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IMPACT NOISE REDUCTION: LABORATORY AND FIELD MEASUREMENTS OF DIFFERENT MATERIALS PERFORMANCES

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ABSTRACT

An investigation of the impact sound insulation performances of different materials currently used as floor coverings in buildings to reduce impact noise is presented in this paper. The following floor coverings for commercial, industrial and residential buildings were tested at the Acoustics Laboratory of the University of Perugia: carpet covering, PVC, corkboard, corkboard with a PVC layer on top, recycled rubber with a PVC layer on top, cork-wood covering, synthetic rubber, undercarpet with carpet on the top.

Measurements to evaluate the performances of the floor coverings were carried out, in compliance with UNI EN ISO 140-8: the sound pressure level reduction, due to the installation of a floor covering, was measured in the reverberating room below a heavyweight standard floor. Results were used to calculate, in compliance with UNI EN ISO 717-2, the impact sound attenuation index, ΔL_w, useful for a direct comparison between different kinds of floor coverings.

Results show that the tested materials haven't good performances: the ΔL_w values range from 14 dB (rubber covering) to 35 dB (carpet with undercarpet), so floating floors must be carefully installed to provide a better impact sound attenuation.

Finally, field impact sound insulation measurements of a floor equipped with two different coverings were carried out. Results allowed to verify a calculation model for acoustic performances estimation of buildings materials, in compliance with EN UNI 12354-2. A good agreement between measured and calculated data was found.

1 INTRODUCTION

Impact sounds, due to footsteps, to falling objects or to moving furniture, are an important source of noise annoyance in residential buildings. Two ways of providing a floor surface impact sound insulation properties could be considered: resilient (flexible) layers, such as vinyl or carpet, or floating floors, consisting of a slab of rigid material supported on a resilient material [1], [2].

In this context, some floor coverings for commercial, industrial and residential buildings were investigated in the present paper. At the Acoustics Laboratory of the University of Perugia measurements to evaluate the performances of the same floor coverings were carried out. Reduction of transmitted impact noise was evaluated, in compliance with UNI EN ISO 140-8 [3]. Results of measurements vs. frequency were employed to calculate a single number rating of reduction in impact noise transmission by the floor covering ΔL_w [4]. Values were compared in order to evaluate the performances of the tested materials.

Finally, field measurements of impact sound insulation of a floor equipped with two different coverings were carried out, in compliance with UNI EN ISO 140-7 [5]. Results were used to validate a calculation model for acoustic performances estimation of buildings materials, in compliance with EN UNI 12354-2 [6].

2 EXPERIMENTAL METHODOLOGY

Measurements of impact sound reduction of floor coverings were carried out in compliance with ISO 140-8 [3]. This international standard specifies a laboratory method to measure the impact sound insulation properties of materials for floor coverings by using a standardized tapping machine. Measurements were carried out at the Acoustics Laboratory of University of Perugia, by using the coupled reverberating rooms built in compliance with ISO 140-1 [7]. Three floor covering samples of small size (0.5 m x 1.0 m) were put on the heavyweight standard floor of the receiving room: the impact noise levels at the different microphone positions were measured in the receiving room with the tapping machine over the sample. Measurements were then repeated with the tapping machine over the floor slab, without covering material (fig. 1). Therefore reduction of transmitted impact noise ΔL vs. frequency due to installation of the tested materials was calculated as the difference of the measured values.

Figure 1. Tapping machine on the floor and positions of the samples.

In order to measure the impact noise levels, four microphone positions were used, distributed over the room, respecting the minimum distances, in compliance with ISO 140-8. Sound pressure levels were measured using one-third octave band filters, in the range 100 Hz - 5000 Hz. Noise levels were corrected in order to considerer the sound absorption of the receiving room; therefore reverberation time was measured in compliance with ISO 354 [8]. Finally background noise levels were measured in order to ensure that the observations in the receiving room were not affected by extraneous sound.

All tests were carried out by using the acquisition and elaboration system SYMPHONIE (01 dB [9]) and the software of analysis and elaboration data dB BATI 32 [10].

3 DESCRIPTION OF THE TESTED SAMPLES

Laboratory measurements were carried out for eight floor coverings, employed in commercial, industrial and residential buildings: carpet covering (n.1 in fig. 2), PVC (2), corkboard (3), corkboard with a PVC layer on top (4), recycled rubber with a PVC layer on top (5), cork-wood covering (6), synthetic rubber (7), undercarpet with carpet on the top (8). The characteristics of the materials are described in table 1.

