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Research Paper

Acoustic Properties of Aerated Autoclaved Concrete (AAC): Sound Absorption & Reflection Coefficients of Aerated Autoclaved Concrete at Low & High Frequncy

Mr. P. S. Thakur[1], Mrs. G. U. Patil[2], Mr. S. S. Kamble[3]
[1]*Assistant Professor, Department of Physics,*
Changu Kana Thakur A.C.S College (Autonomous) New Panvel
[2]*Associate Professor, Department of Physics,*
Changu Kana Thakur A.C.S College (Autonomous) New Panvel
[3]*Assistant Professor, Department of Physics,*
Changu Kana Thakur A.C.S College (Autonomous) New Panvel

ABSTRACT:
Aerated Autoclaved Concrete (AAC) is an eco-friendly and lightweight building material. Durability, load bearing and highly insulating; these are some of the qualities of AAC which make it the first choice for the construction of buildings as compared to other concrete blocks and red bricks [28] [30] [35]. AAC is a good alternative to wood as it does not decay like the wood and is also lightweight just like the wood. The AAC is made from cement, fly ash, limestone & gypsum which are used in the ratio 8:69:20:3 with aluminum powder as the expansion agent [27] [29]. Along with its other qualities, it is also necessary to know its acoustic properties. It is important for buildings like schools, hospitals, hotels, offices, multi-family housing and other structures to have good sound insulation [16]. Hence it is necessary that these buildings are made of materials that have good sound absorption coefficient and very low sound reflection coefficient. Aerated Autoclaved Concrete, because of its porous nature, does possess very good sound absorption coefficient and hence they are perfect for places like schools, hospitals, etc. In this research work, we attempt to find the sound absorption coefficient and sound reflection coefficient of AAC for various frequencies ranging from 1 kHz to 10 kHz. This paper analyses the acoustic properties of AAC not only at different frequencies butat different sound intensities too.
Keywords: *Aerated Autoclaved Concrete (AAC),fly ash, limestone, gypsum, sound absorption coefficient, sound reflection coefficient.*

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I. INTRODUCTION:

In recent times, the construction, infrastructure & architecture industry has changed drastically, especially in a developing country like India. There was a time when houses in Indian rural societies were built from nothing more than soil and bricks made from soil. Red clay soil was used for making shades for homes. This is no longer the case now. We have moved from houses to towers. Schools & hospitals have also evolved in terms of their size& height. In the urban areas, we have huge skyscrapers, malls, theatres, auditoriums, etc. The architecture of these buildings considers all kinds of factors such as the thermal conductivity, Seismic Resistance, Easy Workability, Design Flexibility, Fire Resistance, Acoustic Performance, etc. Cost reduction and time saving is also one of the important factors considered while construction of tall buildings [30] [29] [31] [34].

Aerated Autoclaved Concrete (AAC) fits in all these qualities. It is lightweight & bears a lot of loads, thereby allowing the construction of tall buildings with ease. It is a good thermal insulator; hence it provides cooling inside the building. Because it is available in different sizes & can be cut, drilled, nailed, milled, and grooved with ease, it also saves a lot of construction time. Since it is made of recycled industrial waste (fly ash)& non-toxic ingredients, it is eco-friendly and sustainable too [27].

The two main factors making the atmosphere in any auditorium or any room pleasant are the thermal insulation and the sound reduction capability of that room. It is desired that the materials used in the construction of buildings to possess these properties along with other mechanical properties. AAC, due to its porous nature, possesses thermal insulation as well as acts as a good sound absorber. When a sound of particular intensity is incident onto a wall, some part of it is reflected, some part is absorbed and a little is transmitted too. However, it is important that the wall is able to absorb most part of sound intensity & reflect a very little in order to get a pleasant stay. It should also not transmit the sound through the walls as it can be quite unpleasant for the people staying in neighbourhood. The sound absorption coefficient of the wall is the ratio of the amount of sound energy absorbed to that of the energy incident. This absorption coefficient depends on many factors, such as the density of concrete,type of aggregates, size and distribution of pores, and changes in concrete mix design constituents. Along with all these parameters, it also depends on the intensity of sound as well as the frequency of the incident sound[21] [24] [25]

