Journal of Natural Fibers

ISSN: 1544-0478 (Print) 1544-046X (Online) Journal homepage: www.tandfonline.com/journals/wjnf20

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To cite this article: Nezha Gueffaf, Bahia Rabehi, Messaouda Boumaaza, Khaled Boumchedda, Ahmed Belaadi, Mahmood M. S. Abdullah, Iryna Klimkina, Hamad A. al-Lohedan, Amar Al-Khawlani & Yazid Chetbani (2025) Performance of Earth Blocks Based on Recycled Dam Sediment and Reinforced with Alfa Fibers : Experimental Study, Journal of Natural Fibers, 22:1, 2512002, DOI: 10.1080/15440478.2025.2512002

To link to this article: https://doi.org/10.1080/15440478.2025.2512002

Published online: 30 May 2025.

JOURNAL OF NATURAL FIBERS
2025, VOL. 22, NO. 1, 2512002
https://doi.org/10.1080/15440478.2025.2512002

Performance of Earth Blocks Based on Recycled Dam Sediment and Reinforced with Alfa Fibers : Experimental Study

Nezha Gueffaf[a], Bahia Rabehi[b], Messaouda Boumaaza[c], Khaled Boumchedda[b], Ahmed Belaadi[d], Mahmood M. S. Abdullah[e], Iryna Klimkina[f], Hamad A. al-Lohedan[e], Amar Al-Khawlani[g], and Yazid Chetbani[h]

[a]Research Unit Materials, Processes and Environment (UR-MPE), University M'Hamed Bougara Boumerdes, Avenue of Independence, Boumerdes, Algeria; [b]Department of Civil Engineering, Research Unit Materials, Processes and Environment (UR-MPE), University M'Hamed Bougara Boumerdes, Avenue of Independence, Boumerdes, Algeria; [c]Laboratory of Civil Engineering and Hydraulics (LGCH), University 8 May 1945 Guelma, Guelma, Algeria; [d]Département de Génie Mécanique, Faculté de Technologie, Université 20 Août 1955-Skikda, Skikda, Algeria; [e]Department of Chemistry, College of Science, King Saud University, Riyadh, Saudi Arabia; [f]Department of Chemistry, Dnipro University of Technology, Dnipro, Ukraine; [g]Jiangsu Optoelectronic Functional Materials and Engineering Research Center, School of Chemistry and Chemical Engineering, Southeast University, Nanjing, China; [h]Laboratory of Mechanics and Materials Development, Department of Mechanical Engineering, Faculty of Science and Technology, University of Djelfa, Djelfa, Algeria

ABSTRACT

River and dam dredged sediments are regarded as waste. Waste sediment disposal involves financial resources and raises issues regarding the environment. Reusing dredged sediments to make building materials like adobe bricks can offer an alternative way to handle and value this waste. Compressed earth blocks (CEB) are environmentally friendly building materials made from clay soil or sediments dam with fibers. Natural fibers addition improves mechanical and thermal characteristics of adobe bricks. The goal of this study was to use Alfa fibers (AF) from Algeria to create adobe bricks from the sediments of the Koudiat Acerdoune dam. This study presents an experimental study of earth blocks stabilized with 10% cement and reinforced with AF fibers at different volume fraction dosages (0.75%, 1.5%, and 2.5%). The new composite of these sediments' capillary absorption, shrinkage, compressive strength, flexural strength, and thermal conductivity was examined. With a flexural strength of 2.30 MPa and a compressive strength of 8.12 MPa for 2.5% AFs, as well as a decrease in thermal conductivity, the fiber/cement formulations demonstrated the best mechanical performance, according to the results of the analysis.

摘要

河流和大坝疏浚的沉积物被视为废物。废物沉积物处理涉及财政资源，并引发了环境问题. 再利用疏浚沉积物制造土坯砖等建筑材料可以提供一种处理和评估这种废物的替代方法.　压缩土块（CEB）是一种环保建筑材料，由粘土或含纤维的沉积物坝制成。添加天然纤维可以改善土坯砖的机械和热特性. 这项研究的目的是使用来自阿尔及利亚的阿尔法纤维（AF）从Koudiat-Acerdoune大坝的沉积物中制造土坯砖. 本研究对用10%水泥稳定并用不同体积分数剂量（0.75%、1.5%和2.5%）的AF纤维加固的土块进行了实验研究. 研究了这些沉积物的毛细吸收、收缩、抗压强度、抗弯强度和导热性的新复合材料.　根据分析结果，纤维/水泥配方的抗弯强度为2.30 MPa，抗压强度为8.12 MPa，AFs为2.5%，导热系数降低，表现出最佳的机械性能.

KEYWORDS
Recycled sediment; Alfa fibers; mechanical resistance; adobe bricks; thermal conductivity

关键词
回收的沉积物; 阿尔法纤维; 机械阻力; Adobe砖; 导热

CONTACT Ahmed Belaadi a.belaadi@univ-skikda.dz; ahmedbelaadi1@yahoo.fr Département de génie mécanique, Faculté de technologie, Université du 20 août 1955-Skikda, Algérie

Introduction

For the purposes of navigation, flow of waters, and offshore operations, sediments are collected from ports, streams and water channels. Globally, millions of tons of sediments are excavated. As waste, these sediments are either held on ground or discarded into the ocean. Dumping sediment into the ocean harms the ecosystem, particularly for aquatic organisms. Similar problems with leaching and cost arise when sediments are stored on land. The financial and ecological issues have led to an increase in the recycling of sediments in many applications (Wang et al. 2018). Polluted sediments are difficult to recycle and require treatment before being used again. Additionally, in order to use excavated sediments, they must be dewatered (Pujades et al. 2014).

Various researchers have utilized river and harbor sediments for a variety of purposes, including backfill, retaining structures, roadways, bricks, and cement clinker (Dorleon, Rigaud, and Techer 2024; Hussain et al. 2022; Solanki et al. 2023). Reusing sediments in the construction industry appears to be a potential solution because it reduces the demand on carbon emissions and natural resources. 10% of the world's carbon emissions are caused by concrete (Dhasindrakrishna et al. 2021). As consequently, using excavated sediments to make clay bricks is crucial and offers environmentally favorable building materials. Adobe blocks are sustainable, eco-friendly building materials that emit the least amount of CO_2. They are desirable building materials due to their lower energy usage, inexpensive and plentiful raw ingredients, and ease of recycling. The chemical and physical properties of sediments are crucial for their recycling as bricks of adobe. These features include chemical and mineralogical composition, Atterberg limits, and granulometry. Important considerations for the suitability of sediments for bricks include the percentages of silt, sand, and clay.

