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Thermal and Mechanical Shock Testing of a Brick Wall and A Polystyrene Wall

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ABSTRACT

Polystyrene is one of the many novel materials being developed today. The goal of our research is to demonstrate that polystyrene is a good construction material in the El Oued region of Southeast Algeria. It can also be a strong rival for other building materials like brick. The results of our research, particularly in thermal testing, are very promising. Polystyrene is a better insulator than brick; the temperature of the polystyrene chamber varies between 26 and 27°C, whereas the temperature of the brick chamber varies between 36 and 37 °C. Polystyrene has a 5 times mechanical impact compared to brick. Despite its lack of availability in the region's markets, polystyrene is a strong rival to other materials such as brick.

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1. INTRODUCTION

El Oued city, in south-eastern Algeria, is a very hot area in summer and cold in winter. Is polystyrene acceptable for use in this environment? Since the area is sandy, the vertical construction is limited. Then what polystyrene is a lightweight material, it may be able to remedy this problem.

Houses are typically constructed with concrete as the primary structural element, particularly load-bearing concrete walls. Walls made of cement can be left uncovered or covered with different materials. Concrete would be used for the foundation, flooring, and even the roof structure of a concrete house. Studies on the history of cement and concrete were published in 2014 (Gagg, 2014). Clay houses are regarded as one of Algeria's most important structures. They feature high-sectioned earthen and timber flooring to adapt to the changing climate. Mud dwellings have been the subject of research thus far (Utama *et al*., 2012; Campbell *et al*., 2017). Plasterboard, also known as drywall, wallboard, or slate board in the construction industry, is typically used as a final coating for walls and ceilings. Plaster blocks are used in the construction of buildings in the same way as concrete blocks. To date, gypsum has remained an important construction material, and research teams are also interested in it (Kamarou *et al*., 2021; Wyatt & Goodman, 1992). The usage of container houses as an alternative to traditional houses since they are low in cost, quick to construct and prepare, but there is a lack in terms of aesthetics, and interest in the aesthetic view has grown over time. The first container homes were built by proprietary builders as do-it-yourself projects. Containers and container houses have become a new trend of development, and many locals have been built using this method. This form of the building has been supported by scientific investigations (Trancossi, *et al*., 2020; Tanyer *et al*., 2018; Sala *et al*., 2006; Abu-Jdayil *et al*., 2019). Wooden houses are used as safe places to rest and relax, as they help their owners break the routine and entertain themselves with green spaces and water sources, and their shapes and designs are changing. They can be made as simple huts with a classic, elegant and simple design. This type of construction with wood and very neglected in the European countries because this material is very available in the markets. This is why a lot of scientific studies are focused on studying this material either on the thermal side or on the mechanical side (Schieweck, 2021; Chand *et al*., 2020; Vestin *et al*., 2018). Prefabricated houses are well-known for their sturdy materials, which are both durable and simple to put together. It is also praised for its pleasing appearance and assurance of comfort. Furthermore, the design ensures thermal and bioclimatic comfort while also allowing for significant energy savings. Many builders and researchers are interested in this sort of construction. He is quite free in all of the world's countries (Masood *et al*., 2021; Li *et al*., 2019; Naji *et al*., 2021). Currently, the method of polystyrene blocks is preferred– known as Insulated Concrete Formwork (ICF) – to create her new eco-mansion. Houses made of polystyrene blocks put together like 'Lego' with space in between to pour concrete have been around since the 1970s. This sort of construction is relatively new, but it is beginning to catch the attention of construction corporations, who are also on the lookout (Dissanayake *et al*., 2021).

The objective of this research is to show that polystyrene can compete with other local building materials, particularly in terms of thermal insulation and mechanical shock resistance.

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2. METHODS AND EXPERIENCE

2.1. Building Materials

Wood, cement, aggregate, metals, bricks, concrete, and clay are the most frequent types of building materials used in construction, as indicated in **Figure 1**. The effectiveness and cost appropriateness of these are factors in their selection. Building materials manufacture is a well-established business in many countries, with certain specialist jobs such as carpentry, plumbing, roofing, and insulation being the most common.

Figure 1. Types of bonding building materials.

2.2. Preparation of Samples

All of the steps for creating our samples are listed in **Table 1**. All of the steps were completed at the level of the University of El Oued's civil engineering laboratory. The objective of this preparation is to make several samples to test them later.

Table 1. Preparation stages.

	A piece of polystyrene and some bricks with dimensions (10 * 20 *30) cm

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Table 1 (continue). Preparation stages.

