EVALUATION OF IMPACT SOUND REDUCTION OF FLOOR COVERINGS ON TIMBER AND TIMBER-CONCRETE FLOORS USING VIBRATION MEASUREMENTS

A. Pereira [1], D. Mateus [1], L. Godinho, S. Monteiro [1], A. Dias [1]

[1] ISISE, Department of Civil Engineering, University of Coimbra, Coimbra, Portugal
{apereira@dec.uc.pt, diogo@dec.uc.pt, lgodinho@dec.uc.pt, sandra@dec.uc.pt, alfgdias@dec.uc.pt}

Abstract

When performing acoustic rehabilitation of timber floors, soft coverings or floating floors may be used to improve impact sound insulation. The impact noise reduction provided by floor coverings is usually reported having as a reference laboratory tests, using the methodology described in the series of standards EN ISO 10140, which requires the use of standard acoustic chambers and a heavyweight bar floor made of concrete. When using these floor coverings on lightweight floors such as timber or timber/ concrete the impact sound reduction obtained may not be the same as in a heavyweight floor. In this paper evaluation of impact sound reduction provided by some floor coverings on timber floors is addressed using an experimental approach. An alternative measurement procedure (non-standard) is applied, where vibration records are performed without and with the floor covering in order to obtain impact sound reduction. Soft coverings and floating floors are tested on a timber floor with small dimensions and the results are compared with those obtained using the procedure described in the Standard ISO 16251-1, using a heavyweight floor. Concrete-timber floors of different sizes with floor linings are also tested and the influence of the area on the evaluation of this parameter is addressed.

Keywords: impact sound reduction, timber floor, timber concrete floor, vibration

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1 Introduction

Timber structures are a common structural solution found, not only in floors of old buildings, but also in new buildings of small size, in some n some countries. It is known, that these types of floors, exhibit poor acoustic performance, mainly in the low frequency range, due to their light weight. In order to improve the floor acoustic performance, changes in structural or non-structural parameters are needed. Johansson [1] carried out tests in a series of timber floors and concluded that the increase in the floor stiffness did not significantly affect its impact sound insulation at low frequencies.

In order to improve the sound insulation, some other techniques may be used that include the increase in mass or damping, such as the construction of a concrete layer and the addition of ceiling layers [2]. Also Ljunggren and Agren [3] refer that construction modifications, such as extra board layers, elastic glue between floor boards and the use of floating floor could improve the acoustic performance of timber floors; however in tests carried out, the results revealed that the impact sound insulation gains were relatively small.

In order to get better results, solutions based on timber-concrete composites in combination with non-structural elements could be an option as shown in the results obtained by Schmid [4], who carried out

a series of field measurements to determine the air-borne sound insulation and the impact sound level in timber-concrete floors and concluded that the installation of ceiling panels improves the acoustic performance of the floors.
Timber-concrete reinforcement has been used as a rehabilitation solution of old timber floors. With this technique, the stiffness and the load carrying capacity increase considerably face to traditional timber floor systems. Also the increase in damping of the structure helps to increase the impact noise insulation. The airborne noises insulation is also improved due to the increase in the system's mass [5].
The use of lightweight concretes for timber floor reinforcements have also been investigated, since they have advantages over the usual heavier formulations, due to the substantially reduced own-weight, while still performing structurally quite well. Note that because the existing timber floor may not have sufficient load bearing capacity, the use of lighter structural solutions may be considered. In the work of Martins et al [6], results of lightweight timber - concrete floors, using concrete with cork aggregates, showed that from the acoustic point of view, good results can also be found when comparing with a similar solution made of standard concrete. If suspended ceilings are applied compliance with acoustic demands for residential buildings can be achieved.
In the present work the authors assess the evaluation of impact sound reduction of floor coverings on timber and timber concrete floors using vibration measurements. The procedure used is inspired in that described in the ISO/CD 16251-1 standard [7, 8]. A setup composed of a simply supported timber floor of small dimensions was built and vibration measurements are carried out when a normalized tapping machine excites the system without and with the floor covering. The same procedure is also used to evaluate impact sound reduction of different floor coverings on timber-concrete-floors of real sizes.

