Research Article

Submission Date
23/ 09/ 2024
Admission Date
30/ 04/ 2025

Use of Recyclable Waste As Acoustic Material For Indoor Applications

İç Mekân Uygulamaları İçin Geri Dönüştürülebilir Atıkların Akustik Malzeme Olarak Kullanımı

Umur ÖZBEK[1]

How to Cite: Özbek, U. (2025). Use Of Recyclable Waste As Acoustic Material For Indoor Applıcations. *Journal of Environmental and Natural Studies*, 7 (1), 58-68. https://doi.org/10.53472/jenas.1554740

ABSTRACT

The construction sector is characterized by an incessant demand for new materials, resulting in the continuous consumption of natural resources and exacerbating environmental degradation. This study aims to innovate within this context by developing a novel acoustic material through the strategic reuse of waste generated from construction and demolition activities. Specifically, brick waste serves as the primary constituent in the formulation of this new composite material. To enhance its acoustic properties, agricultural by-products, particularly paddy husks, are incorporated to introduce a porous structure, which is hypothesized to significantly augment the material's sound absorption capabilities. The overarching objective is to achieve a sound absorption coefficient that surpasses that of traditional brick materials, thereby offering a more effective solution for acoustic insulation in construction applications. This research is grounded in rigorous laboratory experimentation, wherein samples produced in two distinct thicknesses are meticulously evaluated using an impedance tube to ascertain their acoustic performance under controlled conditions. The findings of this study are anticipated to not only contribute to sustainable building practices but also to facilitate the reduction of waste in the construction industry, thereby fostering a more circular economy.

Keywords: Building and Demolition Waste, Acoustic Materials, Sound Absorption Coefficients, Brick Waste, Rice Husk

ÖZ

İnşaat sektörü, doğal kaynakların sürekli tüketilmesine ve çevresel bozulmanın şiddetlenmesine neden olan yeni malzemelere yönelik sürekli bir talep ile karakterize edilmektedir. Bu çalışma, inşaat ve yıkım faaliyetlerinden kaynaklanan atıkların stratejik olarak yeniden kullanımı yoluyla yeni bir akustik malzeme geliştirerek bu bağlamda yenilik yapmayı amaçlamaktadır. Özellikle tuğla atıkları bu yeni kompozit malzemenin formülasyonunda birincil bileşen olarak görev yapmaktadır. Akustik özelliklerini geliştirmek için tarımsal yan ürünler, özellikle de çeltik kabukları, malzemenin ses yutma kapasitesini önemli ölçüde artıracağı varsayılan gözenekli bir yapı oluşturmak üzere bir araya getirilmiştir. Genel amaç, geleneksel tuğla malzemelerini geride bırakan bir ses yutma katsayısı elde etmek ve böylece inşaat uygulamalarında akustik yalıtım için daha etkili bir çözüm sunmaktır. Bu araştırma, iki farklı kalınlıkta üretilen numunelerin kontrollü koşullar altında akustik performanslarını tespit etmek için bir empedans tüpü kullanılarak titizlikle değerlendirildiği kapsamlı laboratuvar deneylerine dayanmaktadır. Bu çalışmanın bulgularının yalnızca sürdürülebilir bina uygulamalarına katkıda bulunması değil, aynı zamanda inşaat sektöründe atıkların azaltılmasını kolaylaştırması ve böylece daha döngüsel bir ekonomiyi teşvik etmesi beklenmektedir.

Anahtar Kelimeler: Akustik Malzeme, Çeltik Kabuğu, İnşaat ve Yıkım Atıkları, Ses Yutma Katsayısı, Tuğla Atıklar.

[1] **Corresponding Author:** A Haliç University, Istanbul, umurozbek@halic.edu.tr, 0000-0002-1145-5372

INTRODUCTION

Natural resources are gradually decreasing due to the direct proportional increase in world population and consumption. Therefore, making existing wastes reusable through recycling is very important to protect natural resources by reducing the consumption of natural materials.

