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RESIDUES UTILIZATION FROM SHOES INDUSTRIES IN THE ACOUSTIC INSULATION IN THE BUILDINGS

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ABSTRACT
This work intend to re-used, in the building construction, the solid residues proceeding from shoes industries, specifically, the copolymers Ethylene-Vinyl Acetate (EVA). From the shoes fabrication process result a lot of residues, after the clip of the outer shoes soles. The residue of EVA grounded, shows great potential in the impact sound acoustic insulation. This type of noise is transmitted by the cover-slab between floors of the buildings and spread out through of the structure for the others floors. To solve this problem it's used the floating floors system, that has a intermediary covering between the structure and the final touch, composed by elastic material which does muffling effects to this noise. Therefore, an alternative material was developed, in order to contribute for the environment preservation, besides to allow the cost optimization for the buildings acoustic insulation, in impact sound.

1 - INTRODUCTION

According to Mollison, B.; Slay, R. (1998) "ethics is a combination of beliefs and moral attitudes in relation to survival on our planet."

Today it is indispensable that man act in ethic way with nature, planning well his attitudes and having in view the sustainability. As such, the industries should give more importance to the question of solid residues produced during their process of fabrication, which compromise the preservation of the environment.

The generation of residues causes an increase in the cost of production, due to the waste of material and the need of designated space for their storage. It is fitting then to have a reassessment of these fabrication processes, through the reduction, management and recycling of residues.

The Rio Grande do Sul, Brazil, through its shoes industries, produces a great volume of residues of EVA (Ethylene-Vinyl Acetate), that comes from the fabrication of outer shoes soles, inner shoes soles and the material between soles. The EVA is produced in plaques that, after its trimming, produces scraps, which cannot be melted and remolded.

Industries in "Vale do Sinos", have been depositing these residues, without discrimination, on the banks of rivers, causing serious damages to the environment.

Actually, the State Foundation of Environmental Protection of Rio Grande do Sul (FEPAM) is preventing this situation from worsening, by establishing a rigid control on the residues produced. The responsible firms are obligated to respond to the administrative process. In so doing, they purchase or rent spaces to deposit their waste, paying to free themselves of this problem (Fig. 1).

This research paper proposes an alternative for recycle and utilization of residues of EVA. The EVA was ground into grains and piled on plaques that are employed in the civil engineering construction industry, in the acoustic isolation for impact noise.

According to Méndez (1995) "impact noises are generated by a mechanical excitation of short duration, applied directly over the structure of the building and are transmitted by solids." This excitation is generated by the fall of objects on the floor, which can cause a dislocation of furniture etc. By acting on

Figure 1: Residues of EVA in Rio Grande do Sul − Brazil.

the ground of the enclosed source, these elements cause the vibration of the structure that propagates the sound in the form of waves to the enclosed receptor.
Through previous studies, realized by Garlet (1998), at the Federal University of Rio Grande do Sul and by Brondani (1999), at the Term-Acoustic Laboratory of the Federal University of Santa Maria, Brazil, the great potential of the residue of EVA grounded, was verified in grains in the isolation of impact noise. The EVA is employed as a resilient material in floating floors, which is the treatment used with more efficiency for the isolation of impact noise in buildings.
Méndez (1995) explains that "the floating floor consists of a contra floor supported on elastic material, without direct contact with the structure, to isolate, the rest of the building from the vibrations generated by the impact."

2 - METHODOLOGY

The EVA residue was processed in a mill, sifted and packed with phenolic resin and with cement. Forms were decorated in compensation of board, which form plaques with dimensions of 500 mm by 500 mm, and thickness of 15 mm, 20 mm and 25 mm.
The tests were done in the Term-Acoustic laboratory of UFSM in its chambers that measure the sounds of impact that are applied. The processing of the tests is determined by international standard ISO 140 VII. The upper chamber is the one that emits the level of the impact noise.
In the emission chamber the resilient material is placed centrally over the paving stone of concrete. The contra floor is placed over this material, that was made of board in the form of blocks with thickness of 40 mm.
The sample was dimensioned to 1 m^2, to permit easy taking out of each type of plaque tested. Later, a machine generating impact noise (tapping machine type 3204, mark Brüel & Kjaer) is placed over this sample of floating floor.
On the reception chamber a rotating microphone (Rotating Microphone- Boom Type 3923, mark Brüel & Kjaer) is placed centrally, which will process the results. The analyzer is calibrated in 93.4 dB at a frequency of 1000 Hz (Sound Level Calibrator Type 4230, mark Brüel & Kjaer).
For reasons of comparisons a whole plaque of EVA, that is employed in the confection of the soles of shoes and the, wool of glass, which is a resilient material used in floating floor were tested in the same conditions as the alternative plaques of granulated EVA.
The Figure 2 presents the rehearsal outline in laboratory:

