The Use of Agglomerated Cork as Underlay for Improvement of Impact Sound Insulation in Buildings

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Summary: Eight different cork agglomerate products were tested to assess their impact sound insulation quality when used as underlay with four different floor coverings (linoleum, ceramic tile and two types of wood parquet). The measurements were made on-site (with flanking transmissions) on a coffered concrete floor and according to the standards EN ISO 140-7 and 717-2. The results show that the use of this underlay improves the weighted normalized impact sound pressure level ($L'_{n,w}$) for each respective reference floor up to 18 dB (for ceramic tiles), 25 (thin parquet), 25 (linoleum) and 23 dB (thick parquet). Prediction formulas, determined by statistical analysis are presented.

INTRODUCTION

The goal of this project was to measure and test the impact sound insulation of different types of floor coverings that include cork underlay.

The cork oak is an important feature of Portuguese landscape and heritage. Because of the climatic conditions, the cork oak is abundant in the Western part of the Mediterranean. The cork oak is one of Portugal's main forest species, covering 660,000 hectares, and accounting for 22 per cent of the total forested area. In Portugal there is more than 40% of the world's cork oak forests, and the country produces more than half of the world's cork.

The cork oak tree produces cork tissue until it is 150 to 200 years old, and during this time it can be stripped 15 to 18 times. In 1991, the annual output was about 170,000 tons. The Portuguese cork industry not only processes almost all the country's production, but also imports cork, and manufactures 70% of the world's cork products. Around 15,000 people are employed in more than 600 industrial facilities in the country.

Cork agglomerates are made of cork granules of various sizes. These granules are the residue of the production of other cork products, or are made of cork that is not suitable for other applications. In this project, only *white* agglomerate products were tested. In its production, synthetic materials are added (bonded) to the granules in the manufacturing process.

METHODOLOGY

To assess the impact sound insulation quality of each floor a standard tapping machine was used for the field measurements research. The measurements were carried out at the *Instituto de Desenvolvimento e Inovação Tecnológica* located at S. M. da Feira. Measurements were made using three locations of the tapping machine relative to the floor sample. A sound level meter at the receiving room, located below the source room, measured the impact sound pressure levels L_i created by the tapping machine. Measurements were taken at three points in the receiving room for each one of the tapping machine positions above using one-third-octave bands (from 100 to 3150 Hz). With the L_i, the normalized impact sound pressure levels were calculated ($L'_n = L_i + 10 \lg A/A_0$) and then the weighted normalized impact sound pressure level $L'_{n,w}$ was calculated. The work was done according to the EN ISO 140-7 and 717-2.

The measurements were not made in a reverberant chamber but using a normal building. The type of the structural floor under test will influence the results. The existent floor was anisotropic, of the coffered concrete floor type with no directly fastened ceiling. The tests were made on the thickest part of the floor, and therefore the results can differ from those for homogeneous concrete structural floors or timber floors. Two 2.2 square meters samples (named Left and Right) were used (positioned side by side on the source room). The tapping machine positions were lain exactly on the same corresponding thickness of the anisotropic floor slab. After a number of positions were tested, it was decided which tapping positions should be adopted. Uniformity in the positioning was achieved, because the three measurement positions lie on the beam of the slab, and they corresponded to similar positions relative to the slab (one edge of the tapping machine was exactly in the middle of the intersection of the thick part of the waffle construction). It was decided to use 18 measurements for calculating the $L'_{n,w}$ for each sample.

Floor finishes: The tests were performed on four different floor finishes:

- Linoleum (*DLW* 3.2 mm thick glued with *THOMSIT* from *Henkel)*;
- Wood parquet (7.2 mm thick oak glued with *DECOL L-608* from *Isar-Rakoll*);
- Wood parquet (10.2 mm thick oak glued with *DECOL L-608* from *Isar-Rakoll*);
- Ceramic tiles (glued with *FERMAPOXY 845-BLANC*. Without the cork underlay the tiles were bonded to the floor with cement paste).

