Innovation of pneumatic waste in building sound insulation systems against internal and external noise

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Abstract – *After the experiment of the same material in thermal insulation, the present work is a new investigation to answer the problem of acoustic comfort of the constructions while clearing the environment of the pneumatic waste which by their long life occupy large spaces and by their incineration emit polluting gases. Numerous tests have been carried out on reduced or real models representing either the floors or partition walls that are the main conductors of sound in a building. In comparison with the expensive materials currently used in acoustic insulation, the proposed innovation has shown unexpected technical sound insulation performances accompanied by a great economic interest.*

Keywords: Acoustic Insulation, Noise, Acoustic Vibration, Building, Pneumatic waste.

1. Introduction

With the changing of life concepts and the demand of the multiple build function, builders will face many challenges. Population growth has forced the latter to design collective dwellings in height to allow a large population to live in a small space. This situation has generated problems and even very significant environmental scourges. Among these scourges noise, subject of the present study, it is caused by the fluctuations of the atmospheric pressure and its transmission speed depends on the modulus of elasticity and the density of the fluid crossed [1]. It poses a direct danger to human health that can range from simple nervous behavior to complete loss of hearing. Faced with this scourge, researchers concerned with acoustic comfort and the "well-being" of occupants have been divided into two complementary categories, some of which have examined the issue of sound evaluation and the search for its sources, while others take care of noise insulation.

In urban areas, heating, ventilation and air-conditioning appliances that promote internal comfort become themselves sources of urban noise pollution. The authors of the article [2] propose as remedy, regulated acoustic emission limits in the manufacture of these devices. For their part, the authors in [3] classify recorded sounds to determine their harmfulness. In the same category, researchers in [4] carried out a high-level holistic analysis to conclude that poorly insulated class design affects up to 50% of students' learning abilities. Aspects of noise propagation in ventilation / air conditioning ducts and the measures needed to mitigate them have had their share of interest with the authors of the article [5].

On the contrary, from the thermal problem where the insulation can be assisted by heating and air-conditioning systems, the noise problem can only be dealt with by an effective acoustic insulation system. The emergence of new materials and the innovation of waste in construction have not only improved the mechanical properties of materials but also the saving of energy by insulation, watertightness and even appearance.

For the second category of researchers, this problem continues to leak a lot of ink. Indeed the work published by the company "Index" [6] shows several solutions by integration of materials even in the structural parts of a building. These same researchers not only perfected their results in acoustic insulation but supplemented them with the treatment of thermal insulation in their edition 2010-1 [7]. In turn, the authors in the paper [8] deal with the determination of the intensity of sound and propose the appropriate material for sound insulation.

In the same concept the present work wants to be an investigation in the acoustic insulation. The innovation of pneumatic waste in the thermal insulation is a first experiment which gave very interesting results. Noting the similarity of the conductors of heat and sound in a building, it is proposed to carry out sound permeability tests on the same specimens made in the laboratory "LFGM" and used in previous non-destructive tests. It seeks to combine comfort and "well-being" with the occupant of the building on the one hand and environmental safeguard on the other.

2. Materials and Methods

Many researchers have invested in waste recycling. The authors of the work [9] proved the very positive influence of recycled aggregates on the mechanical and durability properties of high performance concrete. Other researchers have tried to innovate new materials in concrete formulations. Ahmed Tafraoui [10] proved that Metakaolin offers better performance in the durability of ultra-high performance concrete. In this section a brief overview will be given on the innovative materials in concrete formulation and sound insulation.

2. 1. Used materials.

2. 1.1. Construction material.

In the southern region of Algeria sand dune is found in abundance in nature. Its particularity of displacement makes it an element harmful to the environment especially in recent decades where large agricultural areas in the north are invaded by sand from where the plague of desertification of these zones. Since its creation, the laboratory has been carrying out research on the development of dune sand from Western Erg. This crushed dune sand yielded interesting performances in the strength of self-compacted concrete [11]. The sand dune and the cement used for the manufacture of the different test pieces figure (1), are the same for all the cases of insulation.