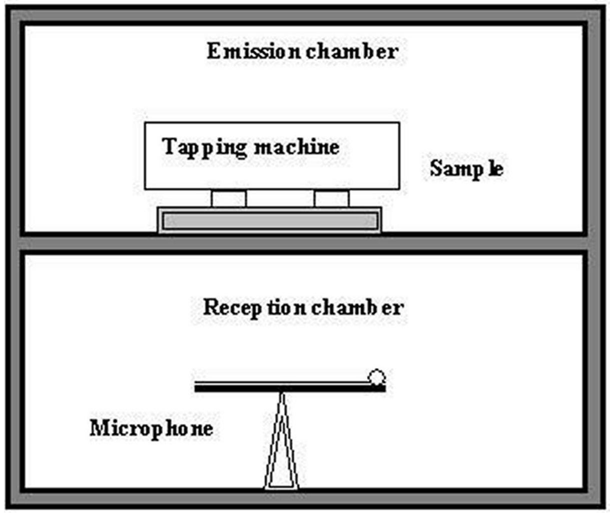

Figure 2: Rehearsal outline in laboratory.

3 - RESULTS OBTAINED AND ANALYSIS OF DATA

The analyzer of acoustics for buildings calculates the levels of impact noise standardized in dB (A), for each frequency in Hz, using the formula:

$$LnT = \mathrm{L}_1 - 10\log\left(T/0.5\right) \quad (1)$$

where:

- **Ln T** is the level of noise impact standardized in dB;
- $\mathbf{L}_1$ is the level of noise impact recorded in the receptor chamber in dB;
- **log** is the logarithm;
- **T** is the reverberation time recorder in the receptor chamber in seconds.

The Table 1 and Figure 3 present the levels of isolation of impact noise recorded for each sample. The following systems of floating floor were tested:

- **Sample 1** (S.1) − covering stone support + board
- **Sample 2** (S.2) − covering stone support + plaque of EVA/cement (1:3) + board
- **Sample 3** (S.3) − covering stone support + plaque of EVA/cement (1:4) + board
- **Sample 4** (S.4) − covering stone support + plaque of EVA/cement (1:5) + board
- **Sample 5** (S.5) − covering stone support + plaque of EVA/cement (1:6) + board
- **Sample 6** (S.6) − covering stone support + plaque of EVA/cement (1:7) + board
- **Sample 7** (S.7) − covering stone support + plaque of EVA/cement (1:8) + board
- **Sample 8** (S.8) − covering stone support + plaque of EVA granulated + board
- **Sample 9** (S.9) − covering stone support + plaque of EVA/asphalt hot + board
- **Sample 10** (S.10) − covering stone support + plaque of EVA/asphalt cold + board
- **Sample 11** (S.11) − covering stone support + plaque of EVA/glues white + board
- **Sample 12** (S.12) − covering stone support + plaque of EVA/shoemaker's glue + board
- **Sample 13** (S.13) − covering stone support + phenolic resin + board
- **Sample 14** (S.14) − covering stone support + wool of glass + board

- **Sample 15** (S.15) − covering stone support + whole plaque of EVA + board

Freq. Hz	S. 1 dB	S. 2 dB	S. 3 dB	S. 4 dB	S. 5 dB	S. 6 dB	S. 7 dB	S. 8 dB	S. 9 dB	S. 10 dB	S. 11 dB	S. 12 dB	S. 13 dB	S. 14 dB	S. 15 dB
100	70,8	63,2	59,3	65,5	60,3	64,2	58,3	65	64	63,2	62,5	56,4	62,9	67,4	66,4
125	70,5	62,3	64,3	63	61,1	62	61,6	63,5	64,1	67,7	62,6	66,1	66,7	68,4	71
160	72,7	66,4	66	64	68,1	61,5	60,8	61,8	66,7	68,6	66,7	64,8	69,5	67,9	72,9
200	74,2	59,9	61,9	61,4	61,5	58,2	59,6	54,1	60,4	61	58,7	57,8	62,3	58,1	71,6
250	74,6	60	61,8	60,6	60,4	59,2	60,1	57	59,4	61,2	57,7	58,2	60,6	54,5	71,7
315	71,6	62,5	59,7	59,8	58,7	60,2	59,6	55,8	57,6	60	55,2	54,7	59,5	51,5	71,9
400	69,6	62,9	57,8	56,6	56,6	58,4	58,8	51,9	54,9	56	52,4	51,3	54,1	46,9	68,8
500	70,5	58,9	56,4	55,2	56	55,5	55,8	54,6	53,3	53	51,6	53,7	53,2	46,2	64,2
630	71,8	53,9	50,4	49,1	51,3	48,6	50,5	45,6	46,4	46,9	44,3	46	46,5	42	58,9
800	72,6	50	46,1	45	47,9	49,2	48	44,8	46,3	44,4	45,3	46,1	45,5	41,6	53,8
1000	68,3	47,1	43,3	41,5	42,9	43,8	43,3	39,1	40,1	38,6	41	40,2	39,6	38,7	50,7
1250	66,5	43,4	40	39	40,3	42,5	41	38,9	38,3	36,9	38,9	38,6	36,4	33,9	50,7
1600	63,8	41	40,6	39,5	40,8	40,2	39,9	37,2	38,8	36,2	40,4	37,9	34,4	34,8	42,4
2000	56,7	37,3	37	37,1	37,5	38,2	36,3	33,5	36,7	32,4	35,4	34,1	29,9	31,7	38,7
2500	52,3	32,7	33,2	33,4	34,7	33,8	32,9	30,1	33,2	28	32,2	30,8	27	28,3	33,8
3150	48	28,9	30,4	31,8	31,4	31,1	29,8	27	30,7	26,1	29	27,7	24,8	25,1	29,5