2 .Measurement procedure

The measurement procedure used in this work was built following some of the recommendations described in the Standard ISO 16251-1[7], consisting of acquiring vibration levels in the upper surface of a slab, in 1/3 octave frequency bands, between 100Hz and 3150 Hz. Several accelerometer positions were defined: some of them were placed above the joists and the other between joists. The source used is a normalized tapping machine placed at three different positions, on the joists and between them with varying angles in relation to the joists.

The measurement procedure is similar to that defined in the EN ISO 10140 series of standards, although here acceleration measurements are used instead. Firstly, the average vibration level is obtained from measurements recorded in the slab without the floor covering specimen ($L_{a,o}$). Then the floor covering is applied on the slab and the corresponding average vibration level provided by the tapping machine acting on the covering is achieved ($L_{a,1}$). The impact sound reduction is then obtained by performing the difference between these levels according to the following expression:

$$\Delta L_a = L_{a,o} - L_{a,1} \, , \tag{1}$$

where $L_{a,o} = 20\log(a_0 / a_{ref})$ is the average vibration level obtained in the bare concrete slab (without the specimen); $L_{a,1} = 20\log(a_1 / a_{ref})$ refers to the vibration level obtained when the floor covering is applied; and $a_{ref} = 10^{-6} m/s^2$, is the reference acceleration.

Measurements of background vibrations should also be performed in order to evaluate whether those vibrations may influence the results. If the difference between the measured vibration levels with the tapping machine acting and the background vibration levels is less than 10 dB, then it may be necessary to perform corrections.

3 Impact sound reduction on timber floors

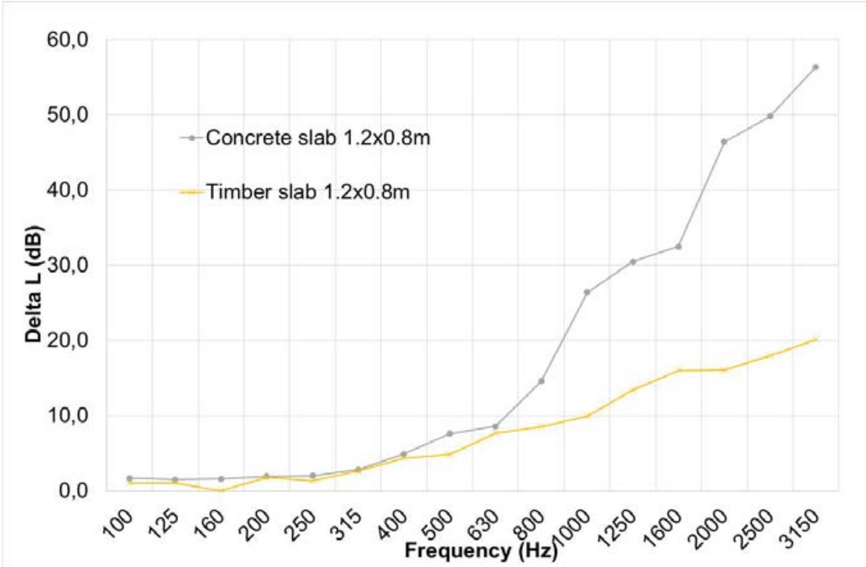
The bar slab used to test impact sound reduction of floor coverings is composed of a timber floor, 0.02(m) thick, with dimensions 1.2(m)x0.8(m), and timber joists 0.07(m) x 0.10 (m) equally spaced 0.301 (m), as displayed in Figure 1a .In this setup only the peripheral joists are simply supported on an elastic layer. Results obtained in a bar slab with similar dimensions made of concrete, 0.20 (m) thick, were used as a reference (see Figure 1b).

a) b)