Fig. 1. Main constituent elements of concrete.

2. 1.2. Insulation material.

Following a literature search, it turned out that the environmental problem of used tires is of particular interest to researchers. The mechanical engineering reliability laboratory published in 2010 [12-13] works on the use of rubber waste in self-compacted concrete. In 2018 the authors in [15] resumed work on self-placing concrete. The authors [14] conclude after reviewing the literature that not only pneumatic waste has found its place in self-placing concrete but its use is economical and presents a solution to an environmental problem. In the same last contexts, the present investigation uses the user tires crushed figure (2) as a filling of the insulation layer.

Fig. 2. Waste Crushed Tires

2. 2. Methods.
2. 2.1 Mixing Concrete.

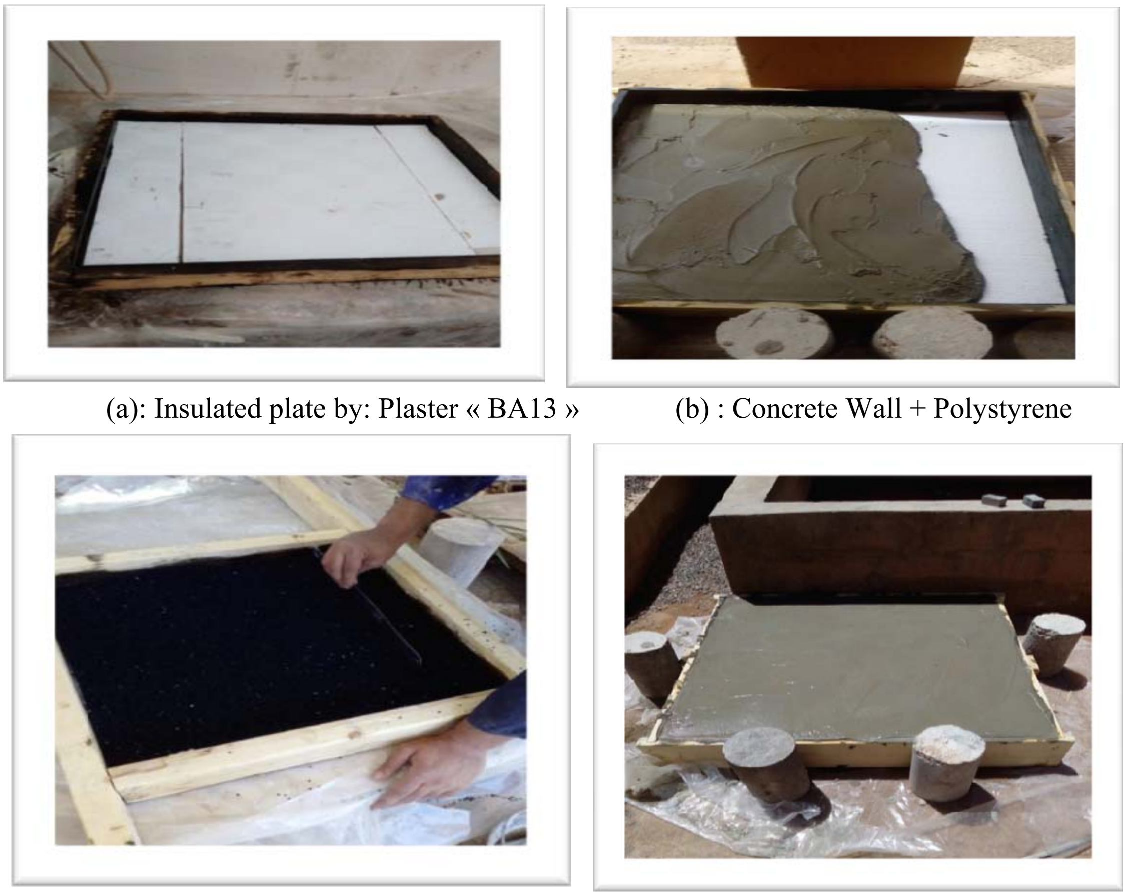
Figure (3) shows the mixing operations of the concretes which are carried out according to the same formulation and the same mixing speed in order to have a uniform concrete for all the specimens.

