MODEL CALIBRATION OF WOODEN STRUCTURE ASSEMBLIES - USING EMA AND FEA

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ABSTRACT: To predict and, when needed to fulfil regularizations or other requirements, lower the impact sound transmission in light weight buildings prior to building, dynamically representative calculation models are needed. The material properties of commonly used building components have a documented spread in literature. Therefore, to validate the junction models, the dynamics of the actual assembly components have to be known. Here, the dynamic properties of a number of component candidates are measured using hammer excited vibrational tests. The spread of the properties of the components are hereby gained. Some of the components are selected to build up wooden assemblies which are evaluated first when they are screwed together and later when they are screwed and glued together. The focus is here on achieving representative finite element models of the junctions between the building parts composing the assemblies.

KEYWORDS: Light weight wooden assembly, Structural Dynamics, Finite element (FE) model, Experimental modal analysis (EMA), Model Calibration

1 INTRODUCTION

Low frequency range (20-200Hz) impact sound are more annoying in light weight residential houses than in buildings made from heavier construction materials. In the low frequency region, the eigenmodes are fairly well separated and a deterministic approach is useful. Having a dynamic model that satisfactorily represents the dynamics of the structure, the impact sound transmission can be predicted and, when needed, modified prior to building. Material properties are shown to play an essential role for analytical models to correlate with experimental analysis [1]. Normally the material properties in an analytical model are adjusted so the analytical result fit the experiment result [2]. Therefore, calculation models, taking the spread of the material properties into account, have to be developed for light weight building structures. Studying the dynamical spread among building component, that ultimately should be identical, constitutes one part of this paper.

To achieve accurate calculation models, more often than not finite element models, functioning as sound transmission prediction tools, the modelling of the junctions are of utmost importance. In [3] the effect of using different connections in an FE model were described and compared; it was concluded that the representation of the junctions used in the FE model had significant effects on the results. The results were not compared with real measurements in that study. In [4] the effect of using or not using glue was evaluated experimentally. It was shown that the glue added damping in the horizontal layer, however the experimental study was made using components having different material properties. In [1] the screwed connections are modelled using springs and dashpots. It was shown that the rotational stiffness needs to be addressed as well, even when the structure is only screwed. Calibration of light weight wooden assemblies focusing on the junctions constitutes the second part of this paper.

2 BUILDING STRUCTURES

To evaluate the spread in material properties for normal construction materials, four chipboards, six short and six long laminated veneer lumber (LVL) beams together with six short and six long construction timber (CT) beams were evaluated. The sizes and number of each building component are given in Table 1. Each of the building parts are hanged in suspensions, mimicking free-free conditions, excited by hammer impacts and the responses are measured by eight to twelve accelerometers, see Figure 1. Four to eight individuals of each component type were examined to find the spread in the material properties of the building components used. Some components were selected to be used within two assemblies; one consisting of four LVL beams together with a chipboard and one

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consisting of four CT beams and a chipboard. When the material properties are known the building components were assembled using screws only, and the dynamics properties were evaluated. Then, the assemblies were remounted and assembled again; this time using glue as well as screws whereby the dynamics were evaluated again.

The purpose is to have assemblies with different junctions but made up of the same components enabling the study of the junctions. The aim is to find reliable models for the different junctions; screwed as well as screwed and glued, in wooden floor assemblies.

Validated finite element models representing each component are used to model the floor building assemblies; the models are used for evaluation of the modelling of the junctions.

<table>
<thead>
<tr>
<th>Material</th>
<th>No. of candidates</th>
<th>Dimensions (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chipboard</td>
<td>4</td>
<td>0.57x1.2x0.022</td>
</tr>
<tr>
<td>Long CT beams</td>
<td>6</td>
<td>1.2x0.045x0.045</td>
</tr>
<tr>
<td>Short CT beams</td>
<td>6</td>
<td>0.48x0.045x0.045</td>
</tr>
<tr>
<td>Long LVL beams</td>
<td>6</td>
<td>1.2x0.045x0.045</td>
</tr>
<tr>
<td>Short LVL beams</td>
<td>6</td>
<td>0.48x0.045x0.045</td>
</tr>
</tbody>
</table>

**Table 1: Evaluated building components and their sizes.**

LMS TestLab was used for the tests and the evaluations. The LMS PolyMAX stabilization diagram supports in selecting the poles [5]. Then, the modeshapes and the damping are extracted, see examples in Figure 3a-d.

**Figure 3:** Some of the modeshapes for chipboard A, a) 43.3 Hz 1.1% damping, b) 52.8 Hz 0.96% damping, c) 115.4 Hz 0.98% damping and d) 118.8 Hz 0.93% damping.

3 DISCUSSION AND CONCLUSIONS

The properties of wooden building materials show large spreads. Hence, to study correlation between test and analysis of wooden assemblies, focusing on the junctions, it is crucial to have knowledge of the properties of the components used. Having accurate models of the junctions, the statistics of the dynamics of the assemblies can be predicted based on the knowledge of the dynamical spread of the building components. For successful model representation of the dynamics of wooden assemblies it is of utmost importance to include rotational stiffness within the junctions.

REFERENCES


