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SUGGESTION FOR A ROUND ROBIN TEST ON THE MEASUREMENT OF VIBRATION REDUCTION INDICES ON CLT JUNCTIONS

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ABSTRACT

Prediction methods for sound insulation require input data for the vibration reduction indices. For heavy buildings, ISO 12354-1 provides methods based on the mass ratio of elements. The same holds for solid timber. However, these data are based on a small number of measurements in buildings without the effect of additional loads or elastic interlayers, highlighting the essential need for additional measured data. ISO 10848-1 [1] describes methods to measure the vibration reduction index. But there is room for interpretation of the guidelines given in this standard. For example previous research showed that the choice of sampling points is crucial [2]. To quantify the measurement uncertainty, this paper suggests a concept for a round robin test for discussion. This could be carried out in the laboratory at the Technical University of Applied Sciences in Rosenheim. This laboratory provides a mock-up that allows to set up either a L-junction or a T-junction formed by CLT (cross laminated timber) panels that can be reconfigured quickly with an overhead crane. The possibility to apply additional loads which can be monitored and controlled with load cells as well as the application of elastic interlayers is given. The mock-up can stay in place to have enough time for several institutions to measure.

Keywords: *vibration reduction index, inter-laboratory test, measurement methods*

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1. INTRODUCTION

The standard ISO 10848 was first publised in 1999 with the title *Acoustics - Labaratory measurement of the flanking transmission of airborne and impact noise between adjoining rooms - Part 1 : Frame document* [3]. The scope of this standard was to describe measurement procedures to determine the characteristics of one or more building elements in terms of flanking transmission. These characteristics can be used as input data for the prediction methods given in the EN 12354 series. Measured data is particularly needed for junctions formed by timber elements. Hence this standard was used widely to gather data that can be used for prediction. Almost two decades after the publication of ISO 10848, Timpte et al. [4] collected data across Europe from six institutions with more than 200 datasets of vibration reduction indices of cross-laminated-timber (CLT) junctions. It was found that there is a significant deviation between vibration reductions indices measured at various institutes for similar junction configurations. These deviations include parameters related to the mock-up, such as the CLT element itself, construction details of the junction, the choice of optional resilient interlayers or additional loads but also parameters related to the measurement procedure and the processing of data.

The intention of this paper is to initiate an inter-laboratory test (round-robin test) on the measurement procedure including the processing of data to determine vibration reduction indices. This suggested test would not consider all parameters related to the mock-up or the CLT elements itself. It is aimed to consider one specific mock-up formed by CLT elements that will stay in place in one laboratory with different people visiting this laboratory to measure the vibration reduction index according to ISO 10848. However, this standard is currently under revision by ISO/TC 43/SC 2/WG 18 where the measurements procedure and the processing of data is considered. The suggested inter-laboratory test will include the application of the current standard in comparison with the proposed revision by WG 18.

2. INTER-LABORATORY TEST

Deviations caused by material properties or details on the construction of the junction will not be considered. Only one mock-up with a single set of CLT elements should be part of the inter-laboratory test. The suggested approach is therefore identical with the *measurement situation B* in combination with section 5.6.2 described in [5]. Following this approach the so-called *in-situ* standard deviation can be obtained.

Although the identical CLT elements will be used in the test, it is aimed to consider not only one fixed junction configuration. Each team should measure the vibration reduction index for a set of junctions formed by the same CLT elements, such as an L-junction and a T-junction with the corresponding different transmission paths. It is also aimed to consider different loads on the junction. In addition a junction configuration with an elastic interlayer should also be considered and could easily be implemented in the test procedure.

This requires a careful documentation and monitoring during the reassembly of the considered junction configurations. To ensure identical configurations, parameters such as tightening torques of screws or a measurement, respectively a monitoring of the applied load is required. In addition parameters such as temperature, humidity and moisture will need to be monitored.

3. SUGGESTED TEST FACILITY

For the suggested inter-laboratory test on the measurement of vibration reduction indices of CLT junctions, the laboratory at Rosenheim Technical University of Applied Sciences can be made available. This laboratory offers a mock-up that was already well investigated. This included a statistical study on the vibration field and the corresponding sampling to determine the plate energy [2]. Figure 1 shows the bottom of the junction with the dimensions given in Figure 2. It is possible to configure either a L-junction or a T-junction. Three CLT elements, two wall and one floor element is already in place. A reconfiguration of junctions is possible with an overhead crane.