Fig. 3: Concrete mixing

2.2.2 Preparation of test pieces.

The test pieces to be made for such tests shall represent the conductive elements of noise in a building. The literature review showed that the principal conductors are the floors through which the vertical transfer between floors is made while the external walls are exposed directly to the different noises coming from the outside and are subject to a horizontal transfer.

From these main constituents, the different test specimens were made by pouring the concrete into two walls separated by the insulating element as illustrated in the different photos (a), (b), (c) and (d) of Figure (4) which show the realization of the different specimens in two layers of concrete separated by the insulation material used.



(a): Insulated plate by: Plaster « BA13 » (b) : Concrete Wall + Polystyrene

(c): Crushed pneumatic waste (b) : Concrete wall without insulation

Fig. 4: Test specimens.

2. 2.3 Appliances used

As illustrated in Figure (5). The device that was used for the various acoustic measurements needed for our study consists of a laptop, an enclosure to simulate the source of noise and a sound meter to measure the intensity of sound.

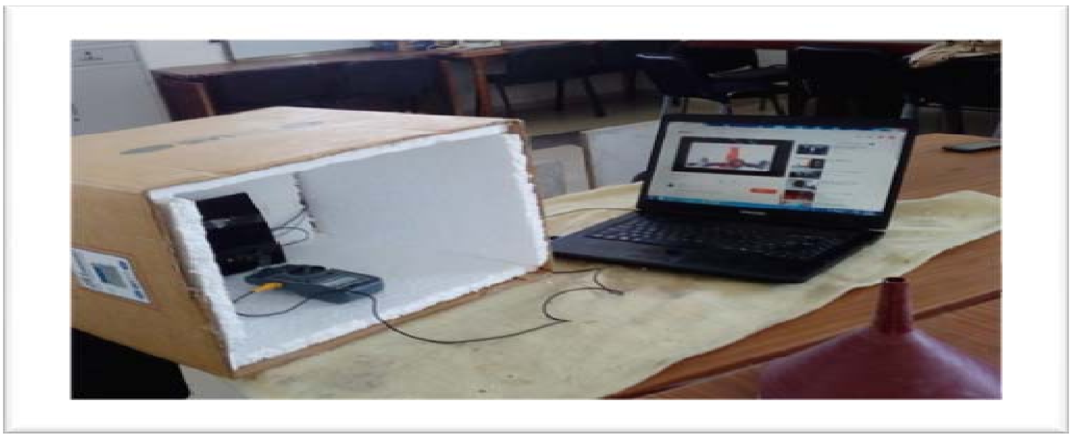


Fig. 5: Operating Mode

2.3. Realized tests

The principle of the test carried out for each specimen is to place a source of noise in a chamber with five insulating walls in which two amps emitting a pre-recorded sound are deposited. The sixth wall of the enclosure is closed by the specimen. On the other side of the test tube is placed the sound acquisition system which is measured by the sound level meter. In addition to the sound level meter setting, a funnel connected to the sound level meter is used to prevent unwanted and accidental noise during the test.

The test is carried out with the same conditions favored for each specimen. The photos in figure (6) show the progress of the different tests.

Concrete plate + plaster

Concrete wall + polystyrene

Concrete plate + crushed rubber

Fig. 6. Conduct of the test on the different test pieces.

The tests were carried out for each material used. Previous photos are given as an example.