Materials considered as waste and suitable for recycling vary from region to region and country to country. The term 'waste' in this study refers specifically to construction and demolition waste, which includes brick waste, concrete, and other building materials that are discarded during construction activities or after the demolition of buildings. These wastes, often considered inert or unusable, are evaluated for their potential to be transformed into value-added materials through recycling and innovative applications.

Brick waste has been extensively studied in the context of sustainable construction materials. Gomes and De Brito (2009) highlighted the mechanical recycling potential of brick waste, emphasizing its application as a substitute for natural aggregates in concrete. Similarly, Silva, De Brito, and Dhir (2014) reviewed the reuse of ceramic waste, including bricks, in construction, demonstrating its viability in various structural and non-structural applications. These studies suggest that brick waste, often considered unusable, can be transformed into value-added materials with proper treatment and integration.

In terms of sound insulation, the utilization of porous materials has been shown to significantly improve acoustic performance. According to Berardi and Iannace (2015), recycled and natural materials with high porosity, such as agricultural by-products, exhibit excellent sound absorption properties. Specifically, rice husks have gained attention as an agricultural waste with unique characteristics. Gupta and Kua (2016) demonstrated that rice husk ash enhances the acoustic and thermal insulation of construction materials, making it a sustainable alternative in composite material development.

The integration of brick waste and agricultural by-products not only addresses environmental concerns but also aligns with global efforts toward circular economy practices. Studies by Torgal et al. (2011) emphasize the importance of utilizing local, abundant wastes to minimize ecological footprints and enhance material properties.

Waste diversity provides information about the climate, economy, life and consumption of the region. In a region that makes a living through agriculture, there are agricultural wastes, and in industrial areas, there are industrial and even hazardous wastes.

Acoustic comfort is one of the most important indoor comfort conditions. Sounds are a constant part of daily life. While listening to music and other pleasant sounds gives pleasure to the user, understanding through speaking and providing some of the methods of warning against dangers through sounds emphasize the technical and comfort importance of acoustic values. Unwanted sounds are called noise. Short and long-term exposure to noise causes different negative effects on human health. The ideal background noise levels that should be provided for spaces with different functions have been determined by academic studies and regulations. Failure to achieve the desired noise levels negatively affects the acoustic comfort conditions in the space.

There are many criteria that affect acoustic comfort conditions in a closed space, other than background noise. One of the most important criteria to be considered in evaluating the acoustic comfort conditions of indoor spaces is to ensure optimum reverberation time. After the active sound source in a closed space is turned off, the time it takes for the sound level in the space to decrease by 60 dB[2] (decrease by one millionth of the energy) is called reverberation time. The materials used on the interior surfaces of the space, furniture and the number of people play an active role in determining the reverberation time in a closed space. The interior materials to be used to ensure acoustic comfort conditions must be efficient and useful. At the same time, the materials used should be of a type that will not pose a risk to human health indoors over time.

[2] Decibel (dB) is a logarithmic unit used to measure sound intensity.

The objective of this study is to develop an acoustic material from construction and demolition waste, particularly brick waste, combined with agricultural by-products. The scope of the study includes laboratory experiments evaluating acoustic properties under controlled conditions. The methodology involves sample preparation with varying compositions and thicknesses, followed by testing using the impedance tube method.

1. Waste and Recycling Concepts

All kinds of substances that remain because of production, consumption, or elimination activities, are unwanted and are intended to be removed, are called waste. Waste and garbage are two different concepts that should not be confused. Garbage is the name given to all residues/materials that have lost their function, are free of reusable substances and cannot be recycled. Waste is all the materials that can be recycled and must be separated and recycled.

1.1 Waste Types

The need for waste management is gaining importance today due to the continuous increase in pollution caused by waste and the resulting increase in environmental risks, the rapid decrease in natural resources, economic and other reasons (Dönmez & Türker, 2017).

Wastes are classified into many types and are subjected to various recycling processes according to their types. After the recycling process, it can be used in different areas. After recycling, some wastes can be reused as materials with the same properties, while in some wastes, the materials resulting from the recycling process have different functions and properties.

