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"Exploring Aerated Autoclaved Concrete (AAC) Acoustic Properties Across Diverse Frequency Bands"

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Abstract

Aerated Autoclaved Concrete (AAC) stands out as an environmentally friendly and lightweight construction material. Known for its durability, load-bearing capacity, and excellent insulation, AAC surpasses traditional concrete blocks and red bricks in construction preferences. Its suitability as a wood alternative is evident, given its resistance to decay and comparable lightweight characteristics. Comprising a blend of cement, fly ash, limestone, and gypsum in an 8:69:20:3 ratio, with aluminum powder as the expansion agent, AAC serves as a versatile building material. In addition to its various attributes, understanding the acoustic properties of AAC is essential. Structures such as schools, hospitals, hotels, offices, and multi-family housing demand effective sound insulation, necessitating the use of materials with favorable sound absorption coefficients and minimal sound reflection coefficients. Due to its porous composition, Aerated Autoclaved Concrete exhibits notable sound absorption coefficients, making it ideal for applications in environments like schools and hospitals. This research delves into the determination of AAC's sound absorption coefficient and sound reflection coefficient across a spectrum of frequencies ranging from 1 kHz to 10 kHz. The analysis extends beyond frequency variations to encompass different sound intensities, offering a comprehensive exploration of AAC's acoustic characteristics.

***Keywords: Aerated Autoclaved Concrete (AAC), sound absorption coefficient, sound reflection coefficient**.*

1. Introduction:

In recent years, the construction, infrastructure, and architecture sector has undergone significant transformations, particularly in developing nations like India. In the past, residences in rural Indian communities were typically constructed using soil and bricks made from the same material, often utilizing red clay soil for shelter. However, this traditional approach has given way to a more contemporary landscape marked by high-rise structures. Schools and hospitals have also experienced a metamorphosis, evident in their increased size and height [1-2]. Urban areas now boast towering skyscrapers, expansive malls, theaters, auditoriums, and more. The architectural considerations for these structures encompass a wide range of factors, including thermal conductivity, seismic resistance, ease of workability, design flexibility, fire resistance, and acoustic performance. Additionally, cost reduction and time-saving have become pivotal considerations in the construction of tall buildings [3-4]. Aerated Autoclaved Concrete (AAC) possesses these characteristics effectively. Being lightweight yet capable of bearing substantial loads, it facilitates the construction of tall structures effortlessly. Additionally, its excellent thermal insulation properties contribute to maintaining a cool interior environment. With the flexibility of various sizes and easy manipulation through cutting, drilling, nailing, milling, and grooving, AAC accelerates the construction process significantly. Notably, its composition, featuring recycled industrial waste (fly ash) and non-toxic elements, underscores its eco-friendly and sustainable nature [5]. The pleasantness of the atmosphere in any auditorium or room hinges on two crucial factors: thermal insulation and sound reduction capabilities. It is preferable for construction materials to possess these attributes alongside other mechanical properties. AAC, owing to its porous composition, not only provides thermal insulation but also serves as an effective sound absorber. When sound of a specific intensity strikes a wall, a portion is reflected, some is absorbed, and a minimal amount is transmitted. However, for a comfortable environment, the wall should predominantly absorb sound and reflect very little, minimizing transmission to neighboring spaces. The sound absorption coefficient of a wall is determined by the ratio of absorbed sound energy to the incident energy. This coefficient is influenced by various factors, including concrete density, aggregate type, pore size and distribution, and changes in the mix design. Additionally, it is contingent upon the sound intensity and frequency of the incident sound [6-8]. Various concrete types exhibit distinct behaviors as sound conductors, with dense mixtures excelling as sound reflectors and lighter ones functioning as sound absorbers. The degree of sound reflection in modified concrete is closely linked to factors such as the type of aggregates, the size and distribution of pores, and alterations in the constituents of the concrete mix design [9]. Extensive efforts have been made to investigate the thermal and acoustic characteristics of various concrete types [10-12]. Different types of concrete blocks are available and are being employed in constructing buildings with favorable acoustical and thermal attributes. This body of work has inspired us to advance our research and explore the acoustic properties of Aerated Autoclaved Concrete (AAC). The primary goals of this research is to investigating the acoustic characteristics of Aerated Autoclaved Concrete (AAC), to determine the sound absorption coefficient of Aerated Autoclaved Concrete (AAC) across various frequencies ranging from 1 kHz to 10 kHz, to determine the sound reflection coefficient of Aerated Autoclaved Concrete (AAC) at different frequencies within the range of 1 kHz to 10 kHz, and to examine whether the sound absorption coefficient is influenced by the intensity of the incident sound at a specific frequency.