3. Results and discussions

For each test, the measurements recorded with the sound level meter and a synchronized camera are recorded and processed by specialized software that gave the variations of the sound passing through the insulation as a function of time. Each curve representing the efficiency of the insulating material used is accompanied by the comparative curve of the sound without insulation.

The results are directly illustrated by the graphs of the following figures:

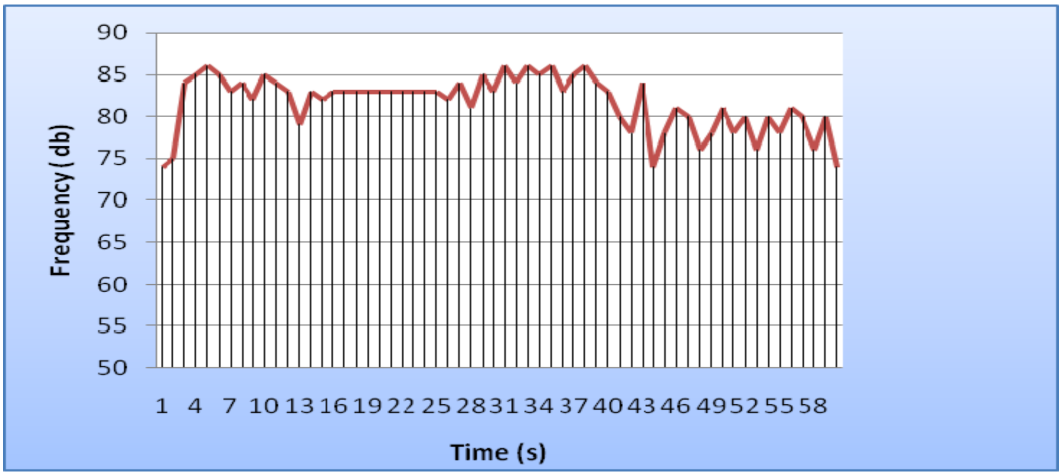


Fig. 7. Sound measurement curve (source) used for testing.

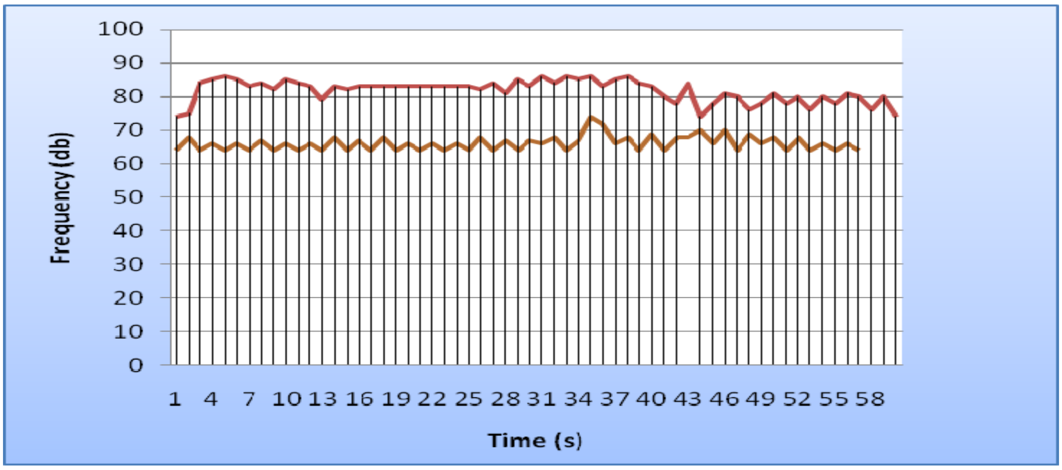


Fig. 8. Sound test curve with rubber insulation.

The upper curve in figure (8) represents the source sound and the lower curve gives the variation of the sound recorded behind the test piece which consists of two concrete plates separated by a 5 cm thick rubber insulating layer. The insulation efficiency to be taken from this graph lies in the ability of the insulating material to attenuate the sound emitted by the source. This property of the material can also be qualified by impermeability or non-conductivity of the noise..

