Sound barrier behavior of geopolymer composite manufactured from industrial waste

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Sound barrier behavior of geopolymer composite manufactured from industrial waste

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A B S T R A C T

Noise pollution is an invisible hazard faced in industries, roads, and public places etc., and has become part of daily life. Noise affects the psychology and physiology of animals and humans and can lead to accidents and health issues. Noise can be reduced by using active or passive materials. Active mediums are in which enormous amount of external energy is used to balance the noise energy, whereas in passive medium sound is absorbed such as by using insulating materials. Conventionally, passive sound barrier panels made of concrete are used, which involve energy intensive manufacturing processes as they use Ordinary Portland Cement (OPC). The concrete sound barrier panels have a large carbon foot print as it releases carbon dioxide (CO_2) during manufacture of OPC and during hydration of concrete. The global warming is caused due to emission of greenhouse gases mainly comprising of carbon di oxide. The cement industry emits 5 to 8 % of the world's CO_2 emissions and thus an alternate building material is required. The search for an ecofriendly green binding material to replace cement leads to discovery of geopolymer. Geopolymers are ceramic materials comprising of polymers made of inorganic aluminosilicate and fabricated by alkali activation of aluminosilicates. In this research work, the induction furnace (IF) slag and Class F fly ash are utilized along with manufactured sand (M Sand) an alternative material for the river sand, as fine aggregate. The environmental advantage of this material is that the ingredients are industrial waste and the geopolymer has negligible carbon foot print. The geopolymer composite specimens were subjected to sound absorption test using impedance tube studies and found to exhibit an increased sound absorption coefficient (α) between 0.2 and 0.35 in the frequency range of 1200 Hz to 6300 Hz. This study establishes that the geopolymer manufactured using industrial waste material can be effectively utilized as sound absorption material and can assist in mitigating noise pollution.

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1. Introduction

Joseph Davidovits a French materials scientist introduced the term "geopolymer" in the 1970 s to represent a class of solid materials formed by chemically reacting aluminosilicate particles in an alkaline solution [1]. According to the Brundtland Commission report, "sustainable development satisfies the requirements of the present without jeopardizing future generation's ability to satisfy their own needs" [2]. Industrial by-products have been utilized for various applications to make the environment more sustainable [3 4 5]. Geopolymer is one among the application of industrial by-products utilization. Steel slag, fly ash, waste glass, silica fume and metakaolin have the aluminosilicate frame work and are essential for the geopolymer binding [6]. Geopolymers are lightweight materials that are a viable replacement for Portland cement because they can tolerate heavy impact and compression. Geopolymers have gained prominence ever since the 1990 s as a result of

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their lightweight and minimal energy consumption [1]. Too far, the only known geopolymerization reaction mechanism is Davidovits' hypothesis of geopolymerization and polycondensation, in which silicon (Si)-oxygen and aluminium (Al)-oxygen bonds are broken and recombined to generate a three-dimensional polymer network under the trigger of an alkaline activator [7 1]. As per studies, lightweight geopolymers have excellent properties such as minimal shrinkage, high sound absorption, high thermal insulation, and high acid resistance [8]. Noise pollution is an invisible hazard produced in industries, roads, and public places and etc., and has become a part of our daily lives. Noise affects the psychology and physiology of animals and humans and can lead to accidents and health issues. Noise can have a variety of undesirable impacts, namely irritation, health complications, decreased privacy, and sleeping disorders [6 9]. However, if sound strikes a material with visible porosity (exposed pores), the acoustic waves will be absorbed by the solid, their energy turned into heat, and the sound will be dispersed (acoustic absorption) [2]. Several contemporary acoustic materials cannot be considered to be sustainable, at least in terms of both energy consumption and greenhouse gas emissions, further, some of these could be hazardous to human health. Mineral wools are commonly used for thermal and sound insulation due to their high performance and inexpensive cost, but aside from skin discomfort, their fibers can settle in the lung alveoli when breathed. As a result, they may be inappropriate for interior noise barrier applications [10]. The global warming is caused due to emission of greenhouse gases mainly comprising of carbon di oxide. The cement industry emits 5 to 8 % of the world's CO_2 emissions. The Old Portland Cement have a large carbon foot print as it releases carbon dioxide (CO_2) during manufacture of OPC and during hydration of concrete [11]. Numerous scientific institutions have developed innovative sustainable materials, such as geopolymeric binders, which look to be a viable alternative to OPC because to their superior mechanical, thermal and sound properties and environmental benefits, geopolymer binders emit much less CO_2 than OPC [12]. Geopolymers are typically produced by the chemosynthesis of aluminosilicate granules in an alkaline silicate solution and they can be produced by mixing calcined kaolin with concentrated alkaline solutions such as NaoH and sodium silicate, and then curing the combination at room temperature [13]. Acoustic efficiency is characterized by a number of experimentally proven constants, which include the absorption coefficient, noise reduction coefficient, transmission loss coefficient, and sound transmission class (STC), but in this research only sound absorption coefficient is being determined.

