Airborne sound insulation and absorption of noise barriers with photovoltaic modules

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Acoustic barriers are one of most common methods used to limit acoustic pollution caused by road noise. In order to reduce expenses due to building and operating these barriers, a theoretical and experimental analysis was carried out on the acoustic properties of last generation barriers with built-in photovoltaic panels. The analysis deals with 4 prototypes with different solutions. The tests on the 4 samples were performed to check both the reliability of the panel and the acoustic properties of the barriers. The present paper reports the sound insulation and absorption test results.

AIM OF THE ANALYSIS AND DESCRIPTION OF THE SAMPLES

Expenses regarding the construction of acoustic barriers can be reduced by introducing systems capable of capturing and converting solar energy, such as photovoltaic panels. The panels in fact can be assembled on the already built-in acoustic barriers; the road infrastructures can then use the electricity produced for lighting tunnels, sings, etc. Therefore, to test conventional acoustic barriers with built-in photovoltaic panels, four different prototypes by four different firms were tested: two of them are built with traditional acoustic barriers (specimen II, III) and two with transparent panels made in PMMA (specimen I, IV); the built-in sun modules were different for each barrier, as shown in Fig. 1. The sun panels were tested for electrical functionality and insulation before and after cycles of accelerated aging in climatic chambers, so to assess their performances after long periods of time; the acoustic barriers were therefore assessed for their acoustic insulation and absorption properties as described in the following.

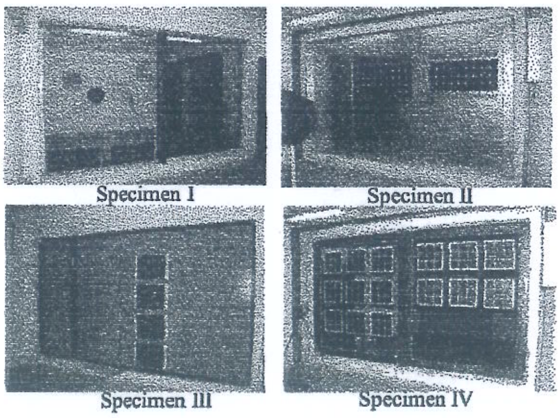

FIGURE 1. Tested samples

EQUIPEMENT USED AND MEASUREMENT RESULTS

The measurement of the sound reduction index and the single-number quantities R_w and DL_R were taken in compliance with ISO 141 [1], ISO 717 [2] and EN 1793 [3]. Figure 2 shows the measurement sequence followed. Each sample *a)* was installed in the reverberating chamber 24 hours before the measuring. Source *b)* and microphone *c)* had been set up in the positions chosen according to ISO 140/3; for each position of the source, five microphone positions were chosen. The sound was generated by a digital recorder *d)* amplified and spread in the room by an omnidirectional source. The trend of the sound reduction index R and of R_w were performed directly by the software *e)*. The trends of the sound reduction index were reported in Fig. 3; for each sample, the experimental curve measured was plotted along with the reference curve (ISO 717). The values of the single-number quantities R_w and DL_R were calculated in compliance with ISO 717 and EN 1793-2 (Tab. 1). In the case of metallic sound barriers, the absorption coefficient (Sample II e III) trend was also measured

