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# Acoustic performance of masonry walls: clay blocks filled with expanded vermiculite

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## ABSTRACT

**Masonry is a constructive system consisting of a cohesive and rigid set of units (blocks or bricks) joined by a bonding material. This construction system is widely used in Civil Construction due to its execution facility, cost and performance. There is the possibility of manufacturing a masonry wall using hollow blocks or massif blocks, although the former is used more frequently than the latter, once it minimizes the building's self weight. On the other hand, these cavities decrease the system's surface mass and increase the internal resonances in the blocks, damaging the sound insulation. To minimize this effect, the cavities of the blocks may be filled with porous material, being expanded vermiculite a material with potential for this purpose. This study aimed to evaluate the influence of the use of expanded vermiculite in the filling of cavities on 14 cm thick clay blocks. Sound transmission loss tests were performed, following the parameters of ISO 10140:2010, where the tests were performed in a horizontal airborne sound transmission room, at UNISINOS' itt Performance. The results to be obtained from the tests will be in bands of octave-thirds and weighed values. Through the tests performed, it was observed that through filling the 14 cm thick block cavities with expanded vermiculite, it was possible to obtain a higher acoustic performance of the wall, achieving around 5 dB plus in the Sound Reduction Index (Rw) in its weighed values.**

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**I-INCE Classification of Subject Number:** 51

## 1. INTRODUCTION

Civil construction, on the last few years, has presented itself as a sector in ascension in the Brazilian industry, aiming the housing construction. Clay blocks, when correctly applied, minimize waste rates and become interesting for construction companies, even the ones that do not possess the domain of state-of-the-art technology.

The clay block market can be found in all states of Brazil, which justifies its large usage, representing around 90% of masonries and flooring systems built in the country, with more than 6,900 factories and generating about 293 thousand direct jobs and more than 900 thousand indirect jobs, according to data of the Instituto Brasileiro de Geografia e Estatística. Inside this group, it can be noticed that the utilization of hollow clay blocks has increased. This type of block contributes to decrease the building's self weight and improve the thermal performance. However, with an increase in the demand of buildings aiming the dweller's comfort, limitations on the application of hollow blocks may appear, especially regarding acoustic insulation. Currently, in Brazil, there are normative criteria for the acoustic performance of vertical sealing systems, which are required for the ABNT NBR 15575:2013.

While there is an increase in the wall's thermal performance that use this kind of block, when compared to walls that use massif blocks, the cavities reduce the blocks' brute density and, consequently, its acoustic insulation will be lower (1). Due to the non-homogeneity resulting from the cavities in its interior, besides the loss of brute density, it is still possible to observe an orthotropic or anisotropic behavior, creating cavities that may hold one, two or three dimensional sound fields in the blocks' interior (2). The cavities perform a relevant role in the sound transmission, once the vibration is not only transmitted through the structural connections among the septa, but also through the sound field in the interior of the cavity. Hence, cavities in walls and floors are partially or completely filled with porous material in order to damp the sound energy (2).

Block filling has become an interesting artifice to improve the acoustic performance of vertical sealing systems, according to researches performed by the National Concrete Masonry Association. It was verified that, in concrete walls of several thickness, with several types of cavity fillings, there was an increase in the Sound Reduction Index (Rw) in systems whose cavities were filled, in opposition to the reference samples, with no filling. As observed in the research, for walls made up of 4" concrete blocks (102 mm), with relative density of 1362 kg/m³, it was verified an increase of 5 dB with the cavities filled with grout and 4 dB with cavities filled with natural sand, in its weighed values, when compared to the reference sample (with no filling). These results enable and justify the study of new materials that may be used to fill the block cavities, mainly regarding its influence in the acoustic performance.

The materials used to fill the blocks may be the most diverse. On the Brazilian civil construction sector, it is observed that the materials and components most commonly used are grout, sand, rice husk and, recently, it has been aiming to apply expanded vermiculite in the filling of these cavities.