The glue used between concrete and underlay was the *DECOL VERN* from *Isar-Rakoll.*

Cork underlay: With each of these four floor finishes eight different cork agglomerate products were tested, in order to assess the impact sound isolation quality of each one. The cork underlay material used in the floor samples was a white cork agglomerate, with 3 mm or 5 mm:

- Ref. R13 - 3 mm thick with specific weight 425 kg/m^3;
- Ref. R15 - 5 mm thick with specific weight 425 kg/m^3;
- Ref. R33 - 3 mm thick with specific weight 445 kg/m^3;
- Ref. R35 - 5 mm thick with specific weight 445 kg/m^3;
- Ref. A43 - 3 mm thick with specific weight 170 kg/m^3;
- Ref. A45 - 5 mm thick with specific weight 170 kg/m^3;
- Ref. A63 - 3 mm thick with specific weight 190 kg/m^3;
- Ref. A65 - 5 mm thick with specific weight 190 kg/m^3.

The equipment used was a Brüel & Kjær (B&K) 3204 tapping machine, a B&K 2144 dual channel real-time frequency analyzer, and B&K 13 mm microphone, model 1625. Both source and receiving rooms have equal dimensions. The volume of both source and receiving rooms is an equal to 116 cubic meters. The microphone height was about 1.4 m.

A total of 34 samples of different floor finish construction were tested, including the reference situation - bare concrete - for both samples L (left) and R (right), and the different floor finishes without agglomerates. In the samples that did not contain the cork underlay, the floor finishes were built directly over the concrete. In the other samples, the agglomerates were placed between the concrete and the floor finishes.

COMMENTING ON THE RESULTS

Table 1 shows the $L'_{n,w}$, $\Delta L'_{n,w}$ and ΔLw of all samples. The results demonstrated a larger improvement on impact sound insulation on the 3-mm products than on the 5 mm ones. This led to speculation whether the quality of the structural concrete below sample Left was different from that of sample Right, because all 3 mm products were tested on sample Left, while all 5 mm products were tested on sample Right. To ensure this was not the case, and make a more rational reference situation, a bare concrete floor was tested on both samples L and R. The reduction in the weighted normalized impact sound pressure level for each floor finish sample ($\Delta L'_{n,w}$) was hence the difference in the weighted normalized impact sound pressure level from the bare concrete floor (left or right depending on the position of the sample) ($L'_{n,w \text{ bare concrete L or R}}$) and the weighted normalized impact sound pressure level with the floor covering ($L'_{n,w \text{ with floor covering}}$). Consequently the $\Delta L'_{n,w}$ were obtained comparing the $L'_{n,w}$ of the samples with regards to their position. The $L'_{n,w}$ for the reference concrete left and right are 62 and 60 dB respectively. To compare the results to a reference normalized floor, the ΔLw was calculated according with chapter 5 of EN ISO 717-2, that is, $\Delta Lw = 78 - L_{n,r,w}$ where $L_{n,r,w}$, is the calculated weighted normalized impact sound pressure level of the reference floor with the floor covering under test.

TABLE 1: Results found (measurements done using one-third-octave bands, 100 Hz to 3150 Hz). [1] $\Delta L'n,w = L'n,w$ *(bare concrete L or R)* - $L'n,w$ *(with floor covering)* and [2] $\Delta Lw = 78 - Ln,r,w$

Floor	L'n,w (dB)	ΔL'n,w (dB) [1]	ΔLw (dB) [2]	Floor	L'n,w (dB)	ΔL'n,w (dB) [1]	ΔLw (dB) [2]
Concrete Left	62	-	-	Concrete Right	60	-	-
T bare (L)	62	0	0	T R15 (R)	49	11	11
T R13 (L)	46	16	14	T R35 (R)	48	12	12
T R33 (L)	45	17	15	T A45 (R)	48	12	12
T A43 (L)	44	18	14	T A65 (R)	48	12	12
T A63 (L)	45	17	14	W7 R15 (R)	62	-2	-4
W7 bare (L)	56	6	6	W7 R35 (R)	64	-4	-4
W7 R13 (L)	58	4	-3	W7 A45 (R)	43	17	15
W7 R33 (L)	60	2	-3	W7 A65 (R)	45	15	14
W7 A43 (L)	37	25	17	W10 bare (R)	61	-1	-1
W7 A63 (L)	39	23	16	W10 R15 (R)	42	18	16
W10 R13 (L)	42	20	15	W10 R35 (R)	45	15	15
W10 R33 (L)	43	19	15	W10 A45 (R)	42	18	15
W10 A43 (L)	39	23	16	W10 A65 (R)	42	18	16
W10 A63 (L)	41	21	16	L bare (R)	56	4	5
L R13 (L)	39	23	17	L R15 (R)	43	17	16
L R33 (L)	42	20	16	L R35 (R)	45	15	15
L A63 (L)	37	25	17	L A65 (R)	42	18	16