II. LITERATURE REVIEW:

1. According to the literature review done by Tzer ShengTie, Kim HungMo, AzmaPutra, Siaw ChuingLoo, U. JohnsonAlengaram, Tung-ChaiLing in the research paper “Sound absorption performance of modified concrete: A review”, there exists limited information regarding the sound absorbing capability of concrete or more generally the cement-based materials. Hence this research work is dedicated to find more information about the sound absorption coefficient of the concrete blocks commonly used in the construction.
2. Seunguk Na, Inkwan Paik, Sung-ho Yun, Huu Chi Truong and Young-Sook Roh in their research paper “Evaluation of the Floor Impact Sound Insulation Performance of a Voided Slab System Applied to a High-Rise Commercial Residential-Complex Building” talk about the interlayer noise complaints, such as footsteps or dragging items in apartment housing, as an inevitable problem in apartment dwelling conditions, because each household in an apartment shares walls and ceilings with other households and a voided slab system is the solution for such problems.
3. Research paper “Acoustic Properties of Innovative Concretes: A Review” published by Roman Fediuk, Mugahed Amran, Nikolai Vatin, Yuriy Vasilev, Valery Lesovik and TogayOzbakkaloglu reviews the acoustic properties of different types of concretes in which it is claimed that different types of concrete behave differently as a sound conductor; especially dense mixtures are superior sound reflectors, and light ones are sound absorbers. It is found that the level of sound reflection in modified concrete is highly dependent on the type of aggregates, size and distribution of pores, and changes in concrete mix design constituents.
4. The research work published by JonathanStolz, YamanBoluk&VivekBindiganavile in their research paper “Mechanical, thermal and acoustic properties of cellular alkali activated fly ash concrete” shows that at an oven dry density near 1000 kg/m3, the alkali activated Class C fly ash mixed with a preformed foam is a viable alternative for thermal and sound insulation with properties comparable to those of current commercially available options.
5. Irina Oancea, CarmenBujoreanu, MihaiBudescu, MarcelinBenchea and Cătălina MihaelaGrădinaru, in their research work published in “Considerations on sound absorption coefficient of sustainable concrete with different waste replacements” emphasize on the possibility of using composite materials made of concrete and various materials considered as waste.
6. Hemp based building materials divided into two categories: Monolayer and Multilayer samples were investigated for their sound absorption coefficient and the thermal conductivity, by Raluca Fernea, Daniela Lucia Manea, Luminita Plesa, Răzvan Iernuțanand Mihaela Dumitran in their research work published in “Acoustic and thermal properties of hemp-cement building materials”.
7. The research work published by JonathanStolz, YamanBoluk&VivekBindiganavile in their research paper “Wood ash as a supplementary cementing material in foams for thermal and acoustic insulation” shows that the use of blended wood ash instead of Portland Cement reduces the thermal conductivity & improves the sound insulation by about 20% but with minor decline in the strength of the material.
8. Research work carried out byM. Mastali, P. Kinnunen, H. Isomoisio, M. Karhu and M. Illikainen published in the research paper “Mechanical and acoustic properties of fibre-reinforced alkali-activated slag foam concretes containing lightweight structural aggregate”investigated the effects of using different types of fibres, including Polyvinyl alcohol (PVA), polypropylene (PP), and basalt, on the mechanical properties of alkali-activated slag binders. The mechanical properties were evaluated in terms of the compressive and flexural strengths.
9. The research work published by Matthias Degrave - Lemeurs, Philippe Glé and Arthur Hellouin de Menibus in the paper “Acoustical properties of hemp concretes for buildings thermal insulation: Application to clay and lime binders” show the concentration of hemp in a mix has a first order effect on the acoustical performance, while binder fluidity and clay type have no effect. Another conclusion of this study is that hemp-clay and hemp-lime behave acoustically in a similar way.
10. Research work published in a paper “Acoustic characteristics of sound absorbable high performance concrete” evaluates parameters such as the porosity, acoustic absorption coefficient, noise reduction

coefficient, compressive strength, and freeze-thaw resistance for the sound absorbable high performance concretedeveloped by them.

