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ACOUSTICAL OPTIMIZATION OF A ROLLER BLIND BOX

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Abstract

Roller blind boxes, also know as blind boxes or roller casings, are quite popular elements in Italian buildings, as total enclosures for the roller blinds. The boxes quite frequently show a removable face, for reasons of access, and in some cases air ventilation vents. The peculiar acoustical behaviour of the boxes is due to the presence of apertures and leaks and for this reason manufacturers are focusing their attention on the improvement of their sound insulation performances. An experimental investigation was carried out by sound intensity measurements in a reverberation room to determine the sound insulation of various steel blind boxes. The initial design showed not satisfying sound insulation ratings. A light, sound absorbing inner lining of the casing demonstrated to be even more efficient than a traditional, denser sound insulating treatment, particularly when noticeable leaks were present at the access faces of the box. Suitable absorbing materials such as mineralized wood fibres and polymeric foams were chosen and compared achieving up to 5 dB of improvement for R_w. Analyses of the frequency behaviour of the sound insulation and of the intensity maps were performed. The influence of leaks was finally estimated, demonstrating that a proper sealing could lead up to a further 10 dB performance rise.

INTRODUCTION

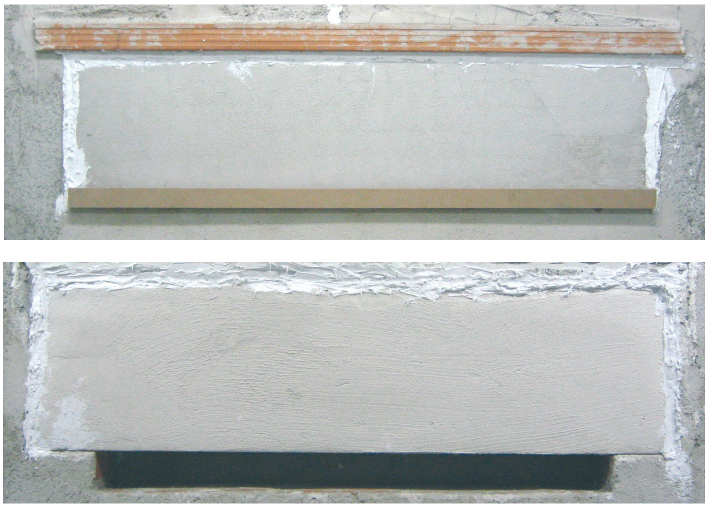
Blind boxes or roller casings are used as enclosures for the blind rollers and, as such, are elements of window frames. They usually have a removable part for access and can be made of different materials as wood and plastic panels, steel plates, hollow brick and expanded clay boards. Manufacturers are nowadays focusing their attention on the sound insulation performances of such components, in the framework of a global acoustic improvement of window systems, thus better achieving the acoustic design criteria of high quality building façades.

Sound insulation performances of two prototypes of steel blind boxes were experimentally investigated. Measurements were performed successively mounting 19 samples on a test opening in a massive brick wall built between two reverberation rooms. The sound intensity discrete point method was employed to study the existence and relative importance of different noise sources.

DESCRIPTION OF THE TESTED SAMPLES

Two different blind boxes were tested, both with a steel plate structural casing but distinct closing solutions: plastered steel plates for the two vertical faces (interior and exterior) and medium density fibreboard for the removable horizontal face (arrangement A, Fig.1 and Table 1), steel plates for the vertical and horizontal interior faces and hollow brick boards for the exterior one (arrangement B, Fig, 2 and Table 2).

Blind boxes of the arrangement A were tested starting from the basic design configuration and progressively modifying their interior linings with different materials mounted on the non-removable sides of the boxes (Figure 3). Blind boxes of the arrangement B were tested with a 10 mm polystyrene lining and different air vents installed on the removable access. All the samples were carefully sealed at the edges with a silicone coating.



(a)

(b)

Figure 1 – Interior side (a) and exterior side (b) view of arrangement A mounted on the test opening.

