MECHANICAL CHARACTERISTICS OF HISTORICAL BEAMS OF Picea abies WOOD. ASSESSMENT BY STATIC BENDING

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ABSTRACT: Five historical full-size structural beams of Picea abies wood were tested in static bending. The static bending tests were useful to assess the modulus of elasticity and the modulus of rupture in full-size historical beams, according to the European Standard EN 408. The beams were classified as indicated by the European Standard EN 384 and their stiffness properties. The results show a similar behavior in beams 1 and 5, and in beams 2 and 3. Only beam 4 presented a different response. The methodology developed in this investigation can be applied to the assessment of other old wood structures if the prudent adjustments of the particular study are considered.

KEYWORDS: Modulus of elasticity, modulus of rupture, old wood constructions

1 INTRODUCTION

The wood that shapes historical buildings has a remarkable quality; even so the technological condition of the wood suffers from the influence of time, weather and working conditions. This frequently found scenario reduces the magnitude of the nominal properties of the element, compared to its actual mechanical characteristics.

The procedures and configuration of static bending tests are well established for timber and full-size wood elements [2,3]. However, it is challenging to apply this approach directly in the context of the structural analysis of old wood structures. It is necessary to have reliable information of the mechanical properties of wood currently used in historical buildings.

This paper presents the modulus of elasticity and the modulus of rupture in static bending of historical beams of Picea abies wood. The beams had an antiquity estimated of 100 years performing as structural elements of the wooden roof of the Prague Masaryk Railway Station, Czech Republic.

2 METHODOLOGY

Five historical full-size structural beams of Picea abies wood were tested. The procedure of the static bending tests adapted the protocol recommended by [2].

The specimens were simply supported. The span distance between the support points was 3000 mm, 11.3 times the depth of the specimens. The distance between the load points was 1000 mm and the specimen overhang was 250 mm. The displacement rate was of 2 mm/min (Figure 1).

Figure 1: Static bending test configuration. Magnitudes in millimeters.

The bending load was recorded with a load cell which had a capacity of 300 kN (*Rukov Rumbuk®*). The deformation of the beams was measured in the middle of the bending span with two potentiometers placed each one in the central point of the opposite edgewise direction of the beam, (Figure 1). Data were acquired and treated using a dynamic switch board Dewe-5000 (*TRADMARK data logger system®*).

The modulus of elasticity (MOE) and the Modulus of rupture (MOR) of the beams were computed with the formulae proposed by the European Standard EN 384 [3].
3 RESULTS

Table 1 shows the results for the five beams studied.

**Table 1: Values of moisture content, density, modulus of elasticity and modulus of rupture from the five historical beams settings**

<table>
<thead>
<tr>
<th>Beam</th>
<th>MC (%)</th>
<th>$\rho_h$ (kg/m$^3$)</th>
<th>MOE (MPa)</th>
<th>MOR (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13.14</td>
<td>448</td>
<td>11,505</td>
<td>32.37</td>
</tr>
<tr>
<td>2</td>
<td>11.08</td>
<td>414</td>
<td>8,516</td>
<td>33.94</td>
</tr>
<tr>
<td>3</td>
<td>11.79</td>
<td>449</td>
<td>8,940</td>
<td>31.42</td>
</tr>
<tr>
<td>4</td>
<td>11.41</td>
<td>366</td>
<td>7,557</td>
<td>16.66</td>
</tr>
<tr>
<td>5</td>
<td>12.16</td>
<td>433</td>
<td>10,402</td>
<td>31.47</td>
</tr>
</tbody>
</table>

Mean 11.92 422 9,384 29.18
SD 0.80 34.37 1,570 7.07
COV(%) 6.67 8.15 16.70 24.23

Figures 2 and 3 show the load-deformation diagrams from the static bending tests.

**Figure 2: Load-deformation diagram for beams 2, 3 and 4**

**Figure 3: Load-deformation diagram for beams 1 and 5**

4 DISCUSSION

The data presented in Table 1 suggests that the beams can be grouped in relation to their modulus of elasticity and their behavior in the static bending tests: beams 1 and 5 have similar behavior as well as beams 2 and 3, in a comparable way. Only beam 4 presented a different response.

The values of the modulus of rupture (MOR) showed in Table 1 represent the mechanical strength. According to the European Standard EN 384 [4] and their stiffness properties, the beams were classified as follows: beam 1: C24; beams 2 and 3: C16; beam 4: C14; and beam 5: C22.

5 CONCLUSIONS

The beams presented the attributes currently found in historical wood structural elements: heterogeneity of the wood tissues, misalignment of the geometry respecting the orthotropic axis of wood, presence of cracks and knots, and traces of weathering. Besides this, the beams were mechanically tested with satisfactory results.

The static bending tests were useful to the evaluation of the modulus of elasticity and the modulus of rupture in full-size beams of *Picea abies* wood. The methodology developed in this investigation can be applied to the assessment of other old wood structures if the prudent adjustments of the particular study are considered.

The computed values of the modulus of elasticity and the modulus of rupture had the usual peculiarities that other wood mechanical characteristics present: anisotropic nature, variability among specimens, and different figures depending of the experimental configuration or technique applied. Considering the particularities of each test and the directions for which every modulus was computed, they can be used as a reference to assess and model historical wood structures.

REFERENCES