2. Methodology:

A straightforward approach was employed to ascertain the sound absorption coefficient and sound reflection coefficient of Aerated Autoclaved Concrete (AAC) blocks. A sound wave with specified intensity and frequency was directed onto an AAC block at a fixed angle through a pipe, ensuring minimal loss of sound energy. The original incident sound's intensity was measured using the Meco 970p sound intensity measuring device, featuring a measurement range of 35 dB to 130 dB, precision of ±1.5 dB, and a resolution of 0.1 dB. The reflected sound was channeled through an identical pipe, and its intensity was recorded using the Meco 970p. For various sound intensities at a given frequency, the sound absorption coefficient and sound reflection coefficient were determined. This process was repeated while varying the frequency from 1 kHz to 10 kHz.

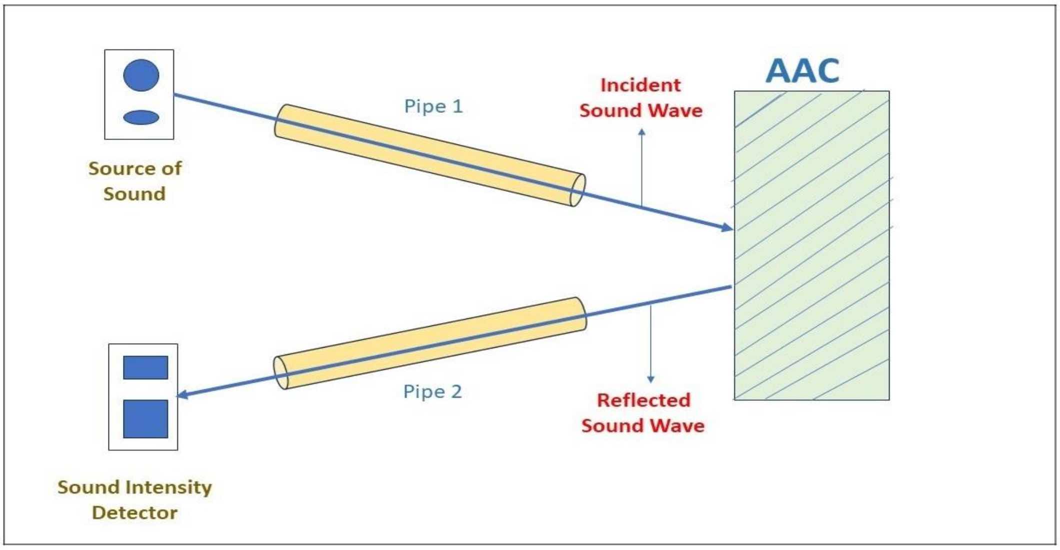

Fig. 1 Measurement of Sound Absorption Coefficient and Sound Reflection Coefficient

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	91.834471
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