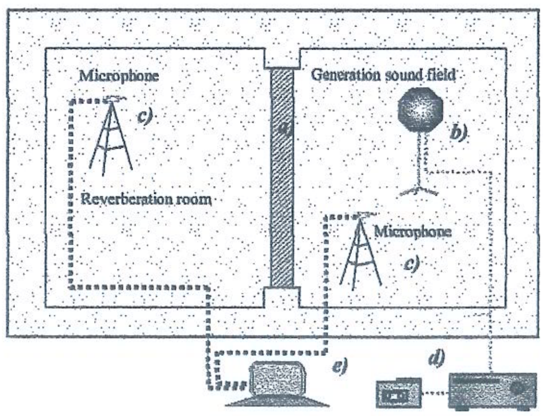

FIGURE 2. Measurement equipment

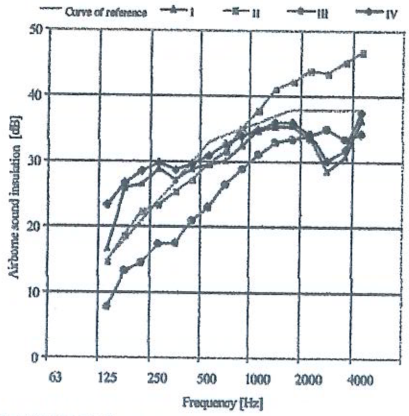

FIGURE 3: Sound insulation vs. frequency of the tested specimens

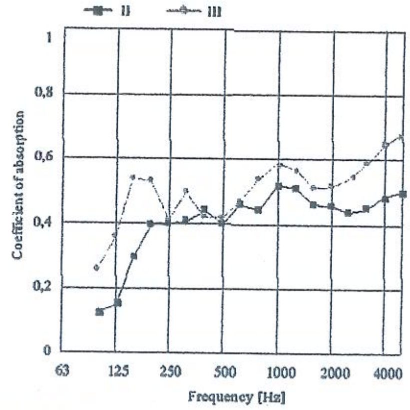

FIGURE 4: Absorption coefficient vs. frequency of specimen II and III

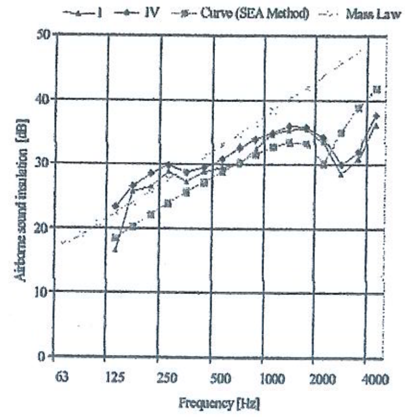

FIGURE 5: Comparison between SEA method, measurements and Mass Law

(Fig. 4) by means of the reverberating time with the Sabine Method [4]; the single number rating of sound absorption DL_α defined in 1793-1 (Table 1) was calculated. Specimens I, II, IV belong to class B3 [3] as regards acoustic insulation, whereas only sample III falls into class B2; as regards sound absorption, both samples II and III belong to class A1 [3].

Table 1: Measurements results

	R_W	DL_R	Cat.*	DL_α	Cat.**
Specimen I	33	31	B3	-	-
Specimen II	36	30	B3	2.62	A1
Specimen III	29	23	B2	3.23	A1
Specimen IV	34	33	B3	-	-

* EN 1793-1 ** EN 1793-2

COMPARISON WITH THEORETICAL MODELS

The sound insulation behaviour of the samples has been estimated with theoretical models able to describe the sound transmission of the panel, so to have foreseeable evaluation of the acoustic behaviour with different engineering solutions. For the samples made of PMMA, the SEA Method (Statistical Energy Analysis) was chosen [5]. As shown in Fig. 5, the expression of the sound reduction R found with the SEA method is in good agreement with the actual behaviour of the homogenous panels made of PMMA: at central frequencies a disagreement in the range of minimal value 0.3 dB and maximum value 2.7 dB was found. In the central frequencies range, the sound insulating behaviour of an infinitely extended panel is also described by the Mass Low; the maximum disagreement found between the interpolar line of the experimental values of R and the line representing the Mass Law is 3.3 dB in the case of sample I and 2.5 dB in the case of sample IV. The behaviour of samples II e III which contain a portion of sound barrier and a portion of photovoltaic panels is not as easy to model.

CONCLUSIONS

In order to set up a check procedure for non conventional sound barriers with built-in photovoltaic modules, the sound reduction and absorption performances of 4 prototypes purposely produced for experimentation have been tested. The single-number quantity of the samples R_w ranges between a minimum value of 29 dB and a maximum value of 36 dB. As regards the evaluation of the single-number rating of airborne sound insulation from road noise DL_R, in compliance with EN 1973-2, three samples fall into the B3 category and one in B2. Samples II e III also belong to class A1 as regards the acoustic absorption (EN 1793-1). The sound insulation trend was compared to the sound insulation resulting from applying theoretical models, which were satisfactorily accurate in the monolayered samples made of PMMA; the modelling of the multilayered walls of the remaining 2 samples appears to be insufficient.

REFERENCES

1. ISO 140 Acoustics - Measurement of sound insulation in buildings and of building elements - Parts 1, 2, 3 and 4.
2. ISO 717 Acoustics - Rating of sound insulation in buildings and of buildings elements - Part 1.
3. EN 1793 Acoustic - Road traffic noise reducing devices - Parts 1 and 2.
4. ISO 354 Acoustics - Measurement of sound absorption in a reverberation room.
5. Beranek, *Noise and Vibration control*, Mc Graw Hill 1988, pp 244-341.