Many studies have examined the effects of natural fibers on reinforcing building materials (Belaadi et al. 2022, 2023; Boudermine et al. 2024; Boukhoulda et al. 2017, 2019, 2023; Boumaaza, Belaadi, Alshahrani, Bourchak, et al. 2023; Boumaaza, Belaadi, Alshahrani, Mohammad, et al. 2023; Ghernaout et al. 2024; Khelifi et al. 2023; Ladaci et al. 2024). Eco-friendly building methods are encouraged by the use of natural fibers in composite materials such as polymer, raw bricks, mortar, and concrete (Boumaaza, Belaadi, and Bourchak 2022; Chai et al. 2023, 2024; Jonnala et al. 2024; Silva et al. 2020; Wang et al. 2024). Natural fibers serve as reinforcement agents, increasing the composite materials' tensile strength and changing the rupture modes from fragile to ductile. Furthermore, adding natural fibers prevents the production of big cracks and shrinkage in crude bricks during quick drying (Babé et al. 2021; Zaryoun and Hosseini 2019). Natural fibers control the absorption and evaporation of humidity, enhancing the heating and hydrophilic properties of raw bricks (Azalam et al. 2024; Brzyski et al. 2017). Brick strength is influenced by fiber attributes including tensile strength and durability, which can be enhanced by treating the fibers. Although it is challenging to regulate the orientation of the fibers within the bricks, the distribution and orientation of the fibers within the matrix are equally crucial for brick strength. The tensile strength of composite materials is mostly influenced by fibers which extend parallel to the brick cross-sectional (Aizaz et al. 2024; Kwiecień et al. 2018).

Mostafa and Uddin (Mostafa and Uddin 2016) have developed a novel compressed earth block known as the Banana-Compressed Earth Block (B-CEB) by combining traditional earth block materials with banana fibers obtained from agricultural waste. Their study's key findings demonstrate that adding banana fibers to earth blocks greatly improves the blocks' load-deflection curves and compressive and flexural strengths. Because of its improved mechanical qualities, B-CEBs may be able to be utilized in multi-story buildings, which would encourage the construction of inexpensive and sustainable structures. The ideal moisture content and Atterberg limits can be used to determine the amount of water needed to mix sediments and fibers (Xu et al. 2024).

Numerous research offers a variety of data, including the strength of walls reinforced with banana and coconut fibers (Thanushan and Sathiparan 2022). Another study by Humphrey Dunso et al. demonstrates that adding natural fiber reinforcement to earthen blocks increases their resistance to water erosion (Jesudass et al. 2021). The impact of cement, coconut coir, and soil on the compression and tensile strength of blocks is demonstrated by a study conducted by Shubham Raj et al. (Raj et al. 2017).

Compaction or the inclusion of stabilizers like cement, gypsum, and lime are two methods for stabilizing the soil in crude bricks (Van Damme and Houben 2018). Samples of stabilized bricks are either sun-dried or oven-dried following compaction. The fibers within the bricks dry as well, and as a result of shrinkage, their volume reduces. Raw bricks are also susceptible to deterioration. Bricks lose strength when they come into contact with water, and they may fail in an inundation. Crude bricks perform poorly in seismic tests and have durability problems.

Since few studies have been done on the reuse of excavated sediments in raw bricks, the present research examines the valorization of dam excavated sediments and waste fibers in raw bricks. Waste sediments excavated from the barrage Koudiat Acerdoune were used to make crude blocks. Crude bricks are made by combining Alfa fibers with dam silt. These fibers are affordable, lightweight, have a high tensile strength, and have environmental benefits. Before being used in bricks of adobe, the properties of the fibers and sediments were investigated. After bricks were manufactured, the properties of CEB, including their compressive and bending strength, water absorption, shrinkage, and thermal conductivity, were analyzed.

The results of this study may represent a major step toward the use of compressed earth blocks (CEBs) reinforced with alfa fibers as a more environmentally friendly substitute for traditional building methods. This strategy tackles two primary issues: the requirement to enhance the mechanical qualities of CEBs and the disposal of trash from excessive AF fibers synthesis. These problems, which historically prevented this building technique from being widely used, particularly in industrialized areas and places vulnerable to powerful seismic and wind forces, can be successfully resolved by incorporating alfa fibers.

Materials

The materials employed in this experimental study include cement produced locally under the commercial name CEM II 42.5, as well as silt from the Koudiat Acerdoune dam (Figure 1), which is situated roughly 60 km east of Algiers and 12 km south of Lakhdaria. In the Lambert system, the coordinates X = 580.10, Y = 354.70, and Z = 217.00 define the location.

Sediment

According to Table 1, the sediment's physical characteristics include an ideal water content of 13.67%, a pH of 8.6 that is slightly alkaline, and an organic matter content of 1.72%. While the liquid and plastic limits are 38.2% and 23.58%, respectively, the maximum dry density is 1820 kg/m^3. These qualities show that the sediment has good compaction, stability, and workability, making it appropriate for building. Its compatibility with cementitious matrices is supported by its alkaline pH and low organic content. With its ideal moisture content, density, and alkaline pH that complements cementitious matrices, these characteristics demonstrate that the Koudiat Acerdoune sediment is appropriate for building.

Additional information on the sediment's mineral composition may be found in Table 2, which shows its chemical composition. Determining the sediment's reactivity, possible contributions to the hydration process, and general behavior when combined with cement and other additives in building applications requires an understanding of its chemical profile.

