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ANALYSIS OF IMPACT SOUND INSULATION PROPERTIES OF RECYCLED RUBBERS FOR TECHNICAL FLOORING IN FITNESS FACILITIES

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***Abstract*—** This work is a comparative analysis of the dynamic stiffness in plates made from recycled rubber intended for their use in technical flooring. The aim is to determine which one of the materials presents the best sound absorbing properties when impact loading conditions for their application in fitness facilities. In addition, the manufacturing of these materials contributes to the optimization of the industrial wastes and reduces the damage to the environment. The recommendations of the standard UNE-EN 29052-1 are considered to determine the dynamic stiffness. The results demonstrate that this product is suitable for its application in technical floors for certain sport activities, because of its low dynamic stiffness, what means that these materials have the capability to isolate the impact sounds quite well. This study is part of a more extensive research project in which some other acoustic parameters are determined, such as the sound transmission loss.

***Keywords*—**Impact Sound Insulation, Recycled Rubbers, Technical Flooring.

I. INTRODUCTION

THERE are lots of tons of crumb rubber from wasted tires that every year are being accumulated. Because of this, some European regulations, such as the Regulation 2008/98/CE [1] are about the treatment of this waste. Nowadays, most of companies try to reuse and recycle.

Some of these industries manufacture rubber floors for fitness facilities. These products usually have two layers: the surface layer made from the recycled rubber and a filler material made from end of life tires. The result is a material with better sound absorbing behaviour than those used classically.

This work has been conducted with the cooperation of PAVIGYM [2], which is a company that manufactures materials used in gyms as technical flooring.

Some previous study has been conducted with Ethylene Vinyl Acetate (EVA) panels, that are mostly used in floors for fitness facilities [3].

Fig. 1 shows different samples of plates of Ethylene Vinyl Acetate with the same thickness and different densities.

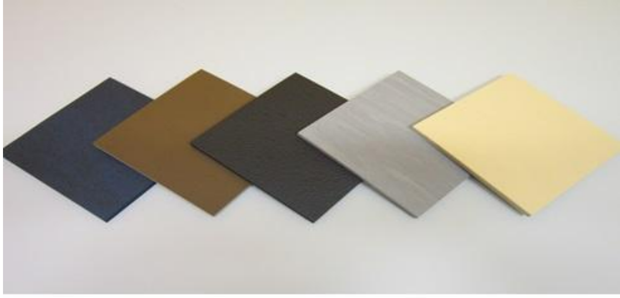

Fig. 1. Samples of EVA panels with different densities and the same thickness.

Fig. 2 shows different plates of Ethylene Vinyl Acetate with the same density and different thicknesses.

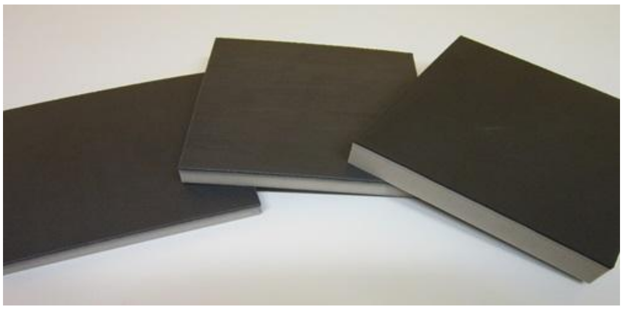

Fig. 2. Samples of EVA panels with different thicknesses and the same density.

The results obtained for the EVA panels, presented in another work, will serve as reference to compare them with the ones obtained for rubber panels.

And the rubber panels that are being investigated in this work are showed in Fig. 3.