2. Materials and processes

2.1. Materials

The Materials required for the preparation of the geopolymer sample is listed down below as shown in Figs. 1-5 Fig. 5a.

1. Sodium Hydroxide
2. Sodium Silicate
3. Fly ash
4. Manufacture sand
5. Water.

Fig. 2. Adding of water to NaOH.

Fig. 3. Sodium silicate solution.

Fig. 1. Sodium Hydroxide.

Fig. 4. Fly ash.

Fig. 5. Manufacture sand.

2.2. Processes

Process was mainly divided into six phases:
1) Preparing molds.
2) Making geopolymer slurry.
3) Pouring the slurry into the moulds.
4) Curing.
5) De-moulding the geopolymer biscuits.
6) Assembling the prepared geopolymer biscuits into the canister.

The following mix design per mold is followed as shown in Table 1:

The preparation of the geopolymer mold is shown in Fig. 6 and the air cured geopolymer samples is shown in Fig. 7.

3. Results and discussion

3.1. Sound absorption test

Sound Absorption Test was done for the geopolymer biscuits to determine their sound absorption coefficient at various levels of

Table 1
Geopolymer mix materials quantity per biscuit.

Fly ash	14.7 gms
Sand	44 gms
H_2o	9 ml
Sodium Hydroxide	0.4 gms
Sodium Silicate	0.8 gms

Fig. 6. Geopolymer slurry mixture.

Fig. 7. Air cured geopolymer sample.

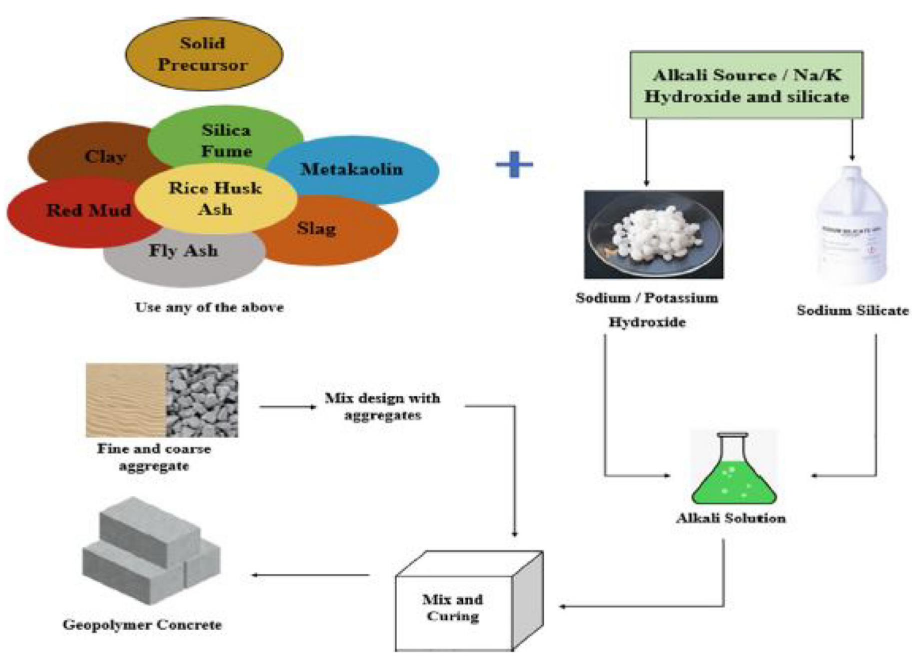

Fig. 5a. Making process of geopolymer concrete [14].