To apply additional loads on the junction a construction with steel girders is installed. This can be seen in

Figure 1. Bottom view of the junction mock-up.

the section drawing in Figure 2 as well as in the photo in Figure 3. These Figures also indicate the two load cells that are installed to monitor the applied load. This mock-up can stay in place for several months in order to allow various teams to come and perform the measurements.

4. CONSIDERATIONS ON THE TYPE OF AVERAGING LEVEL DIFFERENCES

In the course of the round robin test, measurements could as well be compared when applying different calculation approaches of averaging, especially the averaging of results from different excitation positions as discussed in the revision of ISO 10848.

In the current standard of ISO 10848 the velocity level difference $D_{v,ij}$ is calculated using the arithmetic mean of the $D_{v,ij,m}$ for $m = 1 \ldots M$ excitation positions (see equation (2)). Using the familiar physical approach from

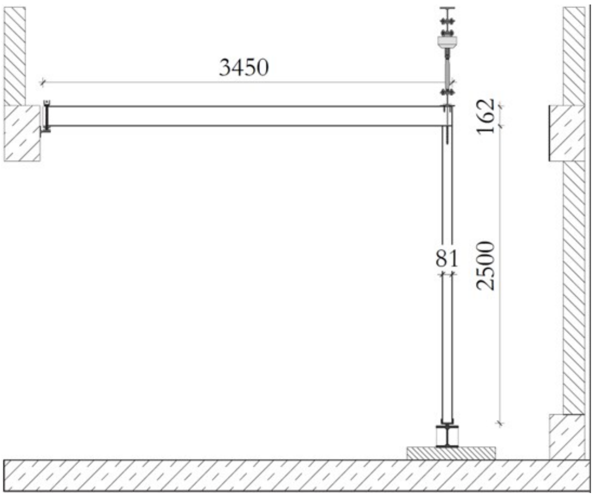

Figure 2. Section of a L-junction configuration indicating the dimensions of the elements. The width of the wall and floor elements not shown in this section is three metres.

EN ISO 10140-4 using transmission coefficients

$$\tau_{ij,m} = \frac{\overline{v^2_{j,m}}}{\overline{v^2_{i,m}}} \tag{1}$$

as the ratio of the mean squared velocity of the receiving element j and the exited element i respectively, the current definition of $D_{v,ij}$ is based on the geometric mean of the transmission coefficients for different excitation positions according to the following derivation.

$$\begin{aligned} D_{v,ij} &= \frac{1}{M}\sum D_{v,ij,m} \\ &= \frac{1}{M}\sum (L_{v,i,m} - L_{v,j,m}) \\ &= \frac{1}{M}\sum 10\lg\left(\frac{\overline{v^2_{i,m}}}{\overline{v^2_{j,m}}}\right) \\ &= \frac{1}{M}\sum -10\lg(\tau_{ij,m}) \\ &= -10\frac{1}{M}\lg\left(\prod \tau_{ij,m}\right) \\ &= -10\lg\left(\sqrt[M]{\prod \tau_{ij,m}}\right) \end{aligned} \tag{2}$$

A comparison using the arithmetic mean

$$D_{v,ij} = -10\lg\left(\frac{1}{M}\sum \tau_{ij,m}\right) \tag{3}$$

Figure 3. Top of the L-junction shown in the section drawing in Figure 2. Steel girders to apply a load on the junction. Between the two horizontal girders load cells are in place to measure the force.

or the harmonic mean

$$D_{v,ij} = 10\lg\left(\frac{1}{M}\sum \frac{1}{\tau_{ij,m}}\right) \tag{4}$$

might be evaluated with the measurement results. This would enable to derive the standard deviation using different calculation approaches for the determination of the vibration reduction index.

5. SUMMARY AND OUTLOOK

The measurement of vibration reduction indices is crucial for the application of the the prediction methods given in EN 12354. However previous research [4] showed that there can be great uncertainty in the measured values. This is not only due to deviations in the material parameters or construction details but also due to the measurement procedure and the processing of data. The suggested inter-laboratory test would enable to identify the *in-situ* standard deviation due to the measurement procedure given in ISO 10848. As this standard is currently under revision, both the current procedure as well as the proposed revision could be considered. For the inter-laboratory test the facilities at Rosenheim Technical University of Applied Sciences can be used. In advance repeatability measurements according to the *measurement situation C* in section 5.3.2 [5] would be carried out and compared with corresponding standard deviations from other laboratory setups. Furthermore the possibility to extend the measurement procedure to include the determination of the structure-borne reverberation time should be discussed with potential measurement teams before.

6. REFERENCES

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