L-Linoleum, T-Tile, W-Wood parquet; (L)-Left side sample, (R)-right side sample

Linoleum: Linoleum on concrete without underlay (L bare) provides an improvement in the impact sound insulation rating ($\Delta L'_{n,w}$) of 4 dB. On finishes with cork underlay and Linoleum, the product A63 (L A63) shows the largest ($\Delta L'_{n,w}$ = 25 dB). The linoleum samples with the 3-mm thick agglomerate have better impact sound insulation performance than the 5 mm ones, with product A63 offering the best impact insulation performance.

Wood parquet W7: Oak wood parquet W7 on concrete without underlay (W7 bare) shows an improvement in the impact sound insulation rating ($\Delta L'_{n,w}$) of 6 dB. On finishes made of cork underlay under W7, the largest value for $\Delta L'_{n,w}$ is achieved by A43 ($\Delta L'_{n,w}$ = 25 dB).

Wood parquet W10: The $\Delta L'_{n,w}$ for W10 bare is -1 dB. Therefore the addition of the W10 finish on bare concrete does not improve the impact sound insulation of the floor. The 3-mm underlay offer better sound impact sound insulation than the ones with the 5-mm underlay. Product A43 offers the highest impact sound insulation ($\Delta L'_{n,w}$ = 23 dB).

Ceramic tiles: The floor sample with Ceramic Tiles (T bare) has no improvement in $L'_{n,w}$, ($\Delta L'_{n,w}$). Better impact sound insulation for floors with ceramic tiles is achieved with 3 mm thick underlay, and the results show that highest rating is achieved with product A43 ($\Delta L'_{n,w}$ = 18 dB).

STATISTICAL ANALYSIS

A statistical equation was found to predict the impact sound insulation behavior ($\Delta L'_{n,w}$) of similar types of floor finishes to the ones used in the tests described in this report. The *SYSTAT*® software was used for this purpose. The equations rely on two variables, the thickness of the underlay and its specific weight. The equations below are only valid within the range of application of the values (thickness from 0.003 to 0.005 m and specific weight from 170 to 445 kg/m³) (symbols: th-thickness, m and sw- specific weight, kg/m³):

- Underlay w/ thin wood parquet W7 $\Delta L'_{n,w} = 48.158 - 3500{*}th - 0.07856{*}sw$ ($R^2 = 1.00$);
- Underlay w/ thick wood parquet W10 $\Delta L'_{n,w} = -5.69 - 15.78\ lg(th) - 5.46\ lg(sw)$ ($R^2 = 0.83$);
- Underlay w/ linoleum L $\Delta L'_{n,w} = -25.62 - 27.05\ lg(th) - 7.92\ lg(sw)$ ($R^2 = 0.91$);
- Underlay w/ ceramic tiles T $\Delta L'_{n,w} = -37.93 - 23.66\ lg(th) - 1.95\ lg(sw)$ ($R^2 = 0.97$).

CONCLUSIONS

The results show that the use of cork underlay can improve the weighted normalized impact sound pressure level ($L'_{n,w}$) for each respective coffered concrete reference floor up to 18 dB (for ceramic tiles), 23 dB (thick parquet), 25 (thin parquet) and 25 (linoleum). The tested floors with the cork underlay achieve a ΔLw (chapter 5 EN ISO 717-2) up to 17 dB.

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