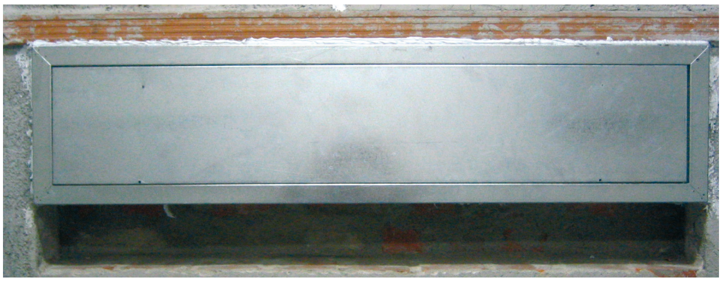


Figure 2 – Interior side view of arrangement B mounted on the test opening.

Table 1 – Mounting configurations for arrangement A boxes.

Sample no.	*Materials (from the outer to the inner side of the structure)*	*Thickness [mm]*	*Density [kg/m³]*	*$R_{I,w}$ [dB]*
A1	no lining	-	-	33
A2	polystyrene	10	30	34
A3	polystyrene	30	30	34
A4	polystyrene partially closed cell foam	10 25	30 32	37
A5	high-density EPDM mineralised wood fibres	4 25	1500 460	34
A6	polystyrene mineralised wood fibres	10 25	30 460	34
A7	polystyrene melammine foam high-density EPDM melammine foam	10 10 2 10	30 10 1900 10	37
A8	polystyrene medium-density EPDM partially closed cell foam	20 5 25	30 700 32	38
A9	the same as A8 but sealing all the leaks with silicone	-	-	48

Table 2 – Mounting configurations for arrangement B boxes.

Sample no.	*Air vent type on the removable face*	*Air vent area [m²]*	*$R_{I,w}$ [dB]*
B1	no air vent	-	35
B2	round (open)	0.011	33
B3	rectangular (closed)	0.032	29
B4	rectangular (open)	0.032	25

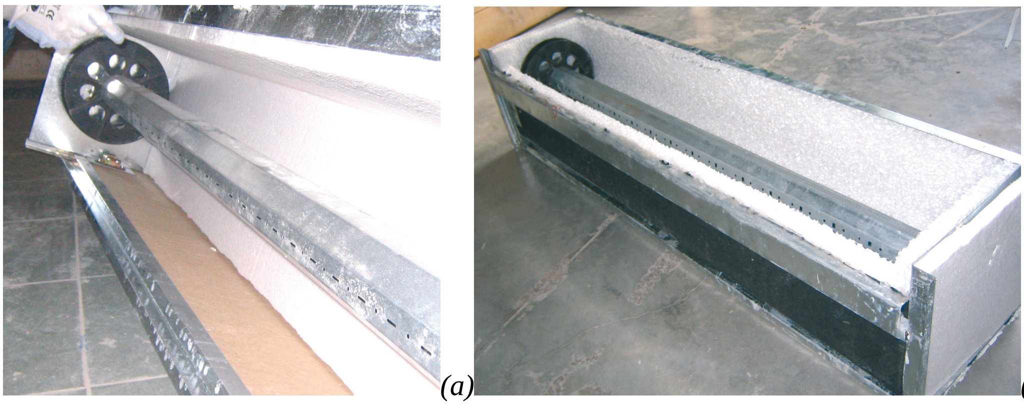

(a) (b)

Figure 3 – Inner linings of type A blind boxes: (a) polystyrene, (b) polymeric foam.

EXPERIMENTAL METHODOLOGY

Measurements were performed mounting each sample within a test opening (area S of 0.4 m^2 for arrangement A and 0.52 m^2 for arrangement B) in a massive, 40cm-thick brick wall built between two reverberation rooms (receiving and emitting), showing negligible sound transmission.

The sound intensity discrete point method was employed according to the standards ISO 15186-1 [1] and ISO 9614-1 [2]. A measurement grid (overall area S_m of 0.92 m^2) was positioned 0.1 m apart from the sample surface in the receiving room and divided into 32 measurement sub-areas. Acquisitions of the sound intensity levels L_{In} and sound pressure levels L_{p2} were performed by a sound intensity probe in each measurement point [3]. The averaging time was chosen after a stationarity test and in any case was not less than 12 s. The receiving room was acoustically treated with dissipative and resonant sound absorbing panels in order to minimize the sound reflection towards the measurement surface and to keep the pressure-intensity field indicator F_{pI} at least 10 dB below the pressure- residual intensity index of the probe [1].