Vermiculite characterizes as a magnesium, aluminum and iron hydrated silicate. This mineral, when commercialized under its expanded form, presents values of relative density that range from 80 to 120 kg/m³. This, associated with the granulometry, turns

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vermiculite an interesting material to use in several areas, where civil construction, agriculture, chemical industries, paint manufacturers, and others can be highlighted (3). Rashad (4) points out in his research that the mines where this material is extracted are located in several locations in the world, but emphasizes that the six countries whose production accounts for 97.5% of all vermiculite produced in the world are South Africa, United States, Brazil, Zimbabwe, Bulgaria and India.

Vermiculite presents interesting characteristics for the civil construction area, mainly when used under its expanded form, where it is put through high temperatures (around 800 °C). Vermiculite is said to be a porous material, and the variability in its porosity originates from its morphology in several interfaces, where these could be between layers, between particles and between aggregates, differentiating in its structure. This way, it is verified that vermiculite contains pores of several sizes and shapes, as well as granular consistency, according to Figure 1.

*Figure 1: Expanded vermiculite used in the blocks' cavity filling.*

The filling of the block cavities with vermiculite seeks to follow the principle of a system cited by Patrício (5), which consists of two rigid materials of same or different materials, separated by an air shaft of certain thickness, similar to a set of two masses joined with a spring. The existence of this air shaft between the two rigid means results in the propagation of stationary waves in its interior, which create losses on the system's insulation, decreasing its acoustic performance. Therefore, one of the main worries centers in the elimination of the influence of such resonances, having as a suggestion the use of some sound absorbing material in the cavity (5).

Hence, this study aims to present the results obtained by laboratory tests on the influence of application of expanded vermiculite as filling material in 14 cm thick hollow clay blocks, in order to verify the acoustic performance of vertical sealing systems with said alterations.

It is highlighted that the chemical composition of the vermiculite does not change during the heating process. Characterized as inert, this is another one of the many justifications of employing this material in the civil construction area, principally regarding building performance, once it can be applied as thermal attenuating and, as discussed in this paper, as a filling resource of block cavities in vertical sealing systems, in order to improve the acoustic performance. (6)

## 2. EXPERIMENTAL PROGRAM

### 2.1 Test specimens description

Through the development of this study, it was assessed the influence of filling 14 cm thick blocks cavities with expanded vermiculite aiming acoustic performance, when

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compared to reference samples, without filling. It was tested three different typologies of vertical sealing systems with the cavities of the clay blocks filled with vermiculite: one consisting of a wall with cementitious coating (M-V), another composed of gypsum plastering (G-V) and one last type without coating (B-V). Also, test specimens were produced with blocks with no vermiculite in its cavities, but using the same typologies as the specimens listed above, being named as follows: M, G and B. Such information are presented in Table 1.

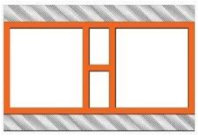
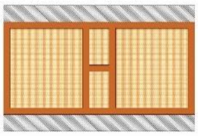
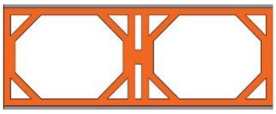
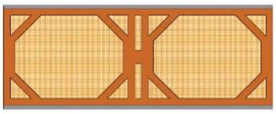
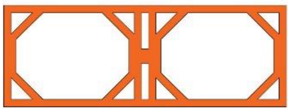
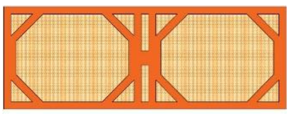
| **Simbology** | Specimen desciption | Typology of the clay block | Block characteristics |
|---|---|---|---|
| **M** | 2.5 cm of mortar coating thickness in both sides, without vermiculite |  | Dimensions: 14x19x29 cm<br>Fbk: 12 MPa<br>Block weight: 6,9 kg |
| **M-V** | 2.5 cm of mortar coating thickness in both sides, filled with vermiculite |  | |
| **G** | 0.5 cm of gypsum plastering coating thickness in both sides, without vermiculite |  | Dimensions: 14x19x39 cm<br>Fbk: 4,5 MPa<br>Block weight: 9,3 kg |
| **G-V** | 0.5 cm of gypsum plastering coating thickness in both sides, filled with vermiculite |  | |
| **B** | Without coating and vermiculite |  | Dimensions: 14x19x39 cm<br>Fbk: 4,5 MPa<br>Block weight: 9,3 kg |
| **B-V** | Without coating and filled with vermiculite |  | |