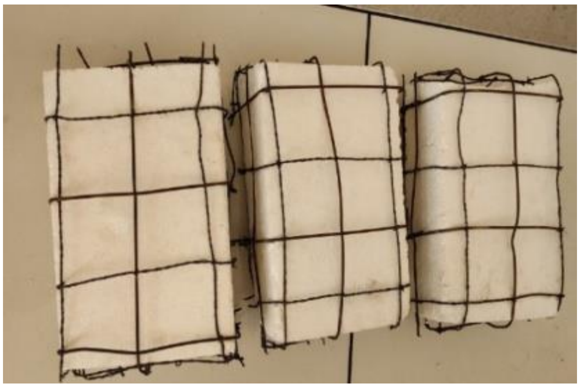
	Cutting the piece of polystyrene keeping the same dimension as the brick
	The piece of polystyrene has become blocks like a brick
	The polystyrene blocks are covered by the construction grid
	The two polystyrene and brick blocks are covered with cement. The cement is dried at room temperature

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Table 1 (continue). Preparation stages.

	This room is the objective of our work. This construction phase is just before coating the walls with cement.

3. RESULTS AND DISCUSSION

3.1. Thermal Study

This research is being carried out to determine the thermal resistance of the two materials and to compare them in terms of charge and discharge. A wall separates two rooms as shown in **Figure 2**. Room 1 has a heating source that heats it, whereas Room 2 is kept at room temperature. There will be heat transmission because there is a temperature differential between the two chambers.

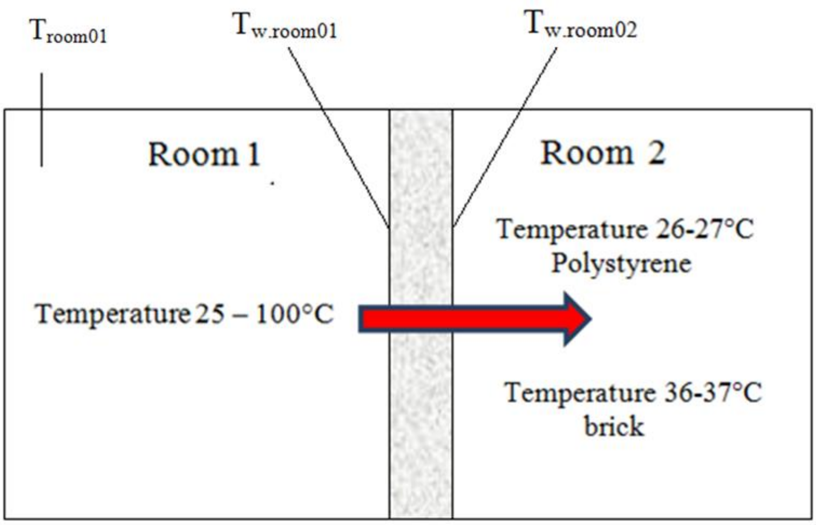

Figure 2. Thermal test.

3.2. Thermal Load In the Brick Wall

Figure 3 shows the temperature of room 02, caused by a heating source in room 01, as well as the temperature variations on each side of the walls, as a function of time. Temperature readings are taken every 30 minutes from 9:00 to 14:30. We see that the temperature of room T_{room01} and the brick wall $T_{w.room01}$ rises throughout the experiment, peaking at 14:3 with a temperature of about 97-99°C, whereas $T_{w.room01}$ rises gradually between 9:00 and 11:30. There is a period of stability from noon to 14:30, with temperatures $T_{w.room02}$ ranging between 36 and 37 °C.

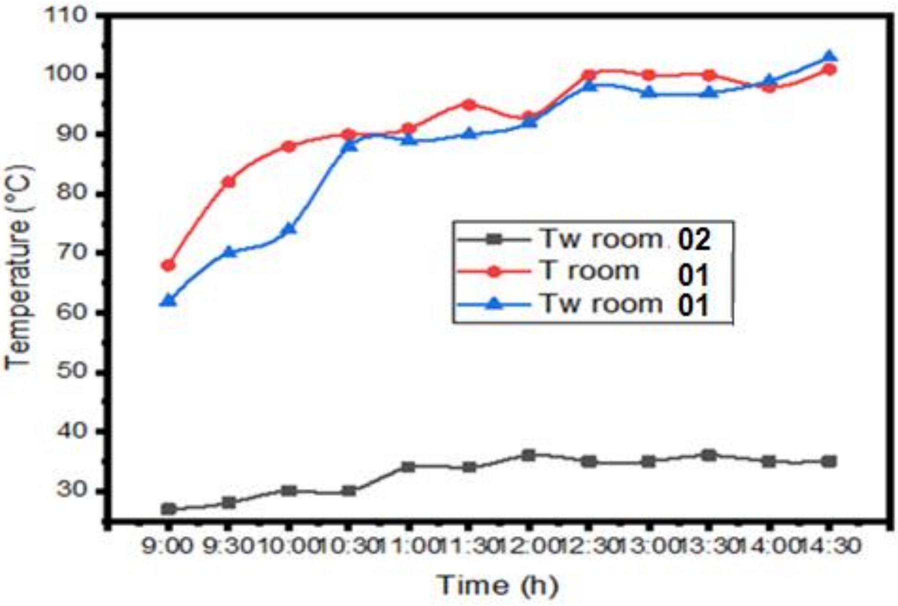

Figure 3. Temperature evolution via a brick wall.