1.1.1 Construction and Demolition Waste

Before starting the construction of a building, the soil resulting from the excavation and leveling works carried out to organize the land in the area where the building will be built is called excavation soil (Yarımçam & Parlak Biçer, 2020). The waste generated during the construction of roads, infrastructure and superstructures is called construction waste. Wastes resulting from the repair, renovation, renewal, demolition of residences, buildings, bridges, roads and similar infrastructure and superstructures or as a result of a natural disaster are also defined as demolition waste.

Although the accelerations in the construction sector cause a directly proportional increase in waste production, it also brings with it the problems of waste polluting nature more and taking up more space. This sector's acceleration in Turkey in the 2000s continues to grow, although it pauses from time to time.

The growth in the construction sector and the problems it brings create a necessary awareness for the solution of these problems (Craighill, 2002). Waste regulations issued, determination of compulsory dumping sites, R&D studies on materials that pollute nature less, and also the reuse of materials used during the construction phase in another building construction or in a different sector after the demolition of the building are among the measures taken to solve and slow down the problems.

An existing structure may be demolished for different reasons. Construction and excavation wastes are generated after demolition. The amount, type and diversity of waste to be generated varies depending on the size of the demolished building, its location, carrier system, construction method and type of building group.

A construction material goes through the stages of being extracted from the source, transported to the processing center or factory, processed, and turned into a product, transported to the site, used at the construction site, demolished, decomposed and recycled.

It is planned to use construction and demolition waste in the new composite material samples to be produced.

1.1.2 Evaluation of Construction and Demolition Waste

It is possible to reuse concrete waste by recycling or without further processing. It is possible to crush concrete waste without any further processing and use it in road construction, as asphalt filler and as a sound barrier. They can also be reused in concrete containing recycled concrete aggregate after undergoing some processes. In these concretes, recycled concrete aggregates obtained and processed as waste are used instead of natural aggregates (Hendriks & Pietersen, 2000).

•Masonry Waste (Bricks, Ceramics, Stones)

Considering the current research, masonry wastes, like concrete wastes, can be used as aggregates in concretes using recycled aggregates. The definition of masonry waste is used for wastes such as bricks, ceramics, and stones.

•Metal Waste

Metal waste can be separated in detail and used directly, or it can be melted and reused in many different sectors. Metal wastes are first subjected to physical grinding in facilities. After this process, they are melted at high temperatures and poured into molds. Then, the metal coming out of the molds is pressed to the desired thickness.

•Wood Waste

Damaged wood waste can be used in the production of cardboard and paper, as well as in the production of wood-based panels, MDF, chipboard and similar using different processes and binders. In addition, some undamaged wood waste can be directly reused elsewhere.

•Glass Waste

It is very difficult to rescue glass from a demolition site without breaking it. However, in cases where uncontaminated glass can be obtained, it is possible to reuse the resulting glass waste in glass production (Hendriks & Pietersen, 2000).

•Insulation Materials Waste

It is possible to use insulation materials such as glass wool and mineral wool in the production of new glass wool and mineral wool materials after they are crushed and sieved.

If EPS(Expanded Polystyrene) sheets are not damaged, they can be reused directly or they can be used in the production of a new sheet by undergoing heat treatment (Hendriks & Pietersen, 2000).

•PVC (Polyvinyl Chloride) Waste

Recycling PVC waste can be easier than other wastes. It can be easily used in the production of a new PVC component by turning it into granules or powder through mechanical separation, grinding and other processes (Aksel Çiçekçi, 2020).

•Plasterboards

Plasterboards are a widely used material for walls and ceilings. After the plasterboards are removed from the place of use, the cardboard on the panelboard can be used in paper production. Additionally, gypsum panels can be used again in the production of gypsum panels.

2. Production and Measurement of New Composite Material

Recycling is becoming more important day by day. The reason for this is that the rapidly increasing consumption of natural resources poses major problems for the future. The first problem is that the danger of depletion of natural resources is inevitable. The second problem is that waste generated as a result of consumption accumulates and pollutes nature. Recycling and reusing existing waste are very important to protect natural resources by reducing consumption and to prevent further pollution of nature.