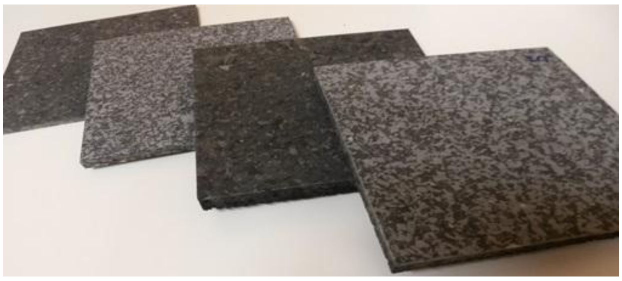

Fig. 3. Rubber panels to be investigated.

Nowadays, the recycled rubber is presented as a substitutive material (Fig. 4), since it can be presented as a final product with a wide range of colours and with similar mechanical behaviour than the EVA.

Fig. 4. Recycled rubber for technical flooring.

II. EXPERIMENTAL METHOD

The type of technical flooring presented in this work is known as ENDURANCE. With the aim of controlling the influence of the compression pressure on the impact sound insulation, some test samples are manufactured at different pressures: 160, 50 and 0 bar.

There is another important parameter to study: the granulometry of the filler. This filler is made from the recycled rubber of the tires. There are test samples with granulometries 1-3 mm, 2-7 mm and 4-8 mm, and also some combinations of them. The acoustic properties of the materials depend on the granulometry of the filler and, as a consequence, of the porosity.

The test samples are manufactured in a steel mould of 200 mm x 200 mm x 55 mm, and they are 20 minutes inside the press at 125 ºC.

The quantity of the tire rubber and of resin (Prepolymer BA1022 and Voramer) does not vary with the pressure. The tire rubber is 630 g and the resin is 10% of the rubber. Adding the external layer, each test sample weights 860g. However, samples processed at 50 bar, have 900 g of rubber and 100 g of resin, to completely fill the mould.

A. Preparation of the samples

To prepare products manufactured with rubbers, there are three basic operations [4]:

a) Adding the ingredients. Rubbers with reinforcement additivies.

b) Scattering. There are some products, such as accelerators, that improve the scattering and reduce the time of the mixing process. These products are usually powders and grains.

c) Homogeneization. After the mixing process, the rubber becomes in a very homogeneous mass.

B. Vulcanization

Vulcanization is a chemical process for transforming the rubber in a more durable material by adding sulfur. After this process, the surface of the material becomes soft, applying a pressure of 200 bar and a temperature of 165 ºC. After 10 minutes, the rubber is completely crosslinked.

By doing this, about 250 tons of rubber are recycled each year, what is according to the standard “ISO 9001:2008. Quality management systems” [5].

C. Recycling

Taking advantage of the waste rubber from a number of industries, as the footwear industry, lots of different products of rubber can be manufactured. In the first stage of the process, the grains of rubber are mixed in a banbury mixer. Next, this product is kept at 200 bar and 165 ºC for 10 minutes.

In the second stage, a sanding operation is applied to the surface of the material. And finally, the surface part and the rest of the material are joined.

Recycled rubber with different granulometries is mixed and then, by means of a controlled pressure and temperature, the final product is made with a range of densities. All the process is developed following the recommendations of the standard “ISO 14001:2004. Environmental management systems – Requirements with guidance” [6]. Fig. 5 shows the materials to be tested.

Fig. 5. Final products of thicknesses 18 and 22 mm.

III. DYNAMIC CHARACTERIZATION

Two different samples of recycled rubber of thicknesses 18 mm and 22 mm are tested to determine their dynamic stiffness. The technique is based on the standard “ISO 9052-1=1989. Determination of dynamic stiffness – Part 1: Materials used under floating floors in dwellings.” [7].

Fig. 6 shows the scheme of the test equipment according to the mentioned standard.

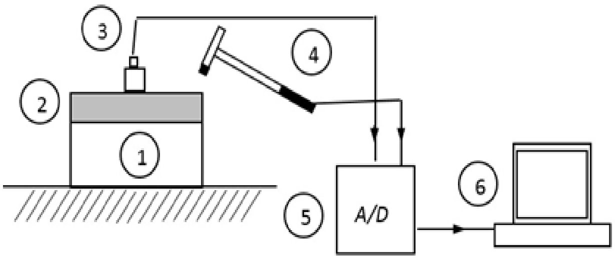

Fig. 6. Scheme of the test equipment.