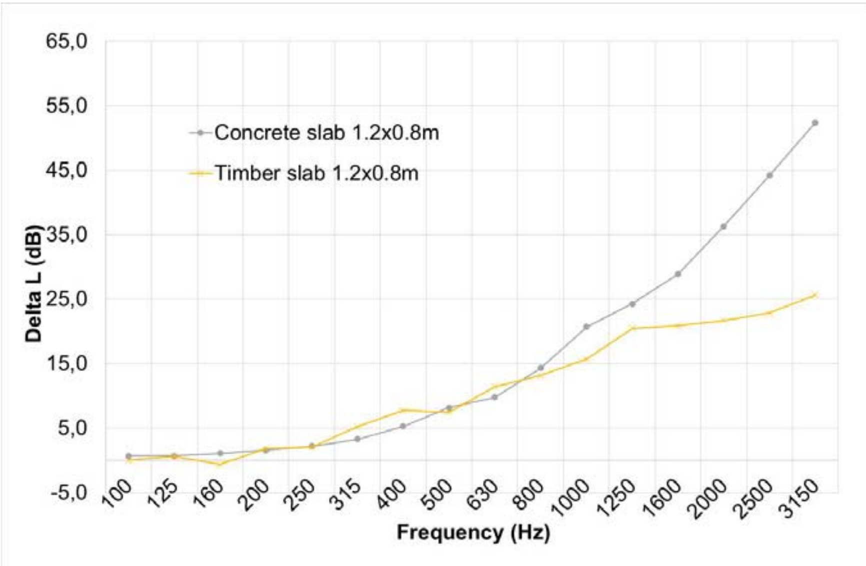
Figure 1. Image of the bar floor 1.2(m)x0.8(m) composed of :a) timber; b) heavyweight concrete.

Impact sound reduction curves provided by two different soft coverings are displayed in Figure 2: Figure 2a displays the result for a vinyl with flexible underlayer and Figure 2b plots the response provided by a carpet.

As expected all curves display very low sound reduction in the low frequency range and a progressive increase in the middle and high frequencies. When comparing the results in timber floor with the concrete ones a clear difference is found in the middle and high frequencies is found being the worst behaviour related to the solution applied on a timber floor. Although measurements have been performed using vibrations the conclusion is similar to that obtained in [9]. In that work, the authors verified, by performing measurements on acoustic chambers and the procedure prescribed in the ISO 140-11, that sound reduction is lower at the middle and high frequencies than the results obtained in a concrete floor, 0.14 (m) thick.



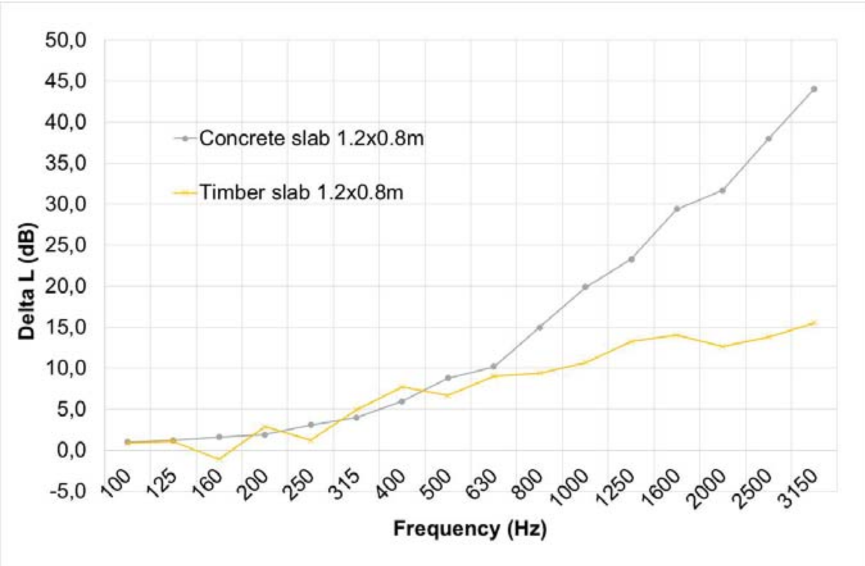
a)



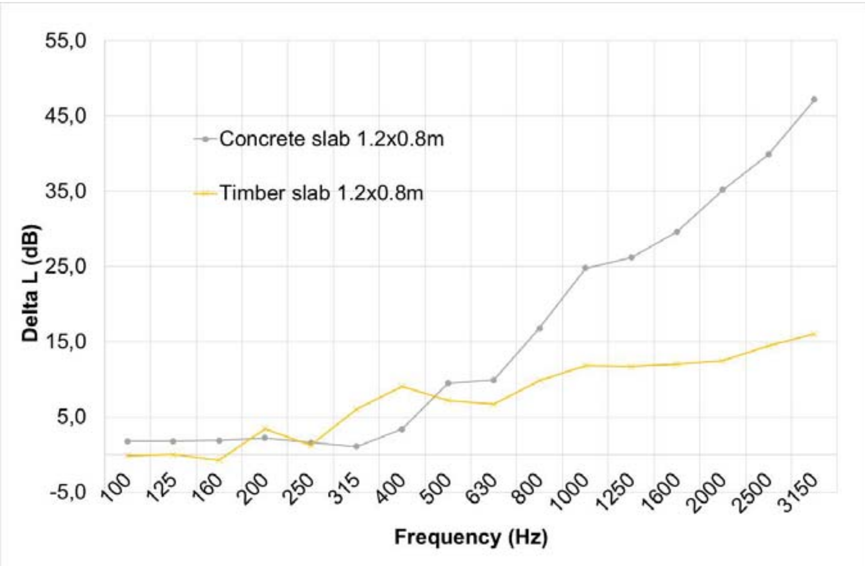
b)