One of the sectors that produces the most waste is the construction industry. In the construction industry, natural materials such as wood and clay and petroleum and plastic-based synthetic-artificial building materials can be used.

Waste is generated during the construction and demolition of a building. The resulting waste consists of wastes such as concrete shards, brick shards, ceramic shards, metal pieces, wooden pieces, glass, insulation materials, PVC, and plaster plates. Some of these wastes can be reused, while some of them are stored in dump sites as useless waste and pollute the nature. It is very important to evaluate these wastes that are abandoned without being used. Based on this idea, the idea was to produce a new acoustic material from construction and demolition waste by recycling method and to evaluate these wastes.

As a result of the research, brick waste was selected among the wastes examined. The evaluation of these wastes as inert and limited reusable wastes after the construction and demolition processes played an important role in the selection. Within the scope of the study with brick wastes, rice husks were used to increase the porosity of newly produced samples. Rice husks were selected for this study primarily due to their unique physical and chemical properties, which are highly conducive to creating porous structures in composite materials. When subjected to high temperatures during the firing process, the organic content of rice husks burns off, leaving behind voids within the material matrix. This phenomenon significantly increases the porosity of the composite, which is directly correlated with improved sound absorption properties, as higher porosity enables better dissipation of sound energy within the material.

The choice of rice husks is supported by existing literature. For instance, studies by Jamil, Kaish, Alam, and Islam (2013) and Torgal, Jalali, Faria, and Henriques (2011) have highlighted the potential of agricultural by-products, including rice husks, in enhancing the functional properties of construction materials. Rice husks contain a high proportion of organic compounds such as cellulose and lignin, which combust during firing, leading to the formation of interconnected voids. This process not only improves the acoustic performance but also contributes to the lightweight nature of the material, a desirable characteristic for acoustic panels (Gupta & Kua, 2016).

2.1 Production of Samples

Samples with 3cm and 5cm thicknesses were produced to examine the differences that thickness may have on the sound absorption coefficients of the new material produced. The mixture for the composite material consisted of 50% brick waste, 49,75% clay as a binder, and 0,25% rice husks by weight. The samples were fired at 840°C, and their porosity and acoustic properties were subsequently tested.

In the samples produced, brick waste was used as the main material and clay was used as a binder. The code names, content, thickness and firing temperatures of the samples examined within the scope of the study are shown in Table 1.

Table 1. Characteristics of the Samples Examined Within the Scope of the Study (Özbek, 2022).

Sample Name	Thickness	Firing Temperature
840C3	3cm	840 °C
840C5	5cm	840 °C

After the planning, the production of sample mixtures started. Mixtures containing rice husks are shown in Figure 1.

Fig. 1. Mixture Containing Produced Paddy Husk (Özbek, 2022).

In the next stage, the mixtures were thrown into the vacuum press machine, the air in the material mixture was sucked out and the samples were started to be shaped into cylinders by extrusion method with the help of a mold at the exit of the machine. Extrusion method is a production process in which a material is pushed through a mold in the desired cross-section and the material is compressed and forced to come out by taking the shape of the mold at the exit end. The sample material is first poured into the chamber of the machine. The air in the poured sample is sucked by vacuum and continues to move inside the cylinder. At the end of the cylinder, there is a mold with openings in the cross-section desired to be produced. When the material moving in the cylinder reaches the mold, it gets compressed and comes out, taking the shape of the mold.

After the samples were produced, they were placed in the drying oven to remove the water they contained. After the drying process, the samples were fired at 840°C. As a result of this process, the samples reached their final state. The final state of the samples is seen in Figure 2.

Fig. 2. Final State of the Samples (Özbek, 2022).

2.2 Sound Absorption Coefficient Measurement Method

Measurements of sound absorption coefficients of the samples were made with an impedance tube within the scope of TS EN ISO 10534-2[3] standard. The parts that make up the impedance tube are as follows.

• Speaker unit,

• Small diameter measuring tube used in high frequency measurements, into which two microphones can be placed,

• Sample holder piston that ensures correct samples are placed into the tube.