An omnidirectional sound source was placed in the emitting room and fed with white noise. Nine recordings were performed in different positions by a ½” condenser microphone (averaging time 30 s) to calculate the averaged sound pressure level in the emitting room L_{p1}. The emitted sound power was able to keep the measured levels at least 15 dB higher than the background noise in the receiving room.

The sound insulation index could be estimated in the third-octave bands centered within 100 and 5000 Hz:

$$R_I = L_{p1} - 6 - L_{In} - 10\log_{10}\left(\frac{S_m}{S}\right) \qquad \text{[dB]} \qquad (1)$$

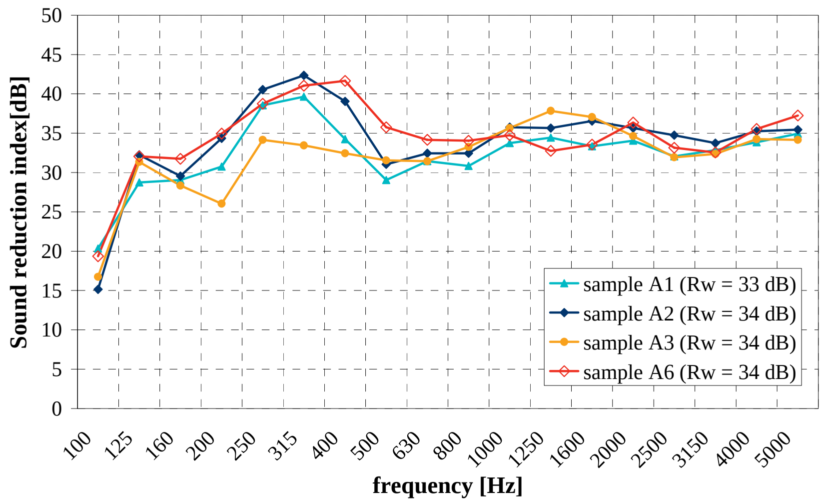
A sound insulation single-number rating $R_{I,w}$ was finally calculated according to the procedure prescribed by the standard ISO 717-1 [4].

RESULTS

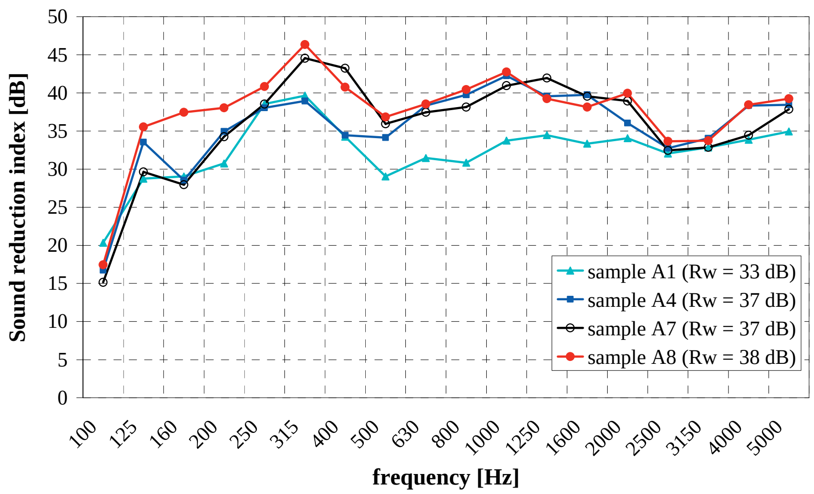
Effect of the inner lining material

The basic design of arrangement A showed not satisfying sound insulation rating (33 dB, see Table 1): looking at the rather flat behaviour of the sound reduction index (Figure 4a), this could be essentially attributed to the presence of apertures and leaks. Sound insulating solutions frequently adopted by the manufacturers (i.e. polystyrene lining of the inner surfaces) proved to be not very effective, at least in the present case. On the other side, the introduction of light sound absorbing inner linings in the casing demonstrated to be more efficient: in Figure 4b it is evident the performance increase due to a polymeric (sample A4) and a melammine foam treatment (sample

A7). A further 1 dB could be earned with an integrated insulating – absorbing approach (sample A8). The employment of mineralized wood fiberboards (sample A6) appeared not very useful, maybe because of their low sound absorbing performance and structural coupling with the casing.