Figure 2. Impact sound reduction provided by soft floor coverings: a) Vinyl with flexible underlayer; b) Carpet.

Figure 3 displays the impact sound reduction obtained for two floating floors. In these results, oscillations are found in the lower frequencies for the timber floor. At the middle and higher frequencies again the sound reduction values provided by the floating floors on the timber floor are lower than the ones obtained for the concrete slab.



a)



b)

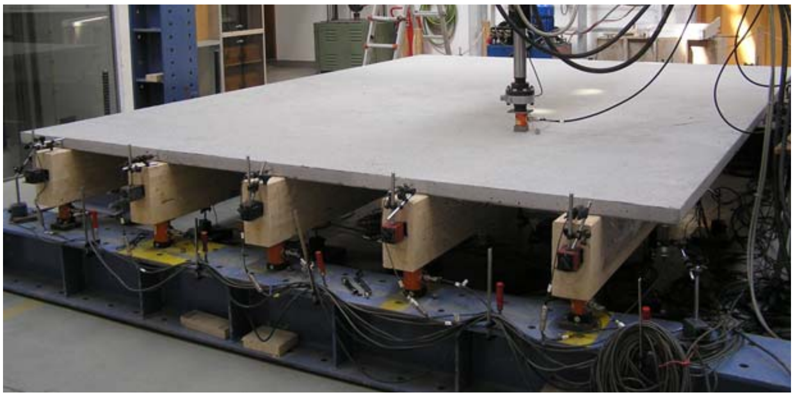
Figure 3. Impact sound reduction provided by floating floors: a) with cork glued underlayer; b) Rubber underayer (not glued).

4 Impact sound reduction on timber-concrete floors

In this section results of impact sound reduction provided by timber concrete floors with several floor coverings, obtained using vibration measurements, are discussed. In all cases the timber joists display sections of 0.12x0.27 (m). Slabs with two different sizes were tested: 3.0 (m)x4.0 (m); 3.0 (m)x2.0 (m). The concrete layers may assume thicknesses of 0.03 (m) and 0.05 (m) for dimension 3.0 (m)x4.0 (m) and 0.05 (m) for dimension 3.0 (m)x2.0 (m). Only in the case that a concrete layer of 0.03 (m) was adopted the timber floor of 0.02 (m) is kept. Figure 4 shows images of the tested floors. Figure 5 shows the source and accelerometer positions used during measurements.

a)

b)



c)

Figure 4. Images of the timber concrete slabs tested: a) 3.0x2.0x0.05(m).;b) 3.0x4.0x0.03(m), c) 3.0x4.0x0.05(m)