3.3. Thermal Load In the Polystyrene Wall

Figure 4 depicts the evolution of room 01's temperature and the temperatures of the walls over time. Around 14:30, we note that the two temperatures $T_{wroom01}$ and T_{room01} rapidly climb until they reach maximums of 100 and 85°C, respectively. While the temperature of room 02 $T_{w. room02}$ wall appears to be almost perfectly stable, that was between 09:00 and noon, which the temperature ranges from 25 to 27°C. Perfect stability is observed between midday and 14:30, with a fixed temperature of 27°C, with a fixed temperature of 27°C.

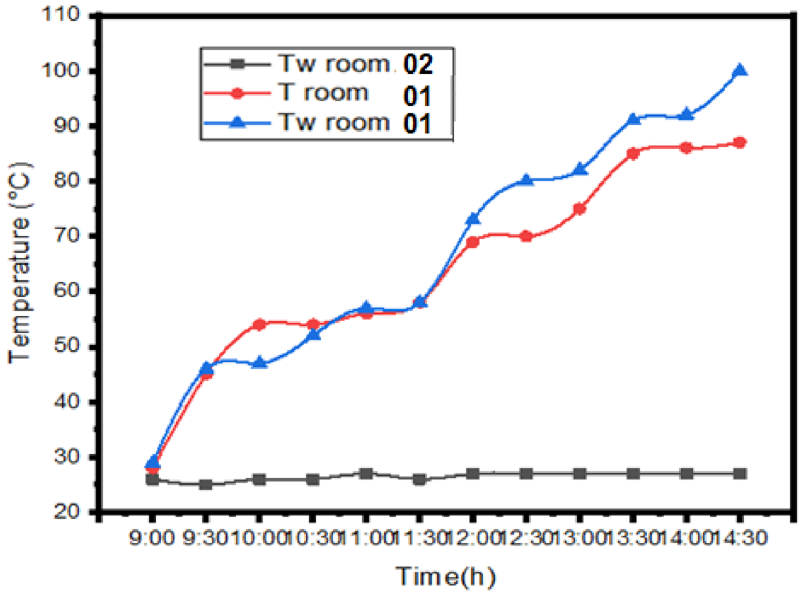

Figure 4. Temperature evolution of the outer room and the wall.

3.4. Thermal Unloaded

Figure 5 represents the variation of the temperature on either side of the wall of the polystyrene as a function of time. We notice that the cooling of the wall is rapid. The temperature drops from 90 to 35°C in a period that varies between 15:00 and 16:00. We also

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notice that the temperature $T_{w.\ room01}$ is stable and varies between 26 - 27°C. **Figure 6** represents the evolution of the temperature on both sides of the brick wall and that as a function of time. There is a rapid degradation of the temperature $T_{w.\ room01}$ while the variation in temperature $T_{w.\ room02}$ is not stable and the variation is between 34 - 37 °C.

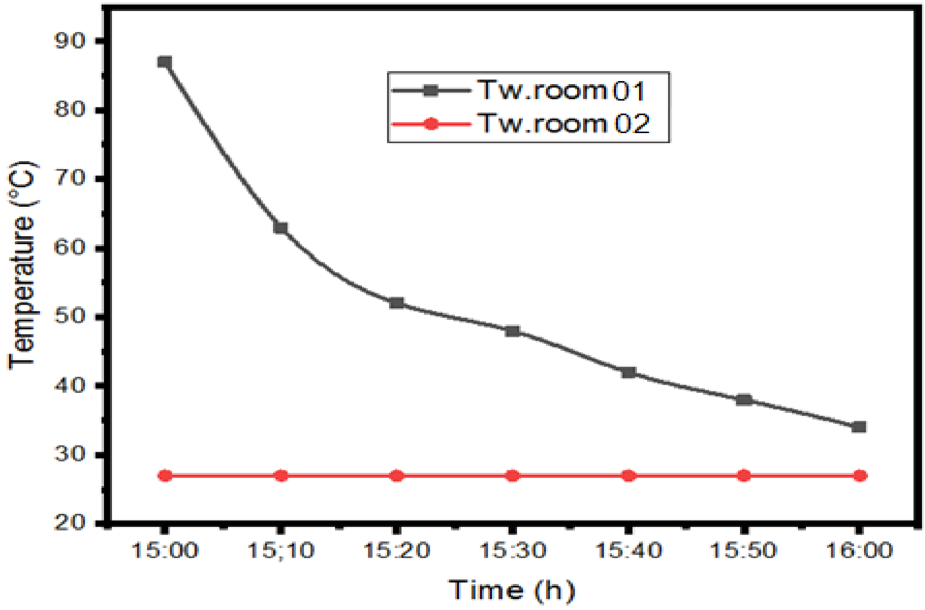

Figure 5. Temperature evolution of either side of the polystyrene wall.