Fibers used

Alfa fibers (AF) are extracted using a well-established technique called retting, which entails soaking the plant stems in water for around two months and then letting them air dry to facilitate fiber separation (Figure 2). To assess their inherent performance in the cementitious matrix and streamline the manufacturing process, Alfa fibers were utilized without undergoing any chemical modifications. While adhesion and mechanical strength can be enhanced by alkaline or thermal treatments

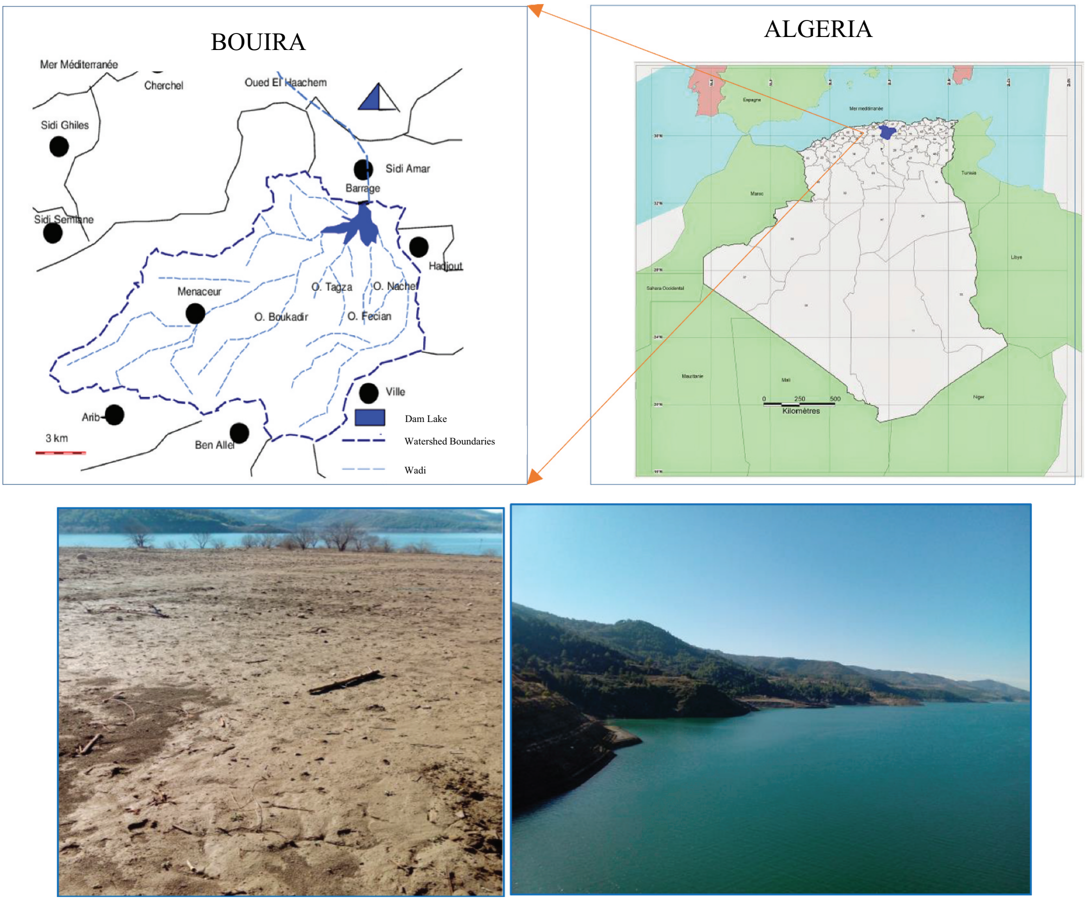

Figure 1. Photography of Koudiat Acerdoune dam sediment.

Table 1. Physical properties of the sediment used.

Characteristics	Unit	Results
Optimum (Wc)	%	13.67
PH		8.6
Organic matter	%	1 .72
Max. Dry Density (c)	kg/m^3	1820
Liquid limit	%	38.2
Plastic limit	%	23.58

Table 2. Chemical composition of the sediment used.

Na_2O	MgO_3	SiO_2	Al_2O_3	SO_3	Fe_2O_3	P_2O_5	CaO	K_2O	TiO_2	Mn_2O_3	Fe_2O_3	PAF
0.51	0.88	57.91	8.81	0.32	4.40	0.10	11.91	0.86	0.52	0.01	4.40	13.50

(Messaoui et al. 2022, 2024), our method seeks to reduce expenses while maintaining the material's ecological qualities. A wire brush is used to refine the fibers for additional processing once they have been softened. Table 3 provides specifics on the physical properties of the isolated Alfa fibers. Alfa fiber bundles are characterized by a mean diameter of 312 μm (ranging from 100 to 400 μm). A Zwick/Roell machine with a 2.5 kN load cell was used to conduct a tensile strength test in order to evaluate their mechanical qualities (Figure 2). We took thirty fibers for the tensile test and a gauge length of 60 mm

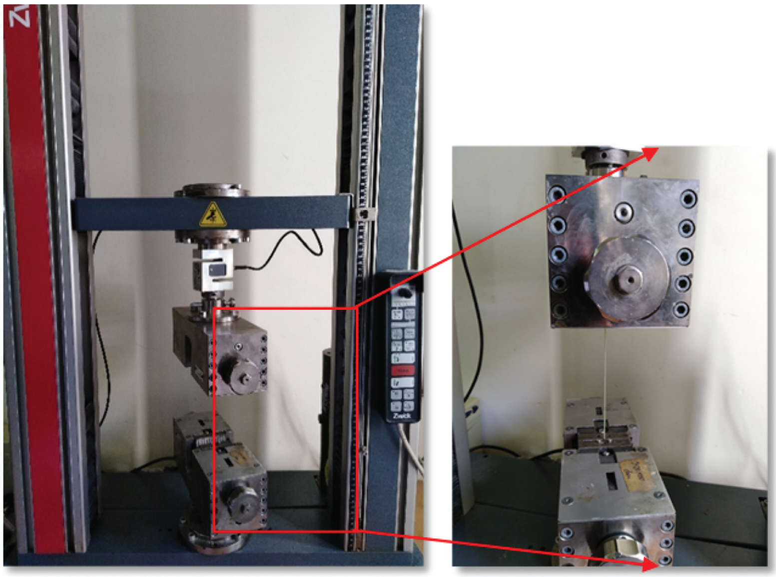

Figure 2. Tensile machine used to testing. fibers.

Table 3. Characteristics of the Alfa fibers used.

Characteristics	Unit	Results
Diameter	µm	100–400
Length	mm	600
Water absorption	%	400–500
Density	g/cm^3	1.4
Deformation	mm	1.04–3.30

with a moving crosshead speed of 2.5 mm/min in compliance with (2009). The stress versus strain curve is shown in Figure 3. Alfa fiber exhibits brittle behavior with a sudden drop in load at the time of failure. The tensile curve consists of two zones: a first linear zone followed by a non-linear zone until the fiber breaks. These characteristics draw attention to Alfa fibers' special qualities, which include their considerable capacity to absorb water, moderate density, and range of deformation. These qualities are essential for assessing their potential as reinforcing materials in composite applications and construction.