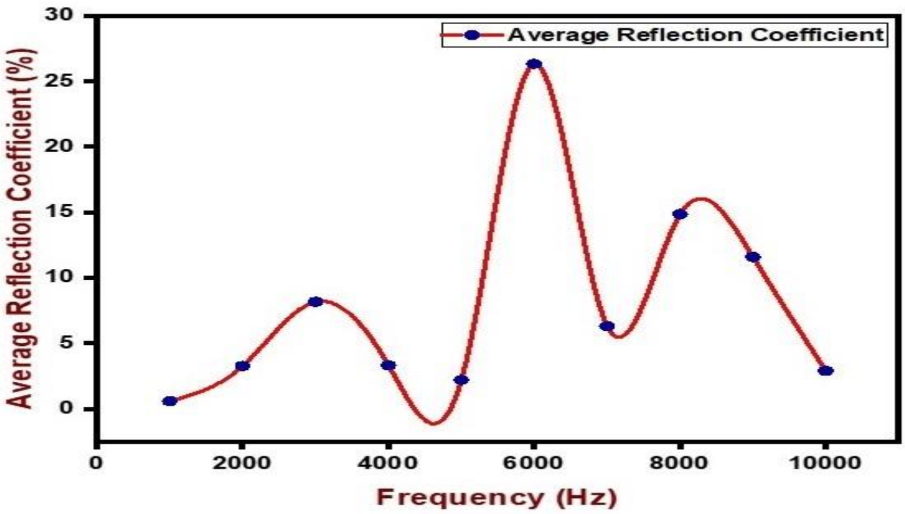

Fig. 2 Sound Reflection Coefficient for frequency between 1 kHz to 10 kHz

The graph depicts the fluctuation in the sound reflection coefficient of Aerated Autoclaved Concrete (AAC) across a range of frequencies from 1 kHz to 10 kHz. At lower frequencies, specifically 1 kHz, the AAC reflects only a minimal amount of sound energy, resulting in the absorption of a significant portion of sound in the frequency range associated with normal human speech. As the frequency rises, there is an increase in the reflection coefficient, reaching its peak at 6000 Hz. Subsequently, the coefficient declines with further increases in frequency. Overall, the graph illustrates that AAC is an ineffective sound energy reflector, reflecting only a small fraction of sound energy across the frequency spectrum.

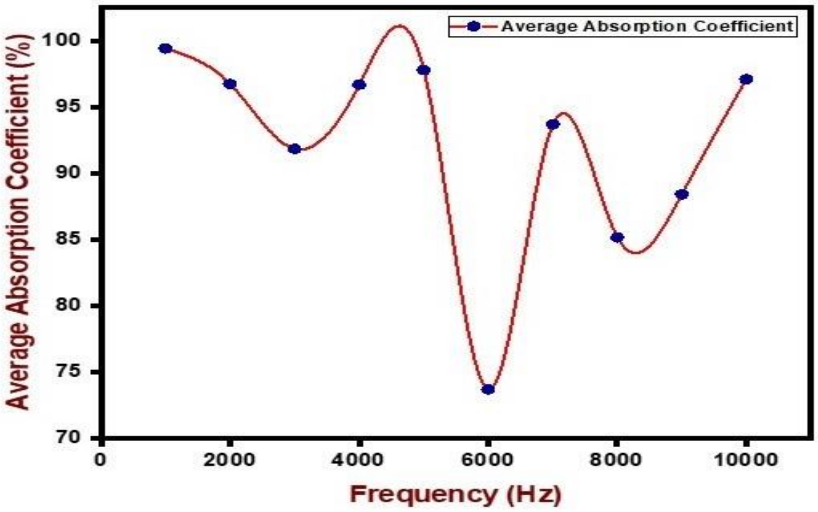

Fig. 3 Sound Absorption Coefficient for frequency between 1 kHz to 10 kHz

The graph above illustrates the changes in the sound absorption coefficient of Aerated Autoclaved Concrete (AAC) across various frequencies ranging from 1 kHz to 10 kHz. The graph indicates that AAC exhibits a substantial absorption of sound energy at lower frequencies, specifically at 1 kHz. Consequently, a significant portion of sound is absorbed in the frequency range associated with the normal human voice. As the frequency rises, the absorption coefficient diminishes, reaching its minimum at 6000 Hz. Subsequently, the coefficient increases again with further increases in frequency. The graph underscores that AAC serves as a highly effective absorber of sound energy, absorbing a substantial fraction of sound energy across the frequency spectrum.

3. Conclusion:

The sound absorption coefficient of Aerated Autoclaved Concrete (AAC) exhibits an intriguing pattern in response to varying frequencies of sound. AAC demonstrates a high absorption coefficient for lower frequencies, approximately 1000 Hz, and diminishes as the frequency increases. The coefficient reaches its minimum around 6000 Hz, indicating increased reflection of sound energy at this frequency. Subsequently, the absorption coefficient rises once more with further increases in frequency. Overall, when considering frequencies from 1 kHz to 10 kHz, AAC consistently displays a commendable absorption coefficient across the spectrum. This suggests that AAC can effectively serve as a sound-absorbing material in construction, contributing to acoustical comfort in buildings constructed with AAC.

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