The impedance tube assembly used in the measurements is seen in Figure 3.

Fig. 3. Impedance Tube Assembly Used in Measurements (Özbek, 2022).

Sound absorption coefficient results were carried out with a small tube arrangement, and the measurements focused on the results in the 1/3 octave band between 500 Hz and 6.4 kHz. Before starting the measurements of the samples, calibration was performed to increase the sensitivity of the device. The microphones on the device were placed in their places, and measurements were made through the software on the computer connected to the device. The results of the measurements were obtained as an Excel table at the end of the procedures.

2.3 Sound Absorption Coefficient Measurements

After the sample production was carried out, sound absorption coefficient measurements were carried out using the impedance tube method. Before the measurements, a calibration process was performed on the impedance tube system. The gaps around the samples placed in the impedance tube were sealed with a thin layer of play dough to ensure sealing. In order to avoid errors in the measurements, the measurement was repeated 5 times for each sample. In each measurement, the sample was removed from the impedance tube and rotated to create a change in the surface angle. Then, the average of the 5 measurement results obtained for each sample was taken. As a result of the measurements, sound absorption coefficients in the range of 500 Hertz (Hz) - 6400 Hertz (Hz) in the 1/3 octave band were obtained. The obtained sound absorption coefficient values are shown in the figures below.

[3] TS EN ISO 10534-2: Turkish Standards European Norm International Organization for Standardization 10534-2 is a standard method for measuring sound absorption coefficients using an impedance tube.

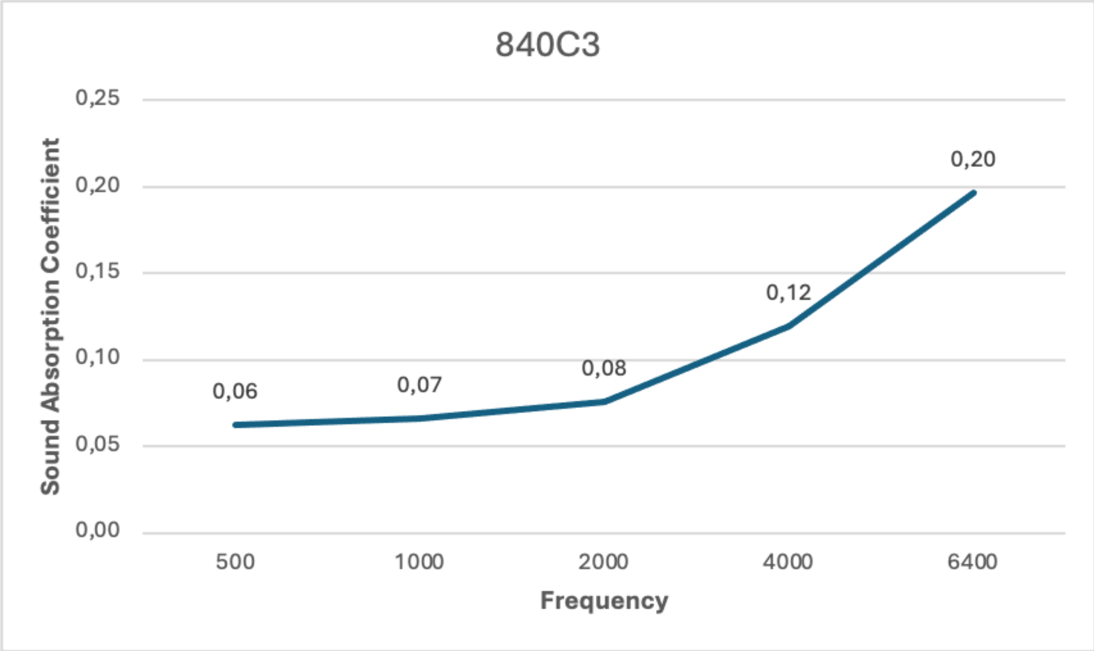

Fig. 4. Sound Absorption Coefficients of the Sample Containing Rice Husk as Additional Material, 3 cm Thick and Cooked at 840°C. (Özbek, 2022).

