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Keywords: comparative analysis, acoustic properties, ICF, conventional masonry.

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Felipe Daniel Bastos Lopes [α], Marco Antônio de Moura Fortes [σ], Pedro Afonso de Araújo Costa [ρ], Tiago de Macedo Lima Moura Fé [ω] & Júlia Almeida Rosal Oliveira [¥]

Abstract- Everything evolves according to the needs of culture and time. At all times, solutions are created by adding more and more to civil construction. In this context, the Insulated Concrete Forms (ICF) construction method appears as an option for regions with aggressive climate, however, as important as the thermal properties are, the acoustic properties are too since they provide comfort and quality of life for the resident. Thus, the present article aims to carry out a comparative analysis of the acoustic insulation properties between the ICF method and the conventional masonry method through data collection performed by a digital sound level meter while its analysis is performed with the aid of Excel. As it is a work based on the volume of collected data, it has a quantitative nature and as the study target is an underexplores topic and focused on a specific case, it is possible to define that the present work is also a case study of an exploratory nature, being that, after carrying out the experiment, the results indicated that the conventional masonry presented an average Leq reduction superior to the ICF by 8.16% compared to the environment.

Keywords: comparative analysis, acoustic properties, ICF, conventional masonry.

I. Introduction

Everything evolves according to the needs of culture and time. However, it always has as a goal a better-quality product, that in general, and includes civil engineering.To reach this goal, a search for materials with favorable properties to construction began.

Among these wished properties, the most important are resistance, ductility, dilation and insulating properties, which has the function of bringing greater safety, reduction of maintenance expenses and better quality of life to the user of the structure.

Furthermore, the search for more efficient methods and growing attention to waste reduction, both to minimize costs and preserve the environment, requires engineering to be remodeled.

Since more than 60% of world's natural resources are wasted by the construction industry, which makes it unsustainable. Currently, the socioeconomic activities are able to promote significant impacts on the global system. (IPEA, 2010 apud BASTOS JUNIOR, 2018).

Driven by this search for more efficient and less environmentally aggressive construction systems, several constructive technologies were developed, among them the Insulated Concrete Forms (ICF), a method based on Expanded Polystyrene (EPS) forms.

Considering that the urbanization process contributes to an increase in noise pollution, a fundamental property to reduce the impacts of the noise is acoustic insulation. In this regard, the present article aims to analyze the acoustic properties of the ICF constructive method and compare them with the conventional masonry one.

II. Materials and Methods

Given the above, it is worth pointing out that this article uses an approach based on volume of collected data, therefore, a quantitative approach. Added to this factor, as the goal of the study is an underexplored topic and focused on a specific case, it is possible to characterize it as a case study of an exploratory nature.

In order to execute the experiment, two prototypes with a volume of 1m³ were produced in the city of Teresina-PI, one of conventional masonry and the other utilizing ARXX VEDA forms, both covered by thermoacoustic roof tiles. The choice of this line is justified by the fact that both the conventional masonry and the ARXX VEDA line has only a sealing function. Next, illustrated by Figure 1,2, photos of the prototypes in execution and finalized.

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Figure 1: Prototypes under construction

Figure 2: Finished prototypes

For data collection, the Octava-Plus All-In-One digital sound level meter was used, and for the emission of sound waves, the BOSE S1 Pro speaker (Figure 3) was used with a pink frequency noise.

Figure 3: Octava-Plus All-In-One digital sound level meter and BOSE S1 Pro speaker

Initially the distances between the prototypes and the sound source were defined, being determined 10 marks distanced 2 meters away from each other and the first mark, near the prototypes is also distant by 2 meters (Figure 4). Then, through the digital sonometer it was possible to capture the sound intensity emitted by the sound source. After that, for each one of the determined points the sound intensity was measured in each prototype and the external environment, in 5 seconds intervals for 2 minutes.

Figure 4: Marking the distances

After the data collection, the appropriate analysis of the measurements was made based on the Equivalent Level (Leq), as this value is used for execute the sound tests in accordance with the Brazilian regulatory norm, NR15.

In sequence, to verify if the construction methods difference has significative relevance in the acoustic isolation, was performed the variance analysis (ANOVA) test, which is a test used to compare 3 or more averages through analysis of sample variances, is based on a sample taken from each group and focuses on determining whether differences between sample averages suggest significant differences between groups or if these differences are caused by other factors (FAVERO, 2017).

Finally, the percentage reduction of the Leq values obtained for both construction methods in relation to the environment was also calculated, in order to obtain a better visualization of the difference in the results. These percentage reductions were expressed in graph and table format.

III. Results and Discussion

After executing the methodology, as ample group of Leq values was generated for the environment and the common masonry and ICF prototypes, which are contained in the following table (Table 1). For a better visualization, these values were also illustrated to in the Chart 1.