Elaboration of specimens

The compaction of the blocks using a semi-automatic hydraulic press with a compaction pressure of 7MPa. The fibers were used at a length of 6 cm as at different dosages: 0%, 0.75%, 1.5%, 2.5% by volume and at a cement dosage of 10%. After demolding, the compacted earth blocks were left in a laboratory in the air until testing. The required test age for sediment/fiber or sediment/cement and fiber blocks is 28 days (Figure 4). The blocks utilized in this study were standard dimensions of 295 × 140× 90 mm (Figure 5) (Afnor 2001). CEB specimens were chosen so they would blend in well with a typical masonry unit. Starting on the day that the constant mass was obtained, the curing process continued for a total of 28 days at a temperature of 20°C. After being wrapped in jute bags for two days, the blocks were allowed to dry for a maximum of 28 days. The blocks were let to dry at room temperature without any particular humidity or temperature management. This study did not examine how drying speed affected the development of cracks and mechanical performance.

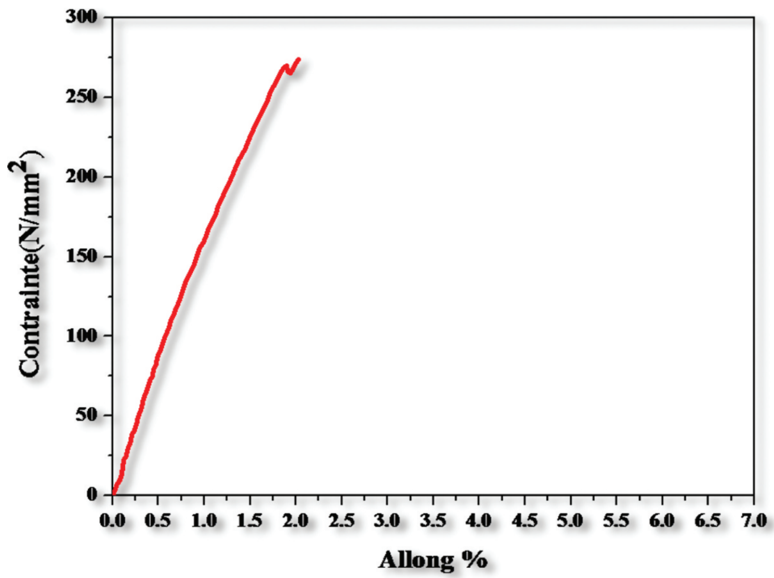

Figure 3. Alfa fiber tensile curve.

Figure 4. The production line for earth blocks reinforced with Alfa fibers.

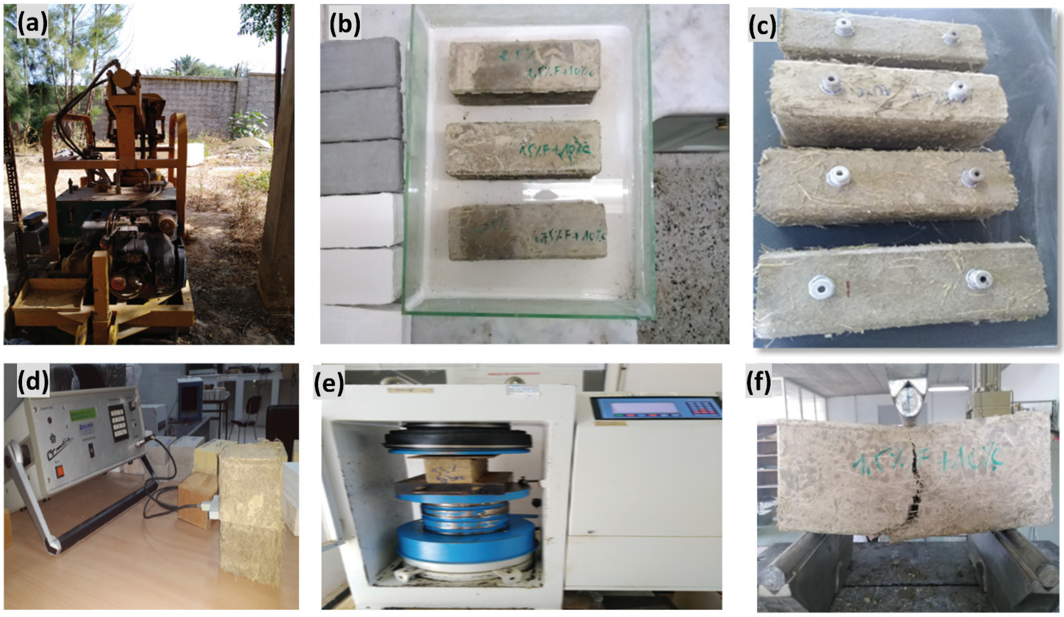

Figure 5. Devices and tests for physical-mechanical characterization: (a) hydraulic semi-automatic press, (b). Capillary absorption test, (c) shrinkage test, (d) thermal conductivity test, (e) compressive test and (f) flexural strength test.

Table 4. Specifics of mix proportions.

Composition	Unit		
Cement	%	0	10
Fibers	%	0	0
		0.75	0.75
		1.5	1.5
		2.5	2.5

The final compressed stabilized earth block is shown in Figure 5, and Table 4 provides a breakdown of the precise percentages used in the combination.

Physical properties

Water absorption

Various fiber reinforcement ratios of 0%, 0.75%, 1.5%, and 2.5% are used to prepare the specimens, together with a soil-cement matrix that contains 10% cement. The water absorption properties of stabilized earth blocks reinforced with Alfa fibers are evaluated using the capillary absorption test, which is conducted in compliance with standard XP P13–901 (Afnor 2001) (Figure 5b). In order to evaluate the material's durability, this test simulates circumstances in which the block would be exposed to soil or air moisture over time by measuring the quantity of water the block absorbs by capillary action.

Shrinkage

The XP P13–901 standard requires the shrinkage test to be performed in order to assess the dimensional stability of stabilized earth blocks reinforced with AF fibers (Afnor 2001). In order to comprehend any problems like cracking or structural deformation when the blocks are utilized in building, this test looks at the block's propensity to shrink or expand under various climatic conditions

(Figure 5c). In this test, epoxy resin is used to attach two measuring pads to the surface of each block. Over time, accurate measurements can be made from these pads' steady, permanent positions. Epoxy sealing the pads reduces the possibility of movement or slippage, guaranteeing precise and reliable data. As the block is dried or exposed to other environmental factors that may cause shrinkage or expansion, the setup seeks to monitor any changes in the distance between the measurement pads.