11. The research paper "Properties of crumb rubber hollow concrete block" published by Bashar S. Mohammed, Khandaker M. Anwar Hossain, Jackson Ting Eng Swee, Grace Wong and M. Abdullahion the properties of crumb rubber hollow concrete block (CRHCB) presents the methods of development of (CRHCB) and show that it has better thermal, acoustic and electrical properties in comparison with conventional hollow block.

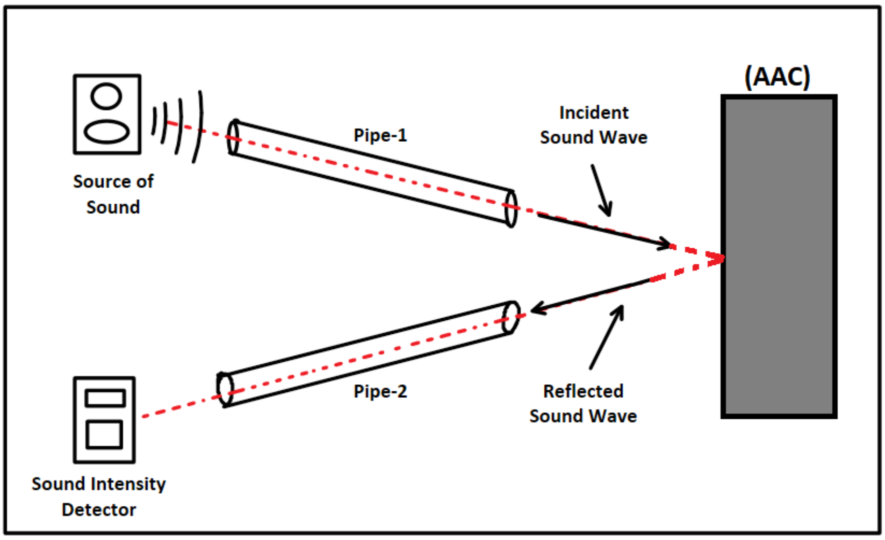
III. OBJECTIVES:

Lot of work has already been done to find the thermal and acoustical properties of different kinds of concretes[5] [17] [19] [21] [23] [[25] [33] [34]. Various kinds of concrete blocks exist and are being utilized in the construction of buildings that have good acoustical as well as thermal properties. All this work has motivated us to carry the research work forward and investigate the acoustic properties of Aerated Autoclaved Concrete (AAC). The main objectives of this research work are:

1. To study acoustical properties of Aerated Autoclaved Concrete (AAC).
2. To find the sound absorption coefficient of Aerated Autoclaved Concrete (AAC) at different frequencies ranging from 1 kHz to 10 kHz.
3. To find the sound reflection coefficient of Aerated Autoclaved Concrete (AAC) at different frequencies ranging from 1 kHz to 10 kHz.
4. To check whether the sound absorption coefficient depends on the intensity of sound that is being incident on it at a given frequency.