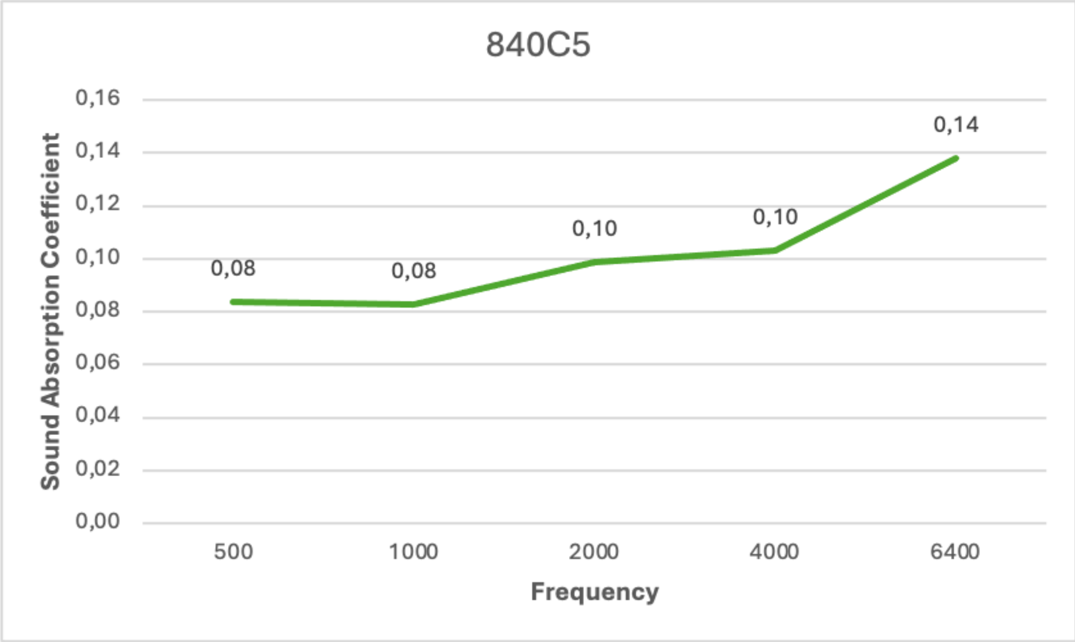

Fig. 2. Sound Absorption Coefficients of the Sample Containing Paddy Husk as Additional Material, 5 cm Thick and Cooked at 840°C. (Özbek, 2022).

Table 1. Sound Absorption Coefficients of the Measured Samples According to Frequencies (Özbek, 2022).

f (Hz)	Sample Name		Sound Absorption Coefficient of Reference Brick Surface4
	840C3	840C5	
500	0.06	0.08	0.03
1000	0.07	0.08	0.03
2000	0.08	0.10	0.04
4000	0.12	0.10	0.05
6400	0.20	0.14	0.05

When the measurement results are reviewed, it is seen that the samples have different sound absorption coefficient values at different frequencies. When we look at all the results, it can be said that the sound absorption coefficients of the samples increase at high frequencies (thin sounds), that is, their absorption increases.

2.4 Effect of Rice Husk Addition on Physical and Mechanical Properties

The addition of rice husks, while primarily aimed at improving the acoustic properties of the material through increased porosity, also has implications for its physical and mechanical properties. Porosity, resulting from the combustion of rice husks during the firing process, can reduce the density and compressive strength of the composite material. This trade-off between acoustic performance and mechanical integrity has been highlighted in previous studies. For instance, Jamil et al. (2013) observed that rice husk ash-based composites tend to exhibit reduced compressive strength due to increased void content, which aligns with the findings of Gupta and Kua (2016).

In this study, while detailed mechanical testing was not the primary focus, preliminary observations indicated a decrease in the material's structural rigidity as the proportion of rice husk increased. This effect is consistent with the behavior of other agricultural waste-enhanced composites, as reported by Torgal et al. (2011). Future research could involve optimizing the ratio of rice husk to clay to achieve a balance between improved sound absorption and acceptable mechanical performance for specific applications.