Where 1) is the test specimen; 2) is the upper steel plate; 3) is the accelerometer (PCB 352C42); 4) is the calibrated impact hammer (PCB 086C01); 5) is the data acquisition card (NI-9233) and 6) is the PC.

According to this standard, a steel plate of 200 mm x 200 mm is required, an impact hammer, an accelerometer and a digital system for acquiring and analyzing the recorded data. The total weight of the system should not be over 8 +/- 0,5 kg. With these requirements, there is a vertical mass – spring system in which the frequency is measured and the dynamic stiffness is determined. Three measurements are carried out for each sample. Fig. 7 shows the experimental set-up for the test.

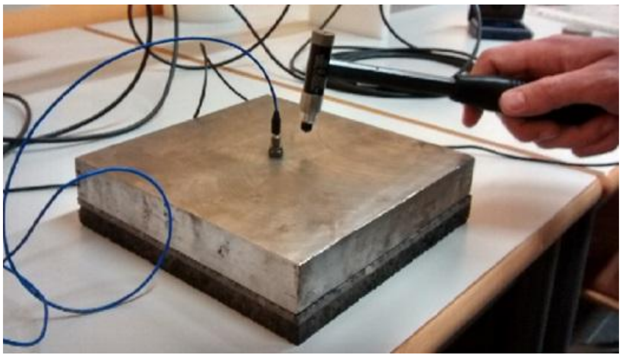

Fig. 7. Experimental set-up for the test.

IV. RESULTS

When the impact force is applied, two signals are recorded and represented in Fig. 8. These two graphs show the signal of the impact hammer (up) and the response of the accelerometer (down).

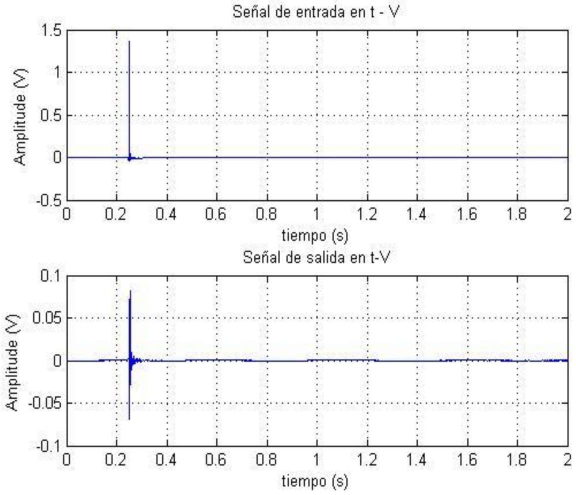

Fig. 8. Input and output signals recorded to determine the dynamic stiffness.

After testing the samples, Fig. 9 to 12 show the frequency of the first mode of vibration for each one of the samples. With this value, the dynamic stiffness is determined.

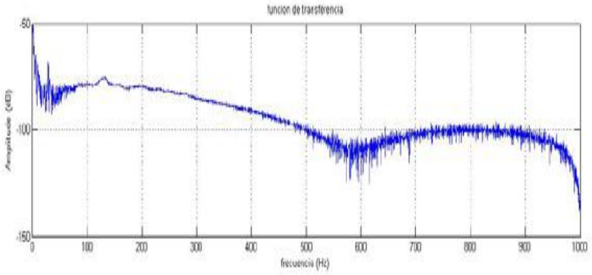

Fig. 9. First mode of vibration of a monolayer recycled rubber of 7 mm.

