three screws (5 × 50 mm) in the timber side and two metal anchors (M8) fixed to the concrete, as shown in Fig. 3.

Applying the expressions of Eurocode 5 [11] Section 8, a value of 3.57 kN is obtained for the resistance of the connections for both directions (parallel and perpendicular to the log axis). This value refers only to the resistance of the connection on the wood side, assuming that the connection device-foundation must be designed according to an appropriate overstrength.

Two types of cyclic tests were performed to evaluate the behaviour of this connection. Using three specimens for each type, the connection was submitted, in the wall plane, to shear (Fig. 4a, loaded in the direction of the log axis) and to tension (Fig. 4b, loaded in the direction perpendicular to the log axis).

For both kinds of tests, a quasi static cyclic loading procedure in accordance with EN 12512:2001 [12] was assumed. For the shear tests complete cycles were used (Fig. 5) while half cycles (only in the tension side) were adopted in the tension tests (Fig. 6).

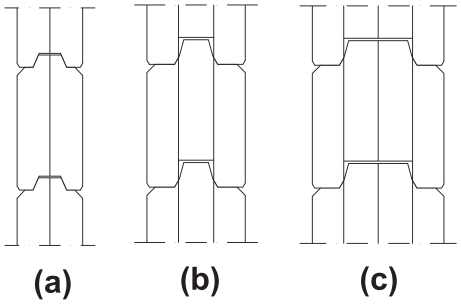

Fig. 2. Available log cross-sections. (a) 80 mm; (b) 120 mm; (c) 160 mm.

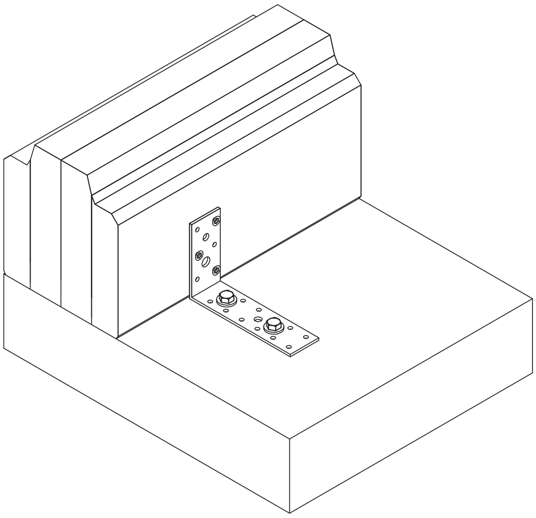

Fig. 3. Connection between the first log and the foundation of the Rusticasa system.

(a) Shear test (b) Tension test

Fig. 4. Specimens layout used for the tests of the connection between the first log and the foundation.

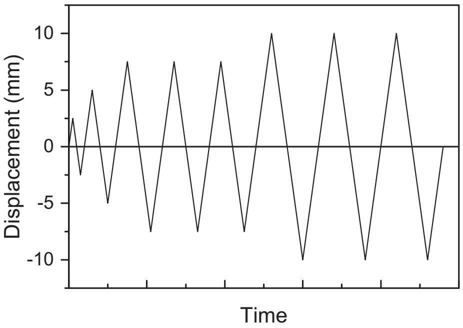

Fig. 5. Loading procedure for shear tests.

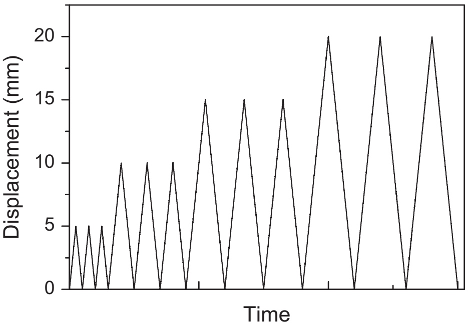

Fig. 6. Loading procedure for tension tests.