Thermal conductivity

The evaluation of stabilized earth blocks reinforced with Alfa fibers' thermal performance depends on the measurement of thermo-physical characteristics, particularly thermal conductivity (λ). This examination provides information about the material's ability to conduct temperatures, which is crucial for use in energy-efficient building designs and is conducted in compliance with the NF EN 993–15 standard (En 2005). The ability of the blocks to insulate or retain heat can be ascertained by measuring their thermal conductivity, which directly affects indoor comfort and energy usage in buildings constructed with these blocks.

A CT-Meter measuring instrument is utilized for this test, as illustrated in Figure 5d. To calculate the rate at which heat moves from one side of the sample to the other, the CT-Meter creates a controlled heat flow through the block. One side of the block is exposed to a heat source during the test, while the other side is maintained at a constant, lower temperature. The CT-Meter's sensors compute the rate of heat transfer and continually measure the temperature gradient throughout the block.

Mechanical tests

For each composition, three samples were examined in order to determine the block compressive strength. For the experiment, a standard load speed of 1.5 mm/min was selected. The tests were carried out using prismatic specimens of dimensions (295 × 140 x 90) mm^3 in accordance with standard (Afnor 1981, 1990). The bending resistance of stabilized earth blocks reinforced with varying ratios of Alfa fibers is assessed using the three-point flexural strength test. The force needed to bend a specimen is measured in this test, indicating the material's resistance to compressive stress on one side and tensile stress on the other. In order to assess the impact of fiber reinforcement on the flexural strength of the blocks, the test setup consists of specimens reinforced with 60 mm long AF fibers with different fiber content ratios. During the test, the loading arm descends at a steady 10 mm/min deflection rate, progressively exerting force on the specimen until failure.

Results and discussion

Capillary absorption

With a cement stabilization level of 10% and after five days of water immersion, Figure 6 displays stabilized earth blocks' overall water absorption in relation to Alfa fiber content. In order to gain an understanding of how fiber reinforcement affects moisture uptake in stabilized earth materials, this test looks at how different Alfa fiber amounts affect the blocks' ability to absorb water. The absorption curve shows a clear pattern: the blocks exhibit a strong initial uptake period during the first day of immersion, as seen by their quick water absorption rate. During this phase, water migrates into the material through capillary action, rapidly being absorbed by the block's open pore network. But as the immersion goes on, the absorption rate gradually drops, and over the course of the following four days, a plateau forms, signifying that the material has nearly reached saturation.

After a day of immersion, the findings show raising the amount of Alfa fiber in the blocks tends to increase the water absorption percentage. In particular, blocks containing 0.75% Alfa fiber absorb 11.3% of their volume in water after a day, whereas blocks with 1.5% and 2.5% fiber content – all of

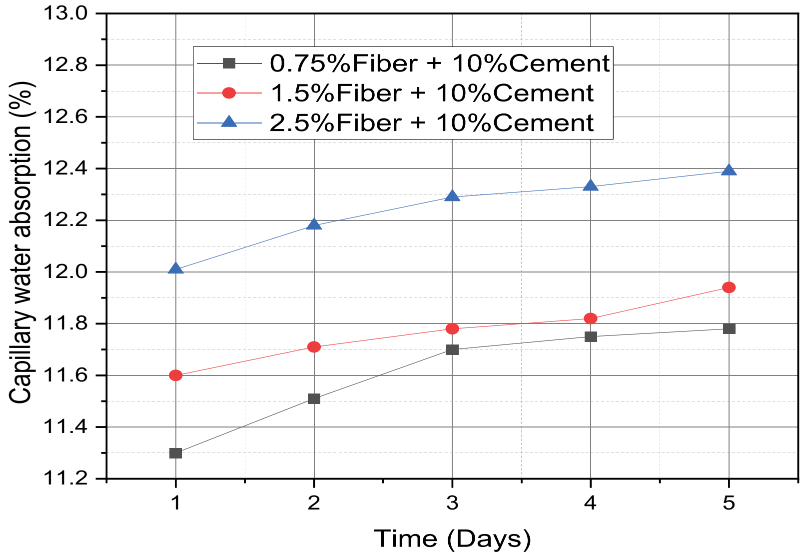

Figure 6. Variation in the capillary water absorption.

which have a 10% cement content – show greater absorption rates of 11.6% and 12.01%, respectively. This pattern implies that the fibers' inherent porosity and water-holding ability aid in water absorption in addition to providing strength and flexibility. It is evident that the Alfa fiber-reinforced blocks with 10% cement show somewhat higher water absorption when compared to the results of Bachir, who reported water absorption rates ranging from 9.2% to 11.2% for blocks compacted at 10 MPa, stabilized with 5–8% cement, and reinforced with date palm fibers (Taallah and Guettala 2016). The particular properties of Alfa fibers, which may have greater porosity or a different fiber morphology than date palm fibers, which permit greater moisture penetration, could be the cause of this discrepancy. In this study, blocks reinforced with 2.5% Alfa fiber and 10% cement had the maximum total water absorption of 12.39%, while blocks reinforced with 0.75% Alfa fiber and the same cement content had the lowest recorded value of 11.30%. This range demonstrates how changing the fiber ratio affects water absorption; higher fiber content results in more significant absorption because the fibers in the block matrix provide more capillary channels. Compared to blocks with fibers, blocks without reinforcement (0% volume portion) exhibit reduced water absorption. This trend is explained by the hydrophilic nature of the fibers, which generate capillary channels within the block matrix, facilitating water absorption. The role of fibers as porosity enhancers is further confirmed by the observed increase in water absorption with higher fiber content. As anticipated, the cement composition has a big impact on how much water the blocks absorb overall. By decreasing the material's permeability and increasing its resistance to moisture penetration, cement serves as a stabilizing agent. The intricate relationship between cement stabilization and natural fiber reinforcement is demonstrated by the fact that, although the 10% cement stabilization helps regulate water absorption, the fibers provide new channels for water flow. These results offer important information for maximizing the composition of stabilized earth blocks for building applications, striking a balance between the advantages of fiber reinforcement for structural flexibility and durability and moisture resistance.