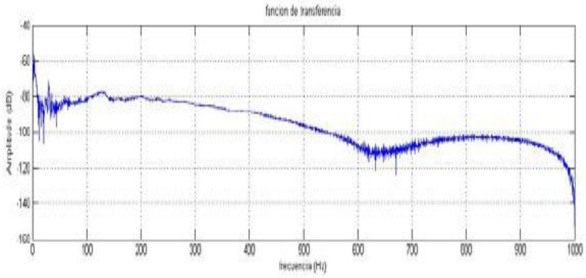

Fig. 10. First mode of vibration of a monolayer recycled rubber of 10 mm.

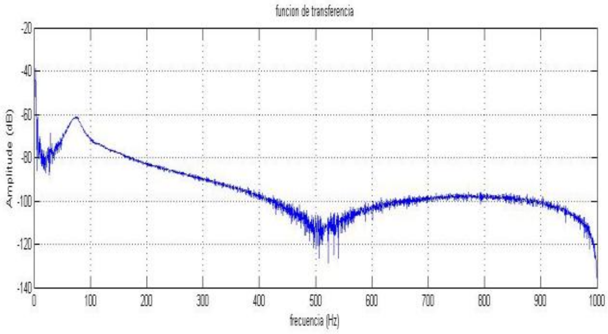

Fig. 11. First mode of vibration of the recycled rubber of 18 mm (two layers).

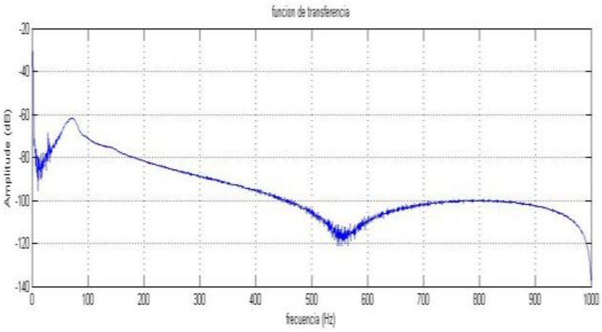

Fig. 12. First mode of vibration of the recycled rubber of 22 mm (two layers).

So, from the first mode of vibration of the system and with the resonant frequency, the dynamic stiffness (s_t) is determined (in MN/m^3), by means of equation 1:

$$S_t = 4 \cdot \pi^2 \cdot m_t \cdot f_r^2 \qquad (1)$$

Where m_t is the mass per area (kg/m^2) and f_r is the resonant frequency (Hz).

Table I shows the results of the dynamic stiffness.

TABLE I.
DYNAMIC STIFFNESS RESULTS

	Thickness (mm)	Density (g/cm^3)	Frequency First Mode (Hz)	Dynamic Stiffness (MN/m^3)
Mat. 1	7	1,25	129,4	150,6
Mat. 2	10	1,25	130,1	152,1
Mat. 3	18	1,1	66,78	40,08
Mat. 4	22	0,97	75,11	50,69

V. DISCUSSION

As indicated in the introduction, Ethylene Vinyl Acetate (EVA) panels are a good reference to compare their dynamic behaviour with the rubber materials.

The dynamic stiffness of EVA panels that have 20 mm of thickness and 3 g/cm^3 of density, is about 165 MN/m^3.

It can be stated that with a smaller thickness and density, it is possible to obtain lower values of dynamic stiffness, which is better for the acoustic insulation capabilities when impact loading.

VI. CONCLUSIONS

From the obtained results, two main conclusions can be pointed out:

- The two-layer materials present the lowest dynamic stiffness values, what means that their capability to absorb the impact sound is much better in front of monolayer rubber materials.
- The two studied materials have similar behaviour since they have similar characteristics.

Finally, it is worth saying that this study is part of a more extensive research project in which some other acoustic parameters are determined, such as the sound transmission loss.

The sound transmission loss is an acoustic property for characterizing the sound insulation capabilities of some materials, mostly for their applications as sound barriers.

ACKNOWLEDGMENT

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