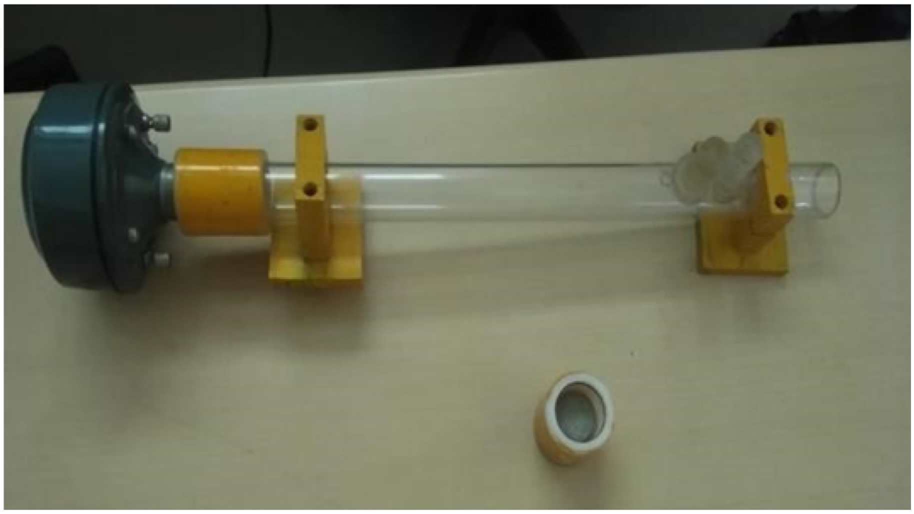

Fig. 8. Geopolymer concrete under sound absorption test.

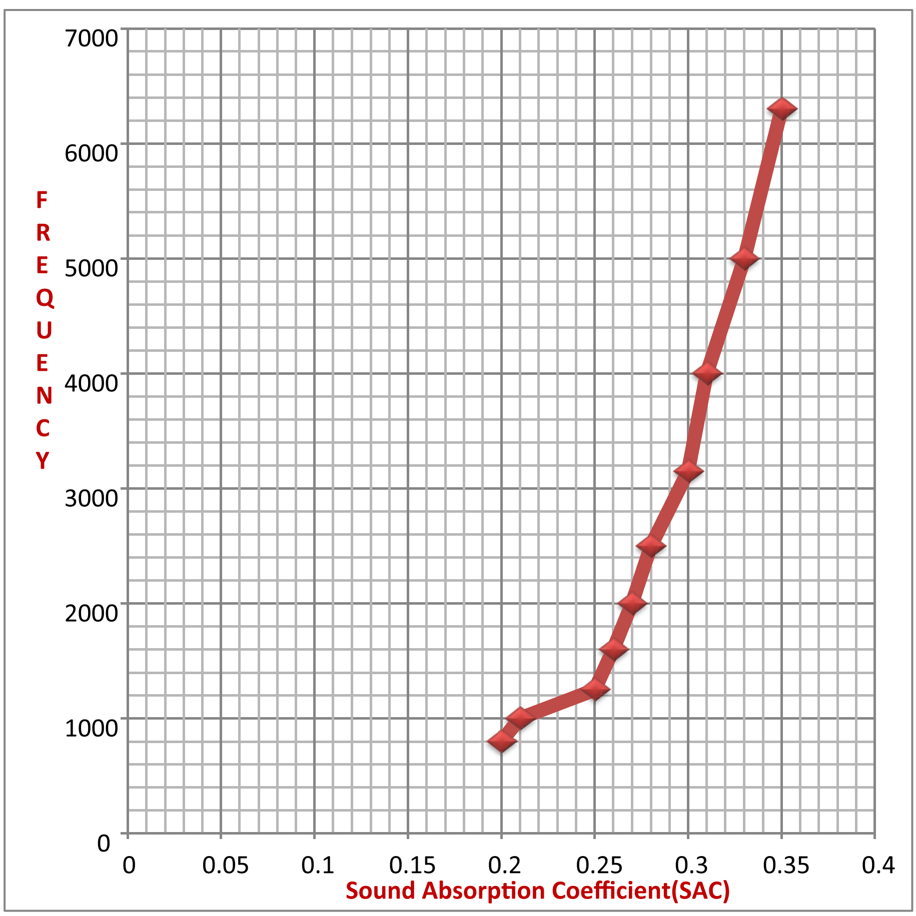

Fig. 9. Sound absorbent Coefficient of the geopolymer sample.

frequency in the experimental setup shown in Fig. 8. In this test the sample piece is inserted into the impedance tube apparatus at one end and at the other end two microphones are set. The sounds that come from the microphones pass through the sample thereby determining its Sound Absorption Coefficient (SAC) of the sample at various frequencies. According to the test results, it was seen that with increase in the sound frequency the SAC of the geopolymer increases. The increasing sound absorption coefficient results in better sound absorption in the filter as shown in Fig. 9. The geopolymer composite specimens were subjected to sound absorption test using impedance tube studies and found to exhibit an increased sound absorption coefficient (α) between 0.2 and 0.35 in the frequency range of 1200 Hz to 6300 Hz.

4. Conclusion

- From the sound absorption test it was seen that this geopolymer sample has yielded good test results.
- The Geopolymer sample turned out to be good in sound absorption and is also very easy to fabricate and is very cheap due to use of the waste materials produced by Industries.
- It is bio-degradable and eco-friendly.

CRediT authorship contribution statement

Sathish Kannan: Methodology.

Data availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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