Table 1: Level of impact noise.

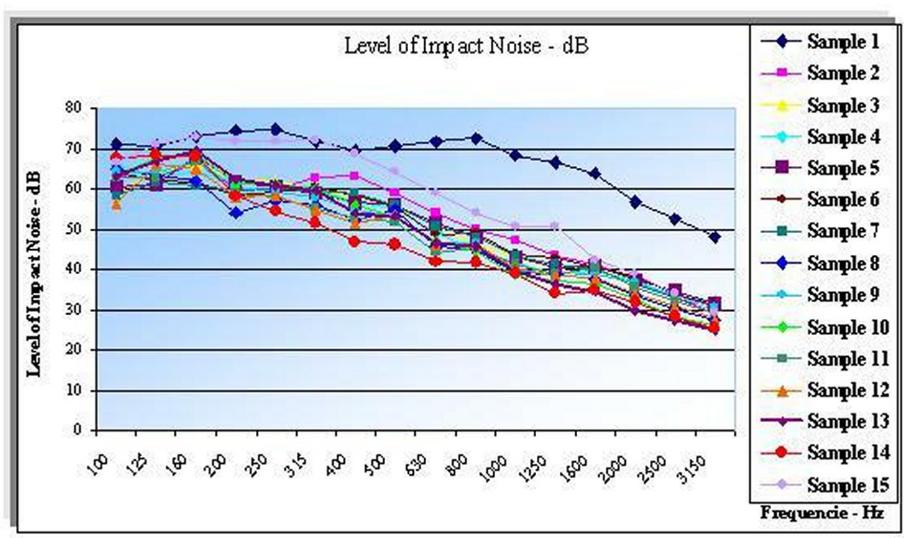

Figure 3: Level of impact noise − dB.

Analyzing the results the best performance, in most of the strips of frequencies, was verified with sample 14, which composes of wool of glass with resilient material. In comparison a very satisfactory performance was detected using the plaques with granulated EVA.
In the tests carried out, was outstanding with a layer of resilient composed of granulated EVA with a grain diameter of about 7 mm. Being like this:

- in the frequencies of 100 and 150 Hz all the EVA samples present results superiors the sample 14 (glass wool), standing out for sample 12 (EVA/shoemaker's).
- in the frequency of 160 Hz the sample 7 (EVA/cement 1:8) presents the best acting.
- in the frequency of 200 Hz the sample 8 (EVA granulated) presents better acting.
- in the frequencies between 315 and 800 Hz the sample 14 (glass wool), presents better acting, as well as in the frequency of 1250 Hz.

- in the frequency of 1000 Hz the sample 14 (glass wool) presents result practically equal the sample 10 (EVA/asphalt cold).
- in the frequencies of 1600 to 3150 Hz the sample 13 (EVA/phenolic) presents results superiors the sample 14 (glass wool).

4 - FINAL CONSIDERATIONS

Civil construction is a potential consumer of noise coming from other industries, in function of the search for alternatives that reduce the cost of habitation.

As such, this proposal suggests an alternative for the utilization of the residues of granulated EVA, coming from the shoes industries a path for the reduction of the environmental impact produced by the deposition of residues on lands. Which apart from polluting, creates waste of a precious resource, which is not none-treminating. Apart from this, the process of grinding of EVA is simple and of low cost, not having the necessity for the utilization of specialized hand work.

Although the floating floor system, employing wool of glass as resilient material presents the best results of isolation, plaques of EVA, ground into grains, a conglomerate with shoemaker's glue has an outstanding performance, in low frequencies. As well as the EVA agglomerate with resin phenolic in high frequencies. The utilization of this material in the isolation of impact noise in buildings, will contribute to the preservation of the environment, apart from making a notable improvement in the quality of life of its users possible.

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