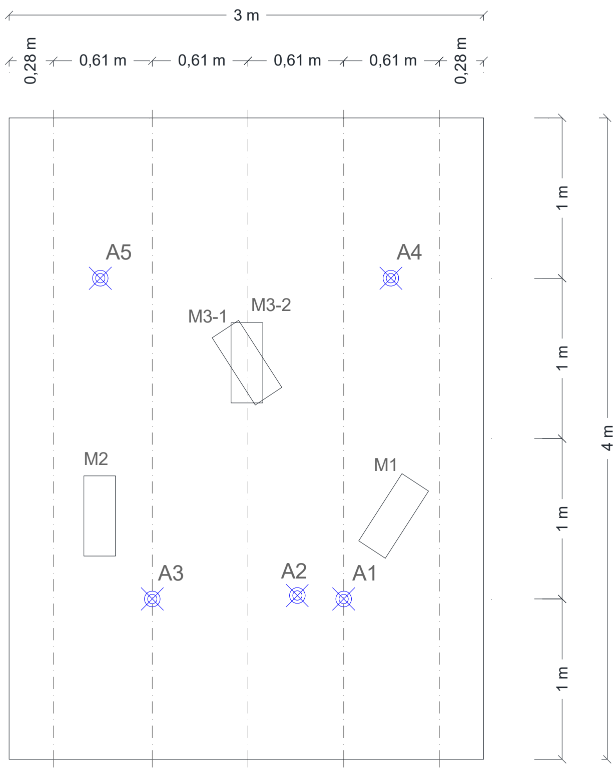
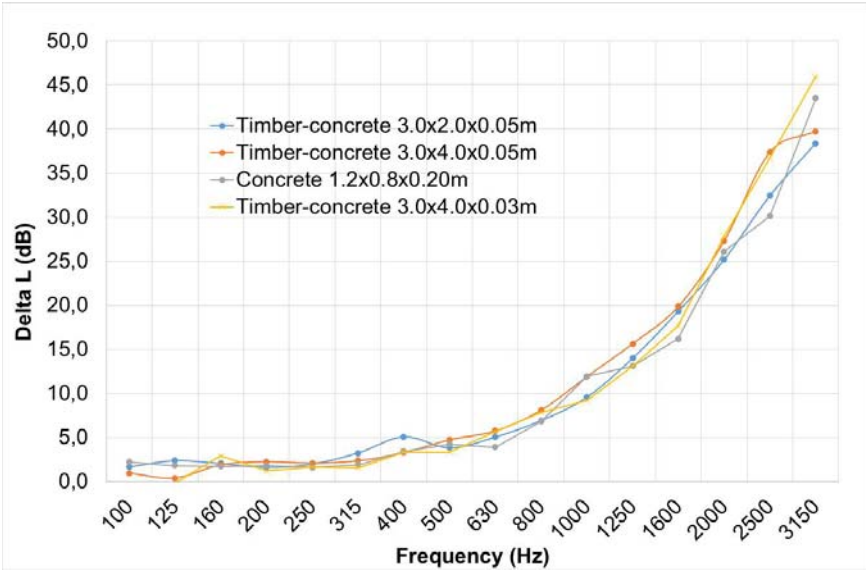


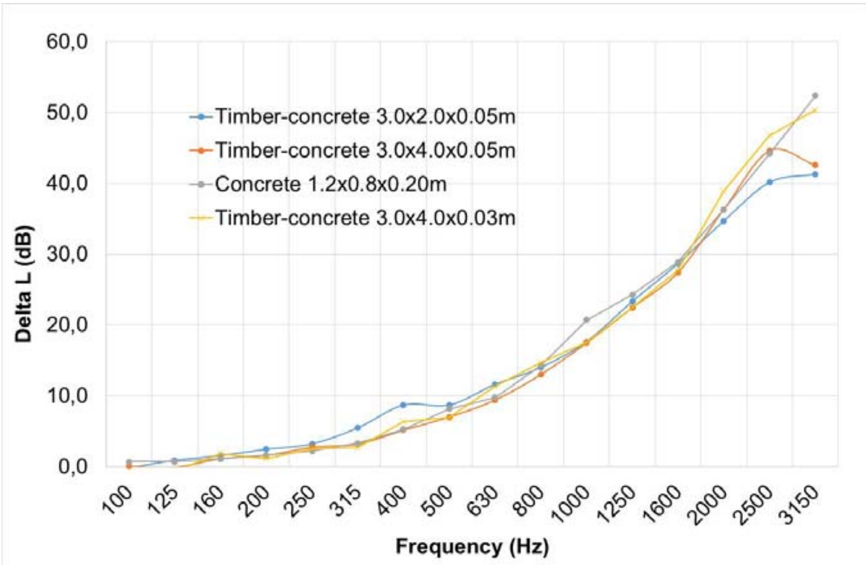
Figure 5 –Timber concrete floor with sources and measurement positions (plan).

Figures 6 and 7 show the sound reduction provided by the floor coverings applied on timber floors. In these figures the responses for the concrete slab 1.2(m)x0.8(m)x0.20(m) are included for reference.

Those figures show that the impact sound reduction provided by the different floor coverings on the timber-concrete floors of different dimensions are very similar and approach the reference curve obtained for the concrete slab with 1.2x0.8x0.2(m). In the higher frequencies some differences are found which may be related with background noise generated during measurements.