IV. METHODOLOGY:

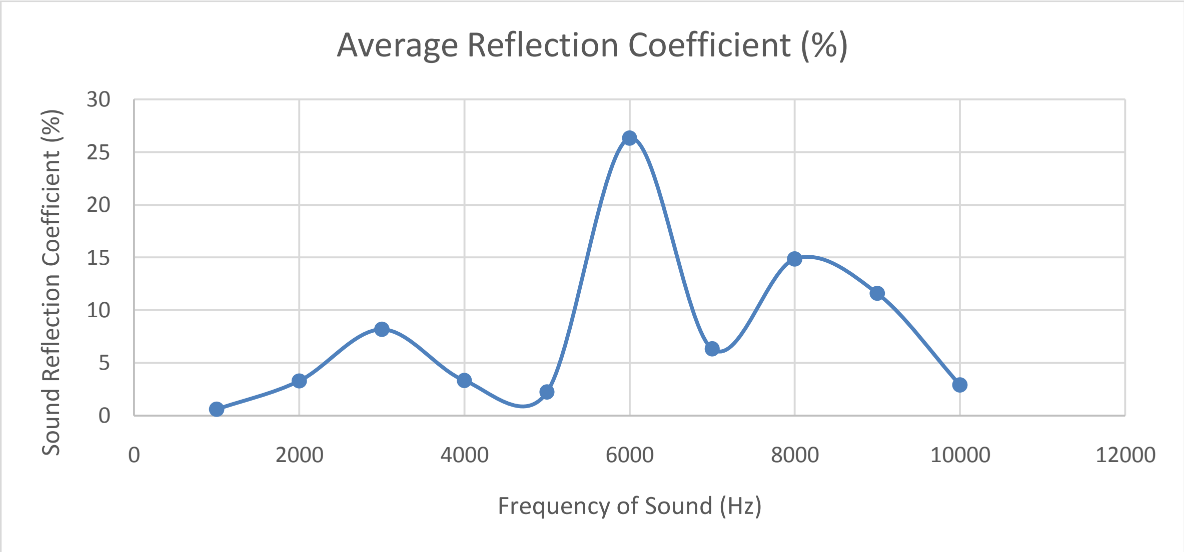
A rather simple method was used to find the sound absorption coefficient and the sound reflection coefficient of Aerated Autoclaved Concrete (AAC) blocks. A sound wave of a desired intensity and desired frequency was made to incident on a AAC block at a fixed angle through a pipe, so that there is no loss in sound energy. The intensity of original incident sound was determined using the sound intensity measuring device Meco 970p which has a measuring range of 35 db. to 130 db., a precision of ±1.5 db. and a resolution of 0.1 db.The reflected sound was made to pass through another identical pipe. Intensity of the reflected sound was noted down with the help of Meco 970p. At a given frequency of sound, the sound absorption coefficient & the sound reflection coefficient were determined for various intensities of sound. The same procedure was followed by changing the frequency from 1 kHz to 10 kHz.



V. OBSERVATIONS:

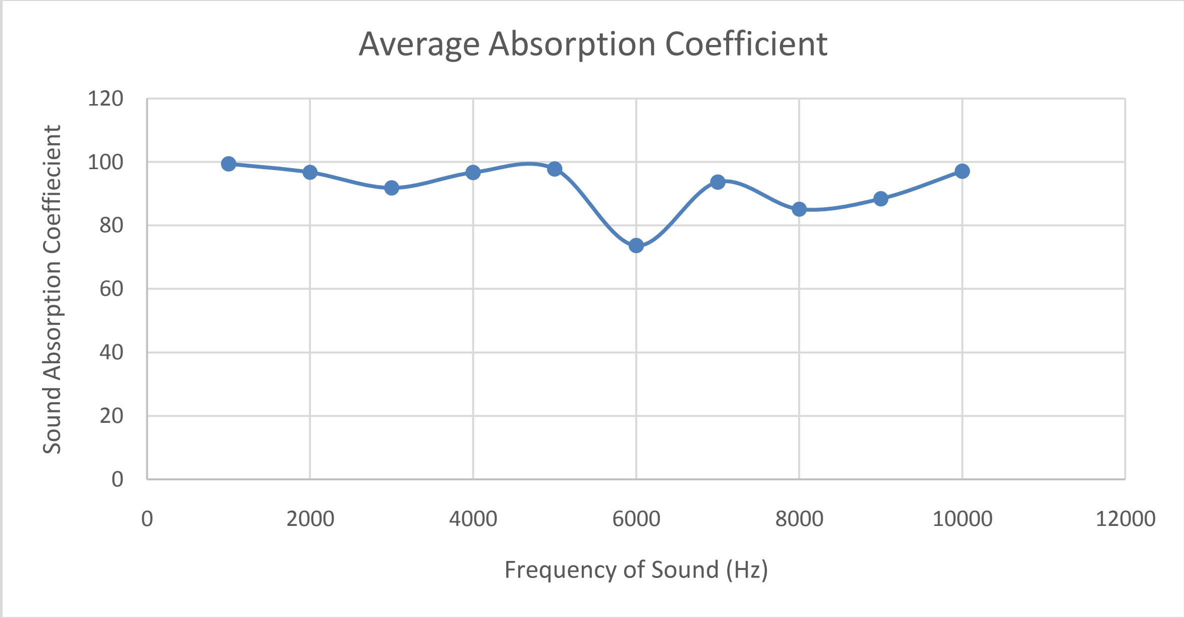
The table below shows the average sound reflection coefficient & the average sound absorption coefficient of the Aerated Autoclaved Concrete (AAC) at various frequencies ranging from 1 kHz to 10 kHz.