Table 1: Leq values

	ENVIRONMENT	MASONRY	ICF
2m	94.53	78.79	78.69
4m	91.33	75.78	76.67
6m	88.71	72.93	73.47
8m	85.02	70.86	72.56
10m	84.13	69.3	70.52
12m	80.37	67.56	69.78
14m	80.46	67.14	68.46
16m	77.96	66.36	67.67
18m	75.37	64.02	64.79
20m	73.9	63.5	63.86

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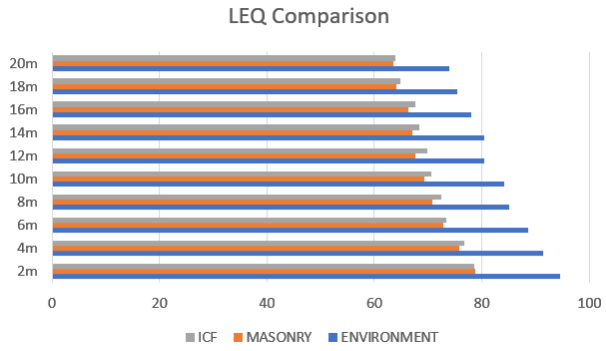

Chart 1: Leq Comparison

Based on the table and chart presented, it is possible to observe that the conventional masonry prototype presents better acoustic insulation than the ICF from 4m away, a result that persists until 20m, at the end of the experiment.

In order to verify the relevance of the differences between the acoustic properties of the constructive methods, the ANOVA test was performed. It is worth noting that in order to guarantee the relevance of the hypothesis, the value of F has to be higher than the Fcritical value, and this relevance is proven if the value of P is less than 0,05.

ABSTRACT				
Group	*Counting*	*Total*	*Average*	*Variance*
ENVIRONMENT	10	831.78	83.178	46.64126
MASONRY	10	696.24	69.624	24.94072
ICF	10	706.47	70.647	23.04182

ANOVA						
Variancy source	*SQ*	*gl*	*MQ*	*F*	*P-value*	*F critical*
Between groups	1139.278	2	569.639	18.06012	1.04987E-05	3.354131
In groups	851.6142	27	31.54127			
Total	1990.892	29				

Figure 5: ANOVA test

Based on the table above, it is possible to conclude that conventional masonry has better sound insulation compared to the ICF method, a difference that is relevant since F > Fcritical, and this relevance is proven since P < 0.05.

To complement the analysis, the percentage reductions of the Leq values of each of the construction methods in relation to the environment were also calculated and then the chart below was generated.

Table 2: Percentage reduction related to the environment

	MASONRY	ICF
2m	16,65%	16,76%
4m	17,03%	16,05%
6m	17,79%	17,18%
8m	16,65%	14,66%
10m	17,63%	16,18%
12m	15,94%	13,18%
14m	16,55%	14,91%
16m	14,88%	13,20%
18m	15,06%	14,04%
20m	14,07%	13,59%

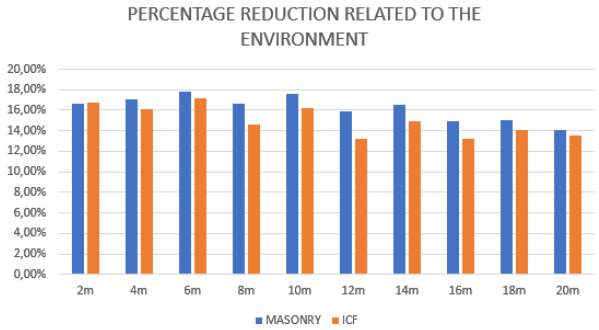

Chart 2: Percentage reduction in comparison to the environment

It is noted that the prototypes reduced the sound intensity coming from the environment between 13% and 18%, in addition, the conventional masonry prototype reduced an average of 16.23%, while the ICF reduced an average of 14.97%, that is, the performance of the masonry prototype was 8.16% higher than that of ICF.

IV. Conclusion

After the study carried out, it was possible to conclude that the conventional masonry construction method has better sound insulation than the Insulated Concrete Forms method, a difference that proved to be relevant thanks to the ANOVA test.

Possibly the construction methods have this difference due to the existing voids in the 6-hole ceramic brick, while the ICF walls are solid solids, as sound is a mechanical wave, the impact of the wave on a massive wall would make it vibrate, aiding in the propagation. the sound to the interior of the environment, while in the wall with voids of conventional masonry this vibration is not so intense, because the voids make it difficult for the sound to propagate.

It is also worth mentioning that the Insulated Concrete Forms constructive method presents a good acoustic performance in sound intensities up to 65 db (something equivalent to a conversation) according to its technical magazine.

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It is suggested for future studies a mathematical analysis of the data obtained in order to generate a scatter plot using linear regression, and then find the function of sound intensity in relation to distance.

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