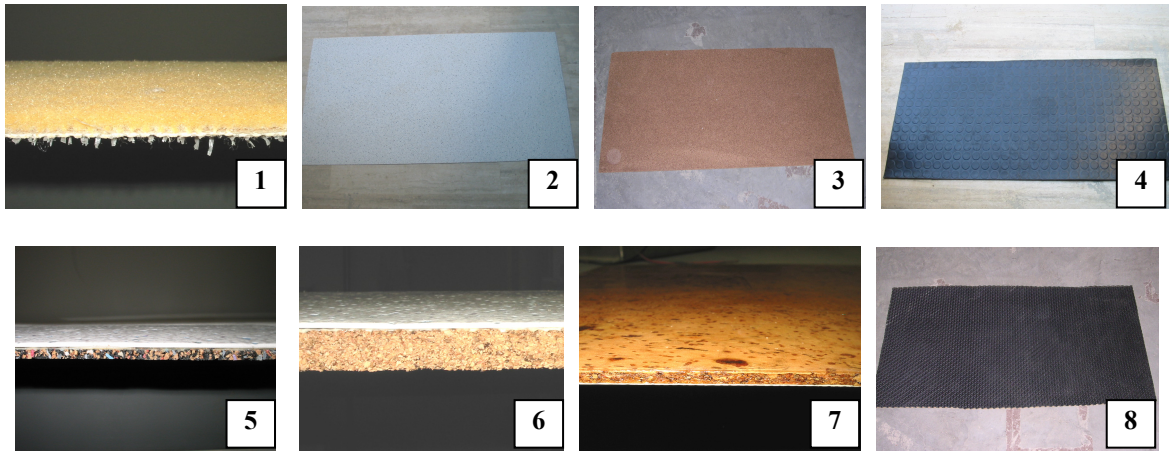

Figure 2. Images of the floor covering samples

Table 1. The floor covering samples

Sample	Description	Thickness (mm)	Weight per surface square meter (kg/m^2)
1	Carpet covering	7.5	1.7
2	PVC	1.5	1.2
3	Corkboard	6.0	1.8
4	Synthetic rubber	3.0	4.2
5	Recycled rubber with a PVC layer on top	5.0	3.2
6	Corkboard with a PVC layer on the top	12.0	4.2
7	Cork-wood	3.2	3.0
8	Undercarpet with carpet	16.1	4.6

4 RESULTS

Figure 3 shows the impact sound reduction ΔL vs. frequency measured for the eight samples. The impact sound reduction is moderate at low frequencies (100 - 1000 Hz) for all the coverings, except for sample 8, a non conventional covering, characterized by a hight thickness if compared to the other samples.