Shrinkage

Figure 7 shows the progression of shrinkage in Alfa fiber-reinforced earth blocks, illustrating the impact of stabilization and fiber content on dimensional stability. The findings show a distinct pattern: as the percentage of Alfa fibers rises, shrinking gradually declines. This impact can be linked to fibers'

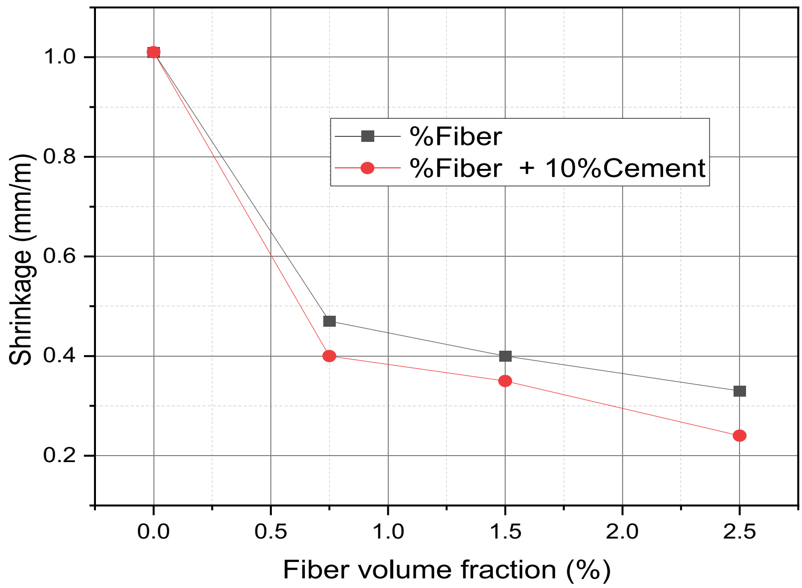

Figure 7. Shrinkage test.

function in preventing drying shrinkage, as they aid in bridging internal fissures and lessen the soil matrix's contraction during drying conditions. The favorable effect of cement as a stabilizing ingredient is highlighted by the fact that blocks with 10% cement and Alfa fibers exhibit even less shrinkage than blocks with only soil and fibers. By better adhering soil particles, the cement improves the blocks' structural integrity and lowers the possibility of deformation from shrinkage. According to precise shrinkage measurements, blocks containing 2.5% Alfa fiber have a shrinkage value of 0.33 mm/m. Shrinkage is further reduced to 0.24 mm/m when stabilized with a cement content of 10% and a fiber content of 2.5%. This decrease demonstrates how cement and fiber work together to minimize shrinkage, especially when the fiber reinforcing helps distribute tensile stresses throughout the block and contributes structural cohesion, both of which mitigate the impacts of drying shrinkage. These outcomes support research by Bouicha et al. (Bouhicha, Aouissi, and Kenai 2005) who found that vegetable fibers had comparable effects on shrinking. Because longer fibers provide more surface area for interaction with the soil matrix, which increases their reinforcing impact, Bouicha's findings supports the idea that fiber length and content are crucial in regulating shrinkage.

Thermal conductivity

Figure 8a shows the change in heat conductivity with AF fibers percentages (0%, 0.75%, 1.5% and 2.5%) after 28 days. The findings show that the thermal conductivity of fiber-free blocks (0% volume proportion) is higher because of their greater density and absence of heat-transfer-obstructing fibers. The results show that the thermal conductivity decreases with increasing fiber content. However, the insulating action of the fibers, which trap air in the material matrix, causes a progressive decrease in heat conductivity when fibers are incorporated. However, the thermal conductivity of earth blocks reinforced with 2.5% AF fibers is 0.798 W/m.k, 39% lower than that of the control block. This result is due to the increased porosity of the hardened earth blocks, caused by the high-water uptake capacity of the AF fibers, which swell when they come into contact with water, leading a decrease in the earth blocks' heat conductivity. The results are in line with observations reported in the literature (Abani et al. 2015; Belayachi, Hoxha, and Redikutseva 2015). The thermal conductivity is higher at zero fiber concentration. When fibers are added, the thermal conductivity first drops because of the increased

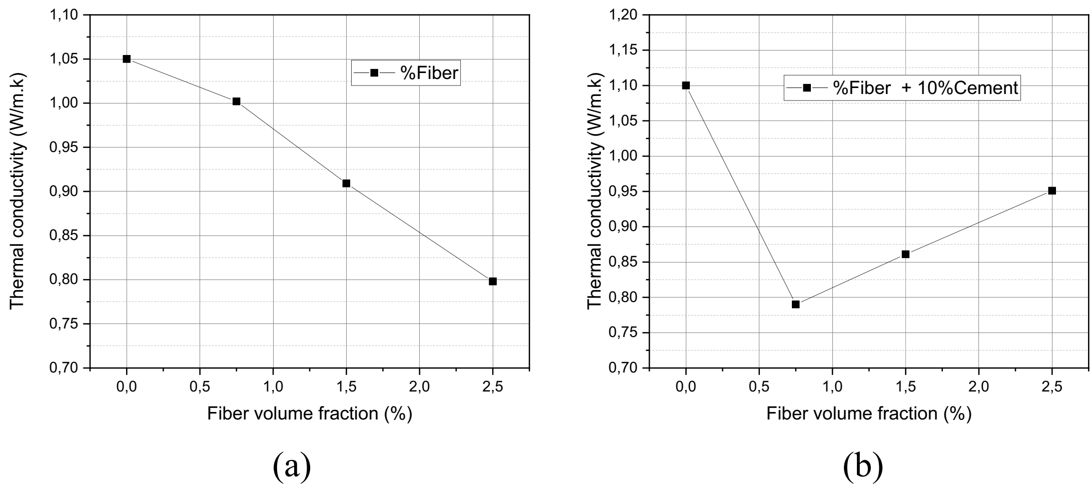

Figure 8. Thermal conductivity, (a) the absence of cement and (b) with 10% cement.

porosity and air-filled gaps they create. However, because of the enhanced connection inside the matrix, the thermal conductivity rises once more for larger fiber concentrations (1.5% and 2.5%) (Figure 8b). Additionally, the thermal conductivity at 0% fiber content is lower with 10% cement than it is without cement. This is probably because cement has a lower intrinsic conductivity than the bare soil matrix. The thermal conductivity further drops at 0.75% fiber content, but because of a denser and more interconnected structure, the thermal conductivity rises at 1.5% and 2.5% fiber content.