(a)



(b)

Figure 4 – Sound reduction indexes for samples of arrangement A: (a) sound insulating inner treatment, (b) sound absorbing inner treatment.

Effect of leaks and apertures

The influence of leaks and apertures was investigated for both the arrangements. Sample A8 (see Table 1) was totally sealed with silicone, including the leaks at the boundaries of the removable face: this led to a further 10 dB rise of the performance (see Figure 5a). Similar results were achieved for arrangement B in presence of round and rectangular apertures, needed for air ventilation. In Figure 5b this effect is showed in terms of level difference with the sound reduction of sample B1 (without air vent). The frequency behaviour, with peaks at certain bands, is peculiarly due to sound diffraction around the edges of the aperture or of the leak [5].

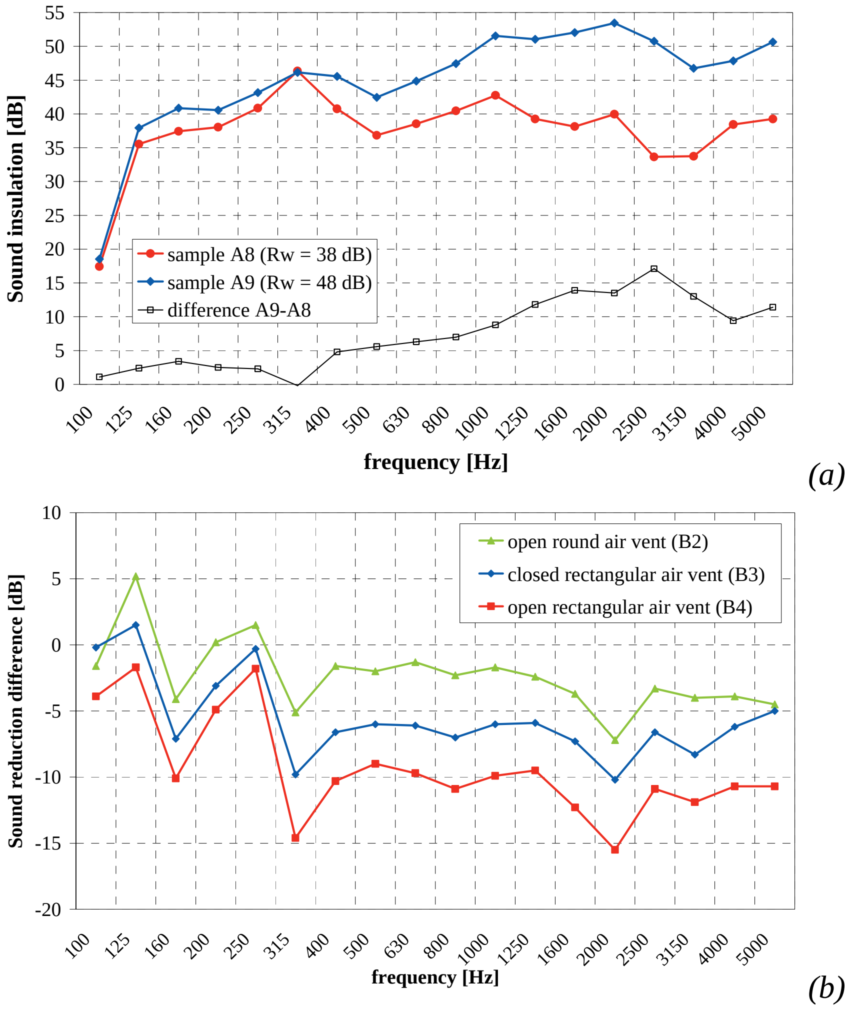


Figure 5 – Sound reduction lowering effect due to leaks and apertures: (a) arrangement A, (b) arrangement B.