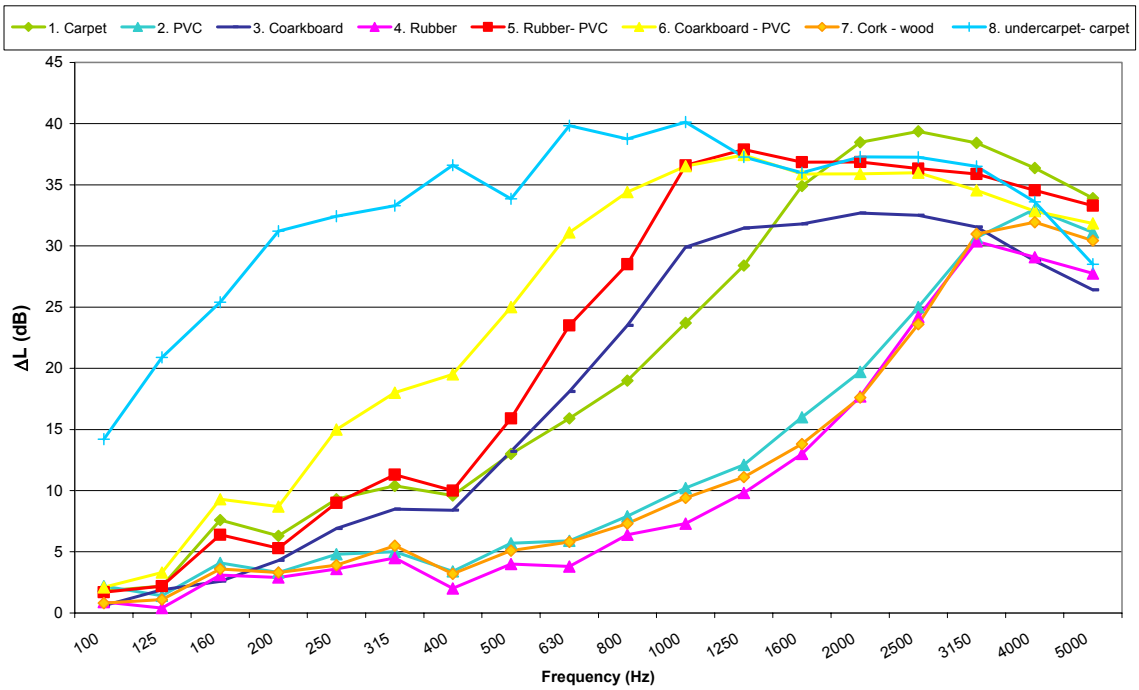

Figure 3. Impact Sound Reduction vs. frequency for the examined samples

Measurements give frequency-dependent values; in order to simplify the comparison between the acoustic performances of the materials, the single number index ΔL_w (impact sound reduction index) was calculated, in compliance with ISO 717-2 [4]. Results (tab. 2) confirm that the tested materials haven't good performances: values are in the 14 dB (rubber covering) - 35 dB (carpet with undercarpet) range.

Table 2. Impact noise transmission reduction index for the examined samples

Sample		ΔL_w (dB)
1	Carpet covering	22
2	PVC	16
3	Corkboard	20
4	Synthetic rubber	14
5	Recycled rubber with a PVC layer on top	22
6	Corkboard with a PVC layer on the top	25
7	Cork-wood	15
8	Undercarpet with carpet	35

5 PREDICTIVE METHODS AND FIELD MEASUREMENTS FOR IMPACT SOUND INSULATION OF FLOOR WITH COVERINGS

5.1 Predictive method for impact sound insulation estimation

The possibility of using theoretical models in order to forecast the acoustic performances of different structures is essential for building acoustics design. EN 12354 European standard supplies simplified models to estimate the acoustic performances of buildings from the ones of their single elements. Concerning the impact sound insulation, normalized impact sound pressure level of floors $L'_{n,w}$ could be calculated with the following relation, in compliance with EN 12354-2 [6]:

$$L'_{n,w} = L'_{n,w,eq} - \Delta L_w + K \quad (1)$$

where:

- $L_{n,w,eq}$ is the equivalent weighted normalized impact sound pressure level of the floor structure, according to ISO 717-2 [4];
- ΔL_w is the weighted reduction in impact sound pressure level of resilient coverings or floating floors, previously described;
- K is the correction for impact sound transmission over the homogenous flanking constructions, in the range 0 - 6 dB [6].

5.2 Field measurements

In order to estimate the impact sound insulation between rooms in real operating conditions, a floor located in a building of the Engineering Faculty of Perugia was examined. The floor has a thickness of 0.35 m and it separe an office and a class - room. In compliance with UNI EN ISO 140-7 [5], field measurements of reverberation time, background noise and impact sound pressure level were carried out in the receiving room below the considered floor (class - room). The same measurements methodology was repeated after a floor covering was placed between the tapping machine and the floor; two of the tested materials were chosen: the carpet and the undercarpet with carpet on the top, characterized by the mean - high acoustic performances between the examined samples.

5.3 Comparison between experimental data and predictive method outputs

In table 3 the results of field measurements are compared to the model output obtained by equation (1) for the same structures. The ΔL_w values shown in tab. 2 were considered in the calculation model.

Table 3. Comparison between the measured and calculated values of the normalized impact sound pressure level ($L'_{n,w}$)

Floor	Measured $L'_{n,w}$ (dB)	Calculated $L'_{n,w}$ (dB)
floor without covering	70	-
floor with carpet covering	48	48 + K
floor with undercarpet - carpet covering	36	35 + K

The comparison confirms that, as far as impact sound insulation for the examined floors with two coverings, the predictive method reported in EN12354-2 supplies reliable results: in fact the K parameter in equation (1) could be 0 or 1, reasonable values for the considered situation.

6 CONCLUSIONS

In the recent years many materials used as floor coverings were proposed in order to reduce the transmitted impact sound between rooms in residential buildings. At the Acoustics Laboratory of the University of Perugia some floor coverings were examined: the impact sound attenuation index, ΔL_w, was measured, in compliance with UNI EN ISO 140-8 and UNI EN ISO 717-2 for eight different samples.

Results show that the tested materials have no excellent acoustic performances: the reduction in impact noise transmission index present values between 14 dB, for a rubber covering, and 35 dB, for a carpet with undercarpet sample; therefore floating floors must be carefully installed to reduce the annoyance due a impact sound transmission between rooms in residential buildings.

Field measurements were also carried out, in order to verify the reliability of a predictive method proposed in the UNI EN 12354-2. A good agreement between measured and calculated data was found, therefore the model can carefully be used to verify and to design building acoustics passive requirements.

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