*Table 1: Typologies of the tested walls.*

The execution of the test specimens and the tests were developed in the Acoustics Laboratory of Instituto Tecnológico Performance, located at Universidade do Vale do Rio dos Sinos, at São Leopoldo campus, Rio Grande do Sul, Brazil. For the execution of the test specimens it was used portico systems, as indicated in Figure 2.

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a) b)

*Figure 2: a) Construction of the test specimen on portico system; b) Filling of the block cavities with vermiculite.*

## 2.2 Tests performed

The tests were performed accordingly to ISO 10140-2:2010 and ISO 717-1:2013. The test facility used is in accord to the premises of ISO 10140-5:2010. It was not considered the measured uncertainty to classify the test results. On all tests performed, the temperature did not drop under 20 ºC and did not go over 30 ºC in the test room, as well as the humidity at the time stayed between 60% and 75%. Figure 3 illustrates one of the specimens in test room.

*Figure 3: Test specimen in the interior of the chamber for the acoustic tests.*

With the values obtained from the tests for each one of the frequencies band analyzed, a comparison between the generated curve and the standard curve, according to ISO 717-1:2013 was performed, resulting in the weighed Sound Reduction Index (Rw). The level represents a weighted value which characterizes the system as a whole.

## 3. RESULTS

The results obtained for the specimens tested in 14 cm thick clay hollow blocks may be verified in Figure 4. It was verified that in all the analyzed test specimens, filling the cavities with expanded vermiculite increased the wall's acoustic insulation, in a weighed value between 4 and 5 dB. In these results, it is verified that masonry walls coated with 0.5 cm gypsum plastering and without any coating obtained the same Rw value, even in its specimens with and without using vermiculite as filling material, demonstrating a difference of 5 dB in the wall's acoustic insulation.

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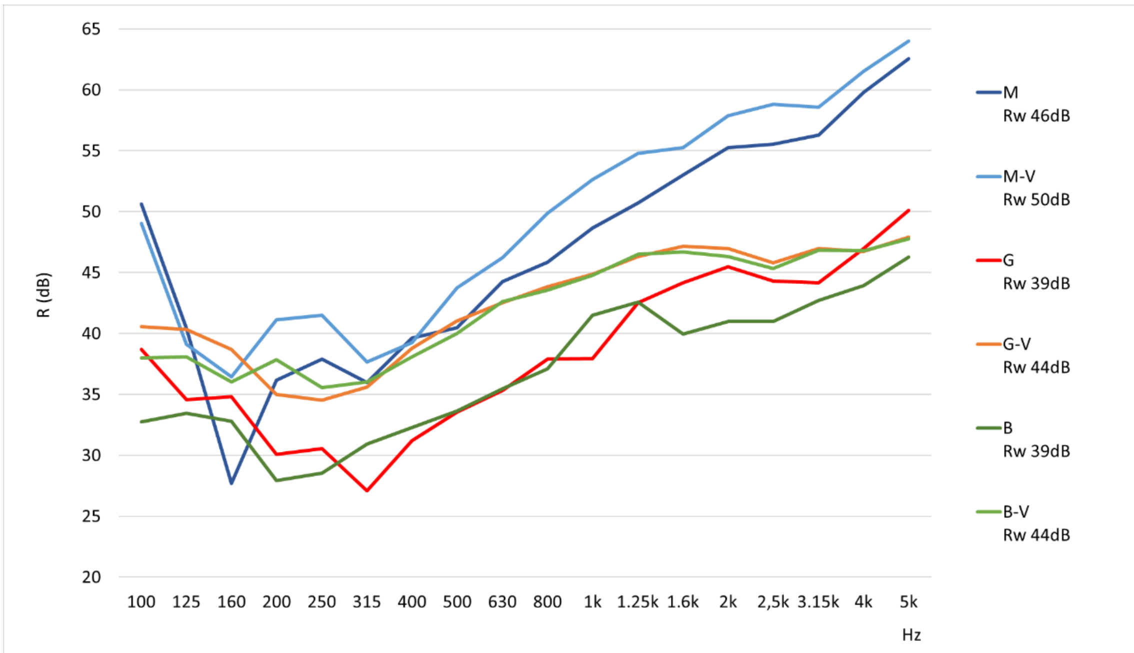