The influence of leaks due to the removable face of arrangement A is also evident from Figure 6, where the sound intensity maps (overall levels in the frequency range of 200-5000 Hz) computed for the front measurement grid are reported for samples A8 and A9. It can be noticed that, sealing all the edges, there is a significant reduction in the sound levels; moreover the highest levels move from the lower (where the removable face is placed, Fig. 6a) to the upper part of the box (Fig. 6b).

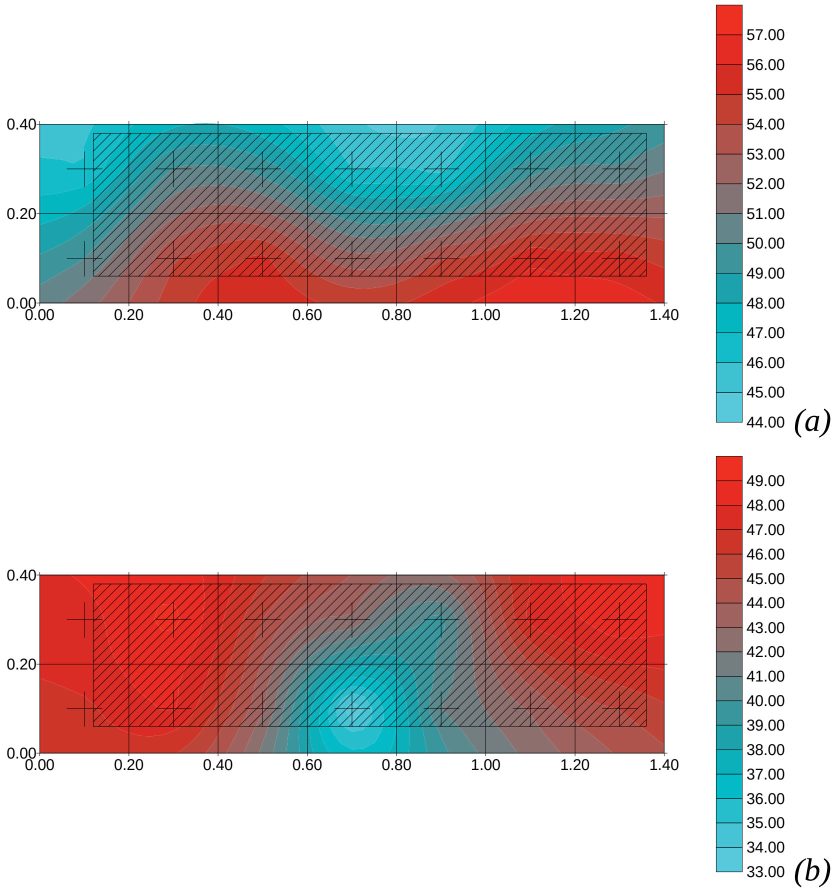


Figure 6 – Maps of the overall sound intensity levels(in dB) measured on the front measurement grid for sample A8(a) and sample A9 (b). The hatched area is that of the sample. Note that the scale limits are different.

CONCLUSIONS

An experimental investigation was carried out by sound intensity measurements in a reverberation room to determine the acoustical behaviour of two arrangements of steel blind boxes.

A light, sound absorbing inner lining of the casing demonstrated to be even more efficient than a traditional, denser sound insulating treatment, particularly when noticeable leaks were present at the access faces of the box. Suitable absorbing materials were chosen and compared such as mineralized wood fibres and polymeric foams, achieving up to 5 dB of improvement for R_w. Analyses of the frequency behaviour of the sound insulation and of the intensity maps were performed. The influence of leaks was studied, demonstrating that a proper sealing could, as an optimum, lead to a further 10 dB overall performance rise. To this extent, the effect of the presence of apertures for reasons of air ventilation can be tremendous (up to 15 dB at some frequency bands).

ACKNOWLEDGEMENTS

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