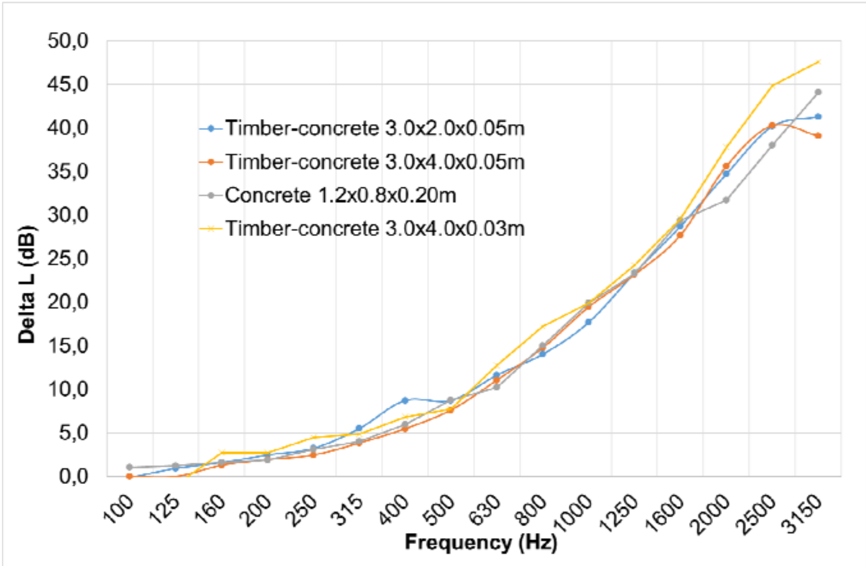


a)

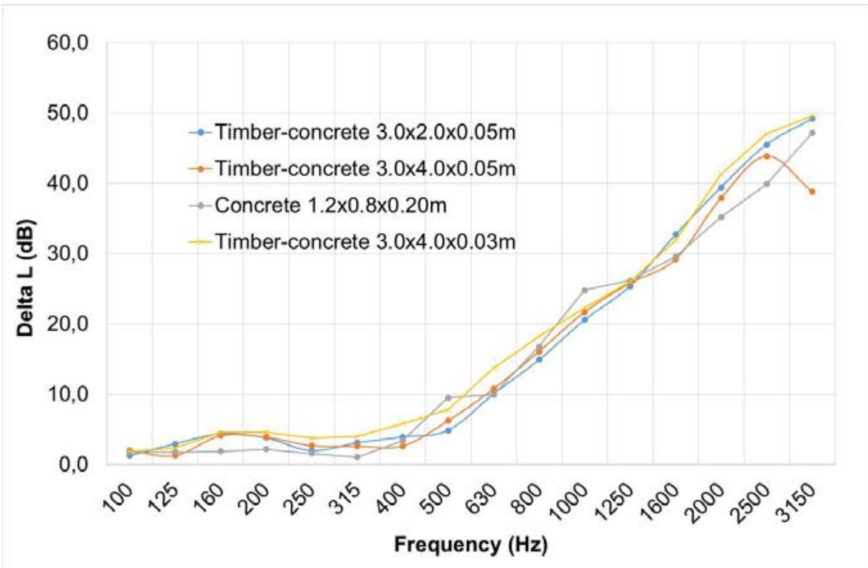


b)

Figure 6. Impact sound reduction provided by floor coverings: a) Vinyl with flexible underlayer; b) Carpet.



a)



b)

Figure 7. Impact sound reduction provided by floating floors on timber concrete floors: a) with glued cork underlayer; b) Rubber underlayer (not glued)

5 Conclusions

In this paper sound reduction of soft floor coverings and floating floors on timber floors and on timber concrete floors are addressed using vibration measurements. The procedure used is quite similar to that described in the recent standard ISO 16251-1, where vibration levels are captured in the bar floor without the floor covering and then with the floor covering using s standard tapping machine. The sound reduction curves are then obtained by performing the difference between these two sound levels.
The results obtained assuming the floor coverings on the timber floor of small sized dimensions (dimensions similar to those defined in the ISO 16251-1 for a heavyweight floor) indicated that sound reduction is lower in the medium and higher frequencies than that obtained in the concrete floor of similar dimensions.

The sound reduction curves provided by the timber concrete floors of different dimension were found to be similar and approach the reference one (concrete floor with 1.2(m)x0.8(m)x0.2(m)).

Acknowledgements

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