Finally and for a better comparison, the curves of the six materials used are superimposed on one and the same graph of the figure (9). It is thus easy to observe the attenuation of the noise of the different materials grouped together in one and the same zone, whereas the curve of the subject material of the present study differs markedly from the bottom of the other materials..

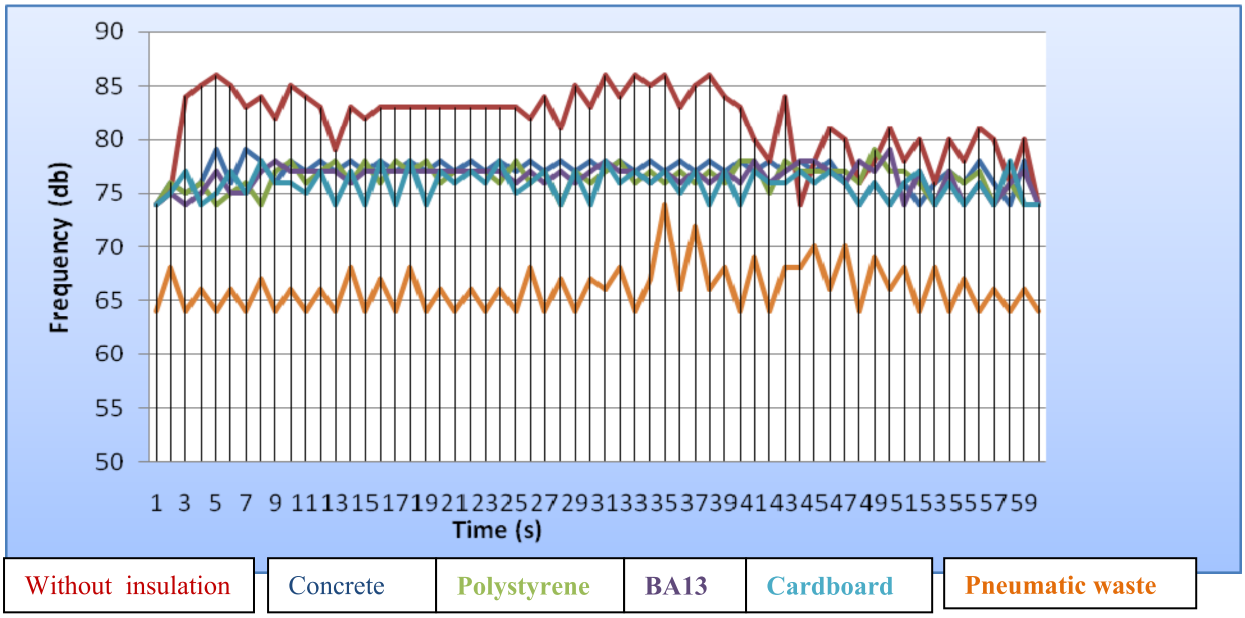


Fig. 9. Summary curve of the isolations used

4. Conclusion

Rubber has always distinguished itself by its ability to absorb noise and wave propagation vibrations which made it essential in these applications but its use in the acoustic insulation of the building was not possible because of the high blow of the raw material. The idea of taking advantage of rubber sound insulation performance by circumventing the cost problem was widely exploited during this investigation. The experience undertaken has shown a clear performance in the case of the use of pneumatic waste. Indeed the minimal permeability conductivity of the sound from the outside to the inside or from one floor to its superior in the same building has yielded very interesting results. This powerful insulation reduces the intensity of noise by 30% by making it fit within the tolerance range of the human ear. This goal alone deserves all interest. In addition to this benefit this work makes the role of such an industrialized experience in saving the environment clear by removing one of the largest bulky and non-biodegradable waste. The steel frame removed from the tires offers a wide scarecrow of use as a reinforcement element.

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