Compressive strength

It is evident that increasing the reinforcing level by roughly 0.75% raises the compressive strength to 6.32 MPa (Figure 9a). The compressive strength for the remaining percentages (1.5 and 2.5%) appears to decrease with further increase. Compared to the other sandy soils, clayey soils showed a greater

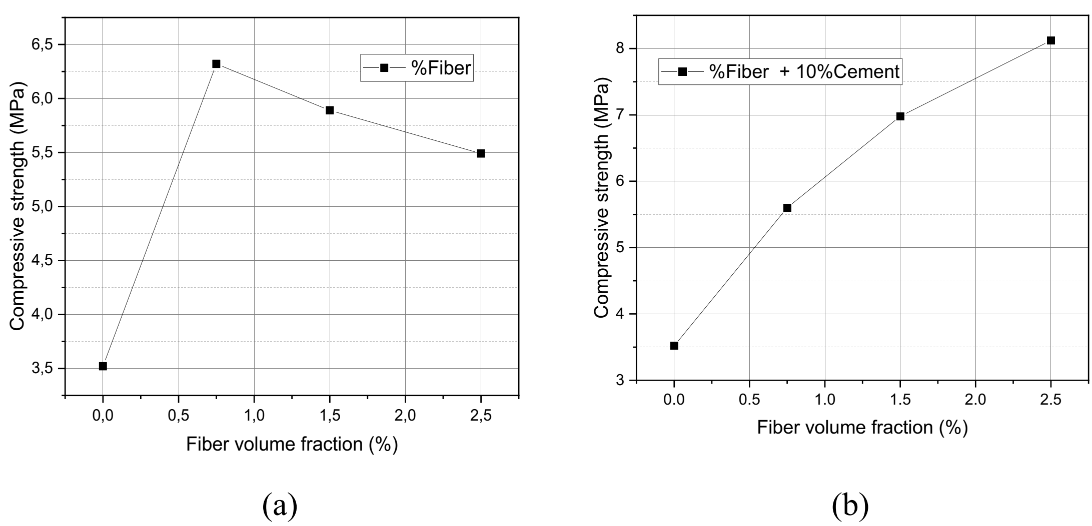

Figure 9. Compressive strength (a) the absence of cement and (b) with 10% cement.

degree of reinforcing efficacy (Bouhicha, Aouissi, and Kenai 2005). Without reinforcing, the earth bricks failed abruptly and brittle, with only one big break.

On the other hand, the bricks of earth reinforced by the AF fibers and 10% of cement show an improvement in the mechanical resistance to compression when the percentage of fiber is increased from 5.6 MPa to 8.12MPa for 2.5% of AF fibers (Figure 9b), which is due to the increasing quantity of C_2S and C3S. The increasing amount of $C_3S_2H_3$ which is derived from the hydration of the better bonded C_2S and C_3S fibers and soil particles within the mix, which strengthens it. It could be expected that a combination of cement and fibers would provide superior strength to the fibers alone (Namango 2006).

Flexural strength

Figure 10 shows the evolution of the flexural strength of Alfa fiber-reinforced earth blocks. An increase in flexural strength was observed for the fiber-reinforced blocks up to 0.80 MPa for 0.75% AF fibers. This increase is due to the role of the fibers as a reinforcement absorbing the tension and ensuring a strong connection among the fibers and the sediment. By serving as reinforcing agents and enhancing the material's capacity to bear loads without breaking, fibers boost flexural strength. The fibers' bridging effect, which reduces crack propagation and increases the material's ductility, is what causes the initial strength gain. Strength is further increased by adding 10% cement, which facilitates more effective load transfer by enhancing matrix cohesion and fiber adhesion. Because the structure of the material remains sufficiently consolidated and the advantageous effect of cement makes up for any loss of cohesion caused by an excessive fiber content, flexural strength does not decrease with increasing fiber content, in contrast to other properties like thermal conductivity or water absorption. For blocks recessed by fibers-10% cement, an increase in flexural strength of up to 1.69 MPa was observed for 0.75% AF fibers; this would be due to $C_3S_2H_3$ compounds caused by cement hydration. In general, a maximum Alfa fiber content of 0.75% offers the best flexural strength; probably, according to Eko (1994). The outcomes of this investigation align with the findings of Ziegler et al. (1998) and

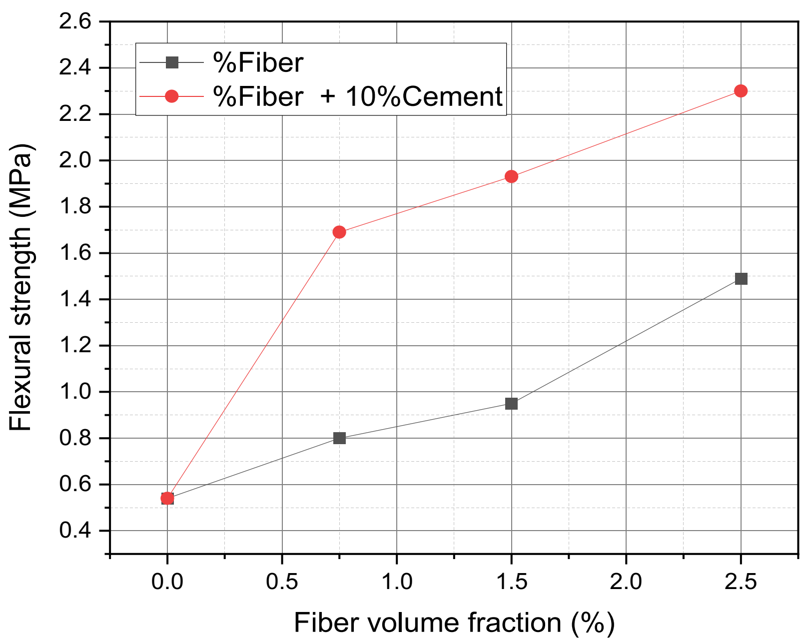

Figure 10. Flexural strength in the absence of cement and with 10% cement.

Millogo et al. (2014). The flexural strength of the fiber-reinforced samples was lower than that of the samples reinforced with fiber and 10% cement.

Materials made of fiber-reinforced earth are very resistant to cracking and the spread of cracks. This is because when the tension increases, the fibers resist cleavage at a potential cleavage plane. The mode of rupture of blocks stabilized and reinforced with F fibers and at different dosages are shown in Figure 11. On the other hand, the earth bricks reinforced with AF failed more ductilely and with more cracks. Simple examples failed abruptly, with only one central crack. It should be noted that the presence of AF fibers prevents sudden breakage of the blocks, creating an anchoring system between the two ends of the blocks, which is advantageous from a safety point of view.