Furthermore, the thermal conductivity of the material may also be affected by the inclusion of rice husks, as increased porosity generally enhances thermal insulation properties. This characteristic could make the material suitable for dual-purpose applications where both thermal and acoustic insulation are desired (Berardi & Iannace, 2015).

While this study primarily focused on acoustic properties, it acknowledges the need for a comprehensive evaluation of the physical and mechanical performance of the developed material in future work. Such evaluations will ensure its suitability for broader applications in construction and interior design.

3. DISCUSSION

The results of this study demonstrate that the addition of rice husks to brick waste-based composites enhances the sound absorption properties, particularly at higher frequencies. When compared with similar studies, the findings align with existing literature on the acoustic performance of porous materials.

For example, Berardi and Iannace (2015) reported that natural fibers, including agricultural by-products, can achieve sound absorption coefficients in the range of 0.1 to 0.3 at frequencies above 2000 Hz. The material developed in this study achieved comparable coefficients, with values reaching 0.20 at 6400 Hz for the 3 cm thick sample. Similarly,

[4]It is the laboratory result obtained from the manufacturers.

https://www.jenas.org
ISSN: 2146-9229

Torgal, Jalali, Faria, and Henriques (2011) emphasized the role of porosity in improving acoustic performance, which is consistent with the observed behavior of the rice husk-infused composites.

In terms of comparison with traditional materials, the developed composite outperforms standard brick surfaces, which typically exhibit sound absorption coefficients below 0.05 across most frequencies (Gupta & Kua, 2016). This improvement highlights the potential of the composite as an effective acoustic solution in construction applications.

Moreover, the study contributes to the broader body of work on sustainable materials. The integration of construction and demolition waste with agricultural by-products aligns with circular economy principles, as highlighted by Silva, De Brito, and Dhir (2014). By transforming waste into value-added products, this study addresses both environmental and technical challenges in material innovation.

However, it is important to note that while the acoustic properties of the material have been extensively evaluated, its mechanical performance and durability under long-term use require further investigation. Future studies should explore these aspects to ensure the material's suitability for practical applications in various construction contexts.

4. CONCLUSION

This study investigated the potential of recycling brick waste and integrating it with rice husks to develop a sustainable acoustic material. The findings demonstrate that the composite material, formed by combining brick waste, clay as a binder, and rice husks, exhibits superior acoustic properties compared to traditional brick surfaces.

Preliminary tests showed that brick waste alone is insufficient for creating cohesive and durable materials due to its brittleness and low bonding properties, as also noted in Silva, De Brito, and Dhir (2014). To address this limitation, clay was introduced to enhance structural integrity, and rice husks were added to increase porosity, leading to improved sound absorption. The material's porosity, resulting from the combustion of rice husks during firing, played a critical role in enhancing its acoustic performance.

Laboratory evaluations using impedance tube tests confirmed that the composite material achieved significantly higher sound absorption coefficients compared to traditional brick surfaces. For instance, the sound absorption coefficient of the 3 cm thick sample reached 0.20 at 6400 Hz, whereas standard brick surfaces typically exhibit coefficients below 0.05 in similar frequency ranges (Gupta & Kua, 2016). These results validate the effectiveness of the material in providing acoustic insulation, particularly in high-frequency ranges.

In addition to its acoustic performance, the study acknowledged trade-offs in other properties. While the increased porosity improved sound absorption, it potentially reduced compressive strength and density. These findings align with prior studies, such as those by Jamil et al. (2013), emphasizing the importance of balancing acoustic and mechanical properties in porous composites.

This research contributes to sustainable construction practices by offering a method to repurpose low-value construction and demolition waste alongside agricultural by-products. The approach aligns with circular economy principles, transforming waste into high-value materials. However, further studies are needed to optimize the material composition for enhanced structural performance and thermal insulation. Long-term durability testing, additional mechanical evaluations, and comparisons with commercially available acoustic solutions would further strengthen the applicability of this material in real-world construction projects.