Frequency Hz	Average Reflection Coefficient	Average Absorption Coefficient
1000	0.57729622	99.42270378
2000	3.270308237	96.72969176
3000	8.165552897	91.8344471
4000	3.319153908	96.68084609
5000	2.212203557	97.78779644
6000	26.32637978	73.67362022
7000	6.312010092	93.68798991
8000	14.85637764	85.14362236
9000	11.58948195	88.41051805
10000	2.895226156	97.10477384



Graph 1 : Sound Reflection Coefficient for frequency between 1 kHz to 10 kHz

The graph above shows the variation of sound reflection coefficient of the Aerated Autoclaved Concrete (AAC) at various frequencies ranging from 1 kHz to 10 kHz. The graph shows that the AAC reflects a very little fraction of sound energy at low frequency i.e., 1 kHz. Therefore, a large fraction of sound is absorbed in this region of frequency wherein the normal human voice lies. As the frequency increases, the reflection coefficient increases. The maximum value of sound reflection coefficient is observed at 6000 Hz. The coefficient then decreases again as the frequency is increased. The graph shows that the AAC is a very bad reflector of sound energy as it reflects a very little sound energy.



Graph 2: Sound Absorption Coefficient for frequency between 1 kHz to 10 kHz

The graph above shows the variation of sound absorption coefficient of the Aerated Autoclaved Concrete (AAC) at various frequencies ranging from 1 kHz to 10 kHz. The graph shows that the AAC absorbs a very large fraction of sound energy at low frequency i.e., 1 kHz. Therefore, a large fraction of sound is absorbed in this region of frequency wherein the normal human voice lies. As the frequency increases, the absorption coefficient decreases. The minimum value of sound absorption coefficient is observed at 6000 Hz. The coefficient then increasesagain as the frequency is increased. The graph shows that the AAC is a very goodabsorber of sound energy as it absorbs a very large fraction of sound energy.

VI. CONCLUSION:

The sound absorption coefficient of Aerated Autoclaved Concrete (AAC) shows an interesting pattern when sound of different frequencies is incident on it. The sound absorption coefficient of AAC is large for low frequencies of about 1000 Hz and decreases as the frequency is increased. The coefficient becomes minimum at about 6000 Hz. This means more of sound energy is reflected at this frequency. The absorption coefficient again increases as the frequency is increased. When the absorption coefficient is found out for frequencies ranging from 1 kHz to 10 kHz, overall, the AAC shows a good absorption coefficient for all frequencies. This shows that AAC can be used as a sound absorbing material in buildings and the buildings constructed with AAC can give acoustical comfort.

VII. SUGGESTIONS:

The Aerated Autoclaved Concrete (AAC), being porous, is an effective solution to reduce the sound reflections and hence the reverberation of sound in the rooms. At the same time, when the walls made with AAC are painted with different qualities of paints, the wall surfaces become very plane & polished. Hence the sound reflection coefficient of these walls increases a little bit after coating them with paints. To reduce the sound reflections, paints like the oil paints should be avoided which make the walls very shiny and plane. Emulsion paints, which are water-based paints can be used instead of oil paints. These increase the shine & glossiness of the walls but does not increase the reflection coefficient much.

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*Corresponding Author: Mr. P. S. Thakur

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