Tests demonstrating notable gains in compressive and flexural strengths led to the decision to use 10% cement stabilization. Considering the high water absorption and minimal adherence of Alfa fibers, this dosage maximizes block longevity, even though (Taallah and Guettala 2016) estimate that 5–8% may be adequate. It improves dimensional stability, lowers porosity, and fortifies the fiber-matrix interface. Adding fibers increases mechanical strength; the effect is maximized when 10% cement is added. The strength reaches 8.12 MPa in compression, which is higher than that of BECs reinforced with banana fiber (6.58 MPa), which exhibit a comparable increase before hitting an ideal threshold. In bending, the maximum strength of 2.3 MPa is more than that of banana-fiber-reinforced BECs (1.2 MPa), demonstrating the efficacy of our strategy, especially when cement is added, which keeps performance steadily improving

One of the most important aspects of mechanical performance is fiber-matrix adhesion. The results obtained indicate that the fiber-matrix interface becomes less efficient when the fiber volume percentage above a particular threshold, resulting in greater capillary water absorption and shrinkage, indicating increased porosity. Poor matrix impregnation of the fibers is frequently blamed for this porosity, which encourages water penetration and speeds up material deterioration. Additionally, the existence of internal cavities may be connected to the observed rise in thermal conductivity, indicating a partial disbonding of the fibers within the matrix. The reduction in compressive strength indicates that these structural flaws interfere with the transmission of mechanical load, indicating that the fibers are no longer completely contributing to the composite's reinforcing. By increasing the volume proportion of fibers, the matrix may

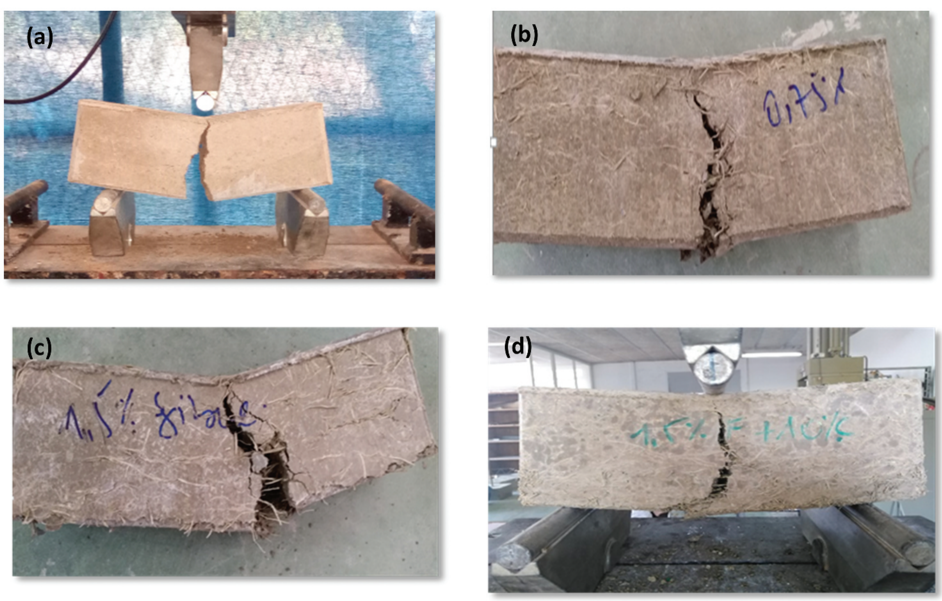

Figure 11. The mode of rupture of blocks stabilized and reinforced with AF fibers, (a) un-stabilized earth block, (b) reinforced with 0.75% AF fibers, (c) reinforced with 1.5% AF fibers and (d) reinforced with 1.5% AF fibers-10% cement.

become less impregnated, and the interfaces may become less cohesive due to an uneven distribution. Internal microcracks are more likely to form as a result of this lack of adhesion, and they have the potential to enlarge under mechanical stress and compromise the material's overall strength. These findings highlight how crucial it is to regulate the ideal fiber fraction in order to prevent internal flaws from forming and enhance interfacial adhesion.

Conclusion

The present work concerns the recovery and recycling of sediments from the Koudiat Acerdoune dam in the building industry for Alfa fiber manufacture reinforced earth blocks. Several important findings can be drawn from the experimental tests that were carried out:

(a) The stabilization of blocks with plant fibers shows interesting values for mechanical strength and physical properties, especially for blocks stabilized with 10% cement and 0.75% Alfa fibers.
(b) Analysis of the findings indicated that the fiber/cement formulations offered the best mechanical performance, with a flexural strength of 1.93MPa and a compressive strength of 8.12MPa for 0.75% Alfa fiber. These compositions best met the criteria for good compressive strength, 3-point flexural stress and heat conductivity.
(c) The addition of AF fibers at different dosages makes the blocks less heat-conductive.

Because of the experiments and in accordance with the chemical and geotechnical characterizations, recovering dam sediments can lessen the environmental impact. Finally, in terms of the use of dam sediments proposed in this work, it can be said that the sediments from the Koudiat Acerdoune dam constitute an important raw material for the manufacturing of stabilized blocks and other building goods. Nevertheless, accelerated aging experiments were not used in this investigation. In the discussion, we will elucidate this constraint and propose this approach as a viewpoint for subsequent research. In this way, we can contribute to solving major ecological and economic problems by preserving the environment and offering a new source of raw materials.

Highlights

- Earth bricks that are environmentally friendly are created by reusing dredged materials.
- Alfa fibers are added to improve the blocks' mechanical and thermal properties.
- The best mechanical strength and least amount of heat conductivity are found in blocks that include 2.50% fibers and 10% cement.
- Alfa fibers reinforced blocks are a sustainable and green building material.
- Elaborate earth compacted block specimens are appropriate as a construction material and provide excellent heat insulation.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Acknowledgement

The authors are extending their appreciation to Deanship of Scientific research, for financial support through Ongoing Research Funding program (ORF-2025-688), King Saud University, Saudi Arabia.

ORCID

Messaouda Boumaaza http://orcid.org/0000-0003-3349-2307
Ahmed Belaadi http://orcid.org/0000-0002-6059-3974

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