By integrating experimental findings with established literature, this study underscores the viability of innovative, waste-based materials as effective solutions for acoustic insulation, addressing both environmental and functional challenges in the construction industry.

ETHICAL STANDARDS:

Conflict of Interest: There are no potential conflicts of interest with the authors or third parties in this article.

Ethics Committee Permission: This article does not require ethics committee approval.

Financial Support: No financial support was received for this article.

REFERENCES:

Berardi, U., & Iannace, G. (2015). Acoustic characterization of natural fibers for sound absorption applications. *Building and Environment*, 94, 840–852. https://doi.org/10.1016/j.buildenv.2015.05.029

Craighill, A. & Powell, J.C., (1999). *Lifecycle Assesment and Evaluation of Construction and Demolition Waste Management* [Ph.D. Thesis]. School of Environmental Sciences, University of East Anglia.

Dönmez E., Türker E. (2017), Literature Investigation on Electromagnetic Shielding, Sound and Thermal Insulation Performances of Surfaces Generated from Textile Wastes [Tekstil Atıkları İçeren Yüzeylerin Sahip Olduğu Elektromanyetik Kalkanlama], *Tekstil ve Mühendis*, 24: 124–135, https://doi.org/10.7216/1300759920172410609

Ergin D. (2014), Acoustic comfort requirements and acoustic design approaches at the performance halls in the light of current technology [Gelişen Teknoloji Işığında Performans Mekânlarında İşitsel Konfor Gereksinimleri Ve Akustik Tasarım Yaklaşımları], MSc. Thesis, Graduate School of Science and Engineering, Yıldız Technical University.

Gomes, M., & De Brito, J. (2009). Structural concrete with incorporation of coarse recycled concrete and ceramic aggregates: Durability performance. *Materials and Structures*, 42(5), 663–675. https://doi.org/10.1617/s11527-008-9411-9

Gupta, S., & Kua, H. W. (2016). Influence of rice husk ash on the mechanical and durability properties of concrete: A review. *Construction and Building Materials*, 121, 207–219. https://doi.org/10.3329/jesnr.v9i1.30287

Hendriks C. & Pietersen H. (2000). Sustainable raw materials–construction and demolotion waste. Rilem Publications.

Jamil, M., Kaish, A. B. M. A., Raman, S. N., & Zain, M. F. M. (2013). Pozzolanic contribution of rice husk ash in cementitious system. *Construction and Building Materials*, 47, 772–778. https://doi.org/10.1016/j.conbuildmat.2013.05.088

Özbek U. (2022), Using Recyclable Wastes as Acoustic Materials in Interiors and an Experimental Evaluation on Composite Forming Materials [İç mekanda akustik malzeme olarak geri dönüştürülebilir atıkların kullanılması ve kompozit oluşturan malzemeler üzerinden deneysel bir değerlendirme], Ph.D. Thesis, Department of Interior Architecture, Mimar Sinan Fine Arts University.

Silva, R. V., De Brito, J., & Dhir, R. K. (2014). Properties and composition of recycled aggregates from construction and demolition waste suitable for concrete production. *Construction and Building Materials*, 65, 201–217. https://doi.org/10.1016/j.conbuildmat.2014.04.117

Torgal, F. P., Jalali, S., Faria, J., & Henriques, F. (2011). Cementitious building materials reinforced with vegetable fibers: A review. *Construction and Building Materials*, 25, 575–581. https://doi.org/10.1016/j.conbuildmat.2010.07.024

Yarımçam Ş., Parlak Biçer Z. (2020), Cost Analysis of Construction Waste from Urban Transformation: Kayseri Küçükali Neighborhood Example [Kentsel Dönüşüm Sonucu Oluşan İnşaat Atıklarının Getirdiği Maliyetin Kayseri Küçükali Mahallesi'nde İncelenmesi], Erciyes University Journal of Institue Of Science and Technology, 36: 102-118.

Zhu L., Zhu Z. (2020), Reuse of Clay Brick Waste in Mortar and Concrete, *Advances in Materials Science and Engineering*, 1-11, https://doi.org/10.1155/2020/6326178