*Figure 4: Results from the specimens tested regarding its airborne sound insulation.*

The behavior of the generated curve for the octave-third bands also displayed similarities, principally on the frequencies ranging from 400 to 800 Hz for the samples without vermiculite and between 315 and 1,250 Hz for the tests performed on walls whose blocks were filled with vermiculite. These assumptions may confirm that the addition of a damp material in the interior of block cavities may compensate the utilization of thin layers of covering, to the point in which occurs a reduction on internal resonances in the block cavities, as portrayed in the studies performed by Fringuellino (1). Figure 5 displays the weighted value found for the specimens tested, considering the ones with and without vermiculite.

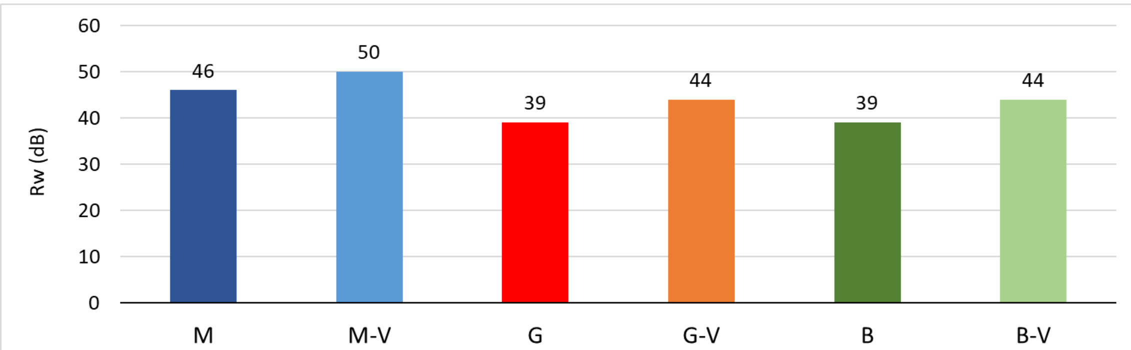


*Figure 5: Summarized board with results of the samples tested.*

The test specimens which received cementitious covering (M and M-V) presented the best acoustic performance due to the addition of mass to the wall through its own covering on both sides of the test specimen. Besides the increase in the airborne sound insulation through the addition of mass to the system, it is verified the softening effect through the insertion of vermiculite on the clay block cavities, once it is perceived an increase in the acoustic insulation on the frequencies band comprehended between 400 and 3,150 Hz.

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## 4. CONCLUSIONS

With the rising demand for new alternatives to improve the acoustic performance on vertical sealing systems, principally when taking into consideration the current Brazilian civil construction conjuncture, this study aimed to assess the utilization of expanded vermiculite as a material to fill the cavities of 14 cm thick clay blocks in masonry walls, seeking for an increase on the airborne sound insulation on these constructive systems.

Through the analysis of the results obtained through the laboratory tests performed, it was verified that, when performing the filling of block cavities with expanded vermiculite, it was obtained an increase topping 5 dB in its weighed values on the wall's acoustic performance.

Therefore, it is highlighted that the vermiculite, as a filling material to mitigate the actions regarding the internal resonances in the block cavities, which puts its acoustic insulation in jeopardy, may rise as an alternative to elevate the acoustic performance of a given vertical sealing system, once the necessity of a behavior that demands a higher performance of the wall regarding airborne sound insulation is required. Besides that, its abundant availability in Brazil makes it even more interesting for national construction companies to employ this material, once they are able to improve their systems with a relatively low cost and without overloading the structure, considering it is a very light material.

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