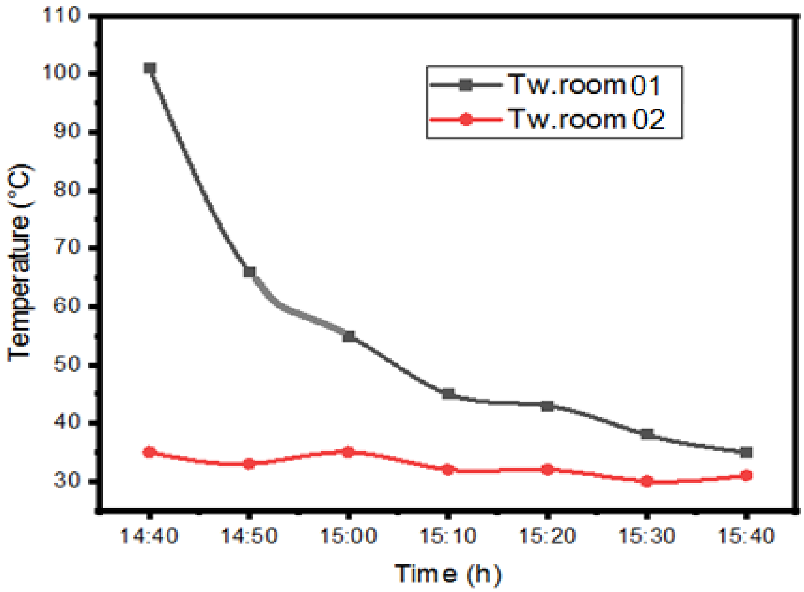

Figure 6. Temperature evolution of either side of the brick wall.

3.5. Shock Results

Our materials are tested by a metal hammer. A mass was projected onto the sample like a pendulum to test the impact resistance. **Figure 7** represents the behavior of the materials as a function of the number of strokes of the hammer.

(i) In the brick block, we noticed after the 3rd hammer hit the brick starts to break, and on the 10th hit it is completely broken as shown in **Figure 7**.

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(ii) In the polystyrene block, we noticed that there is a small hole in the mass-block contact surface and that after 50 strokes. There is no sign of breaking as shown in **Figure 7**.

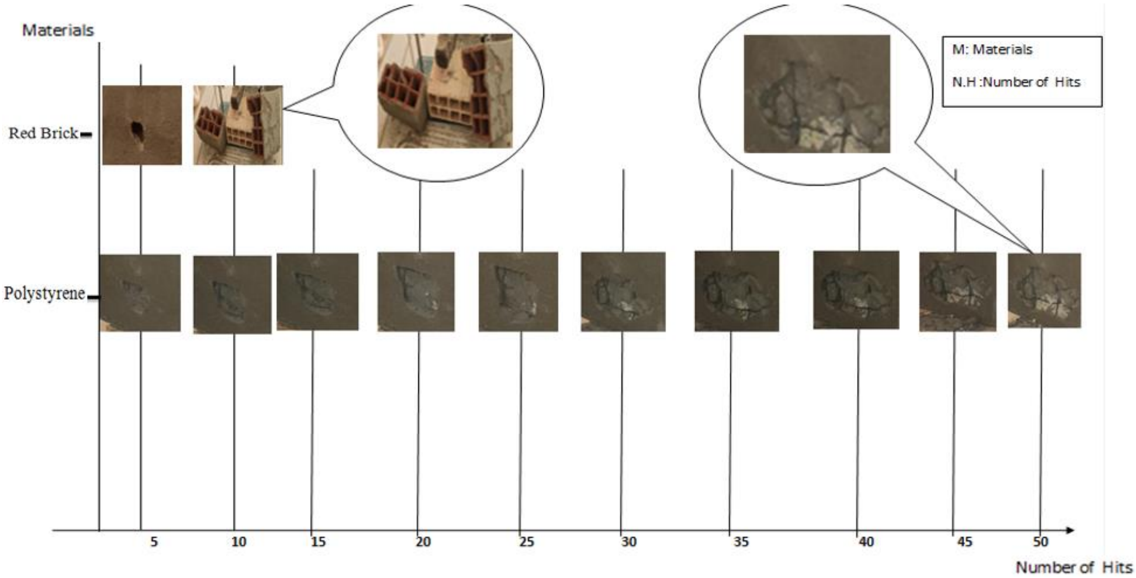

Figure 7. The behavior of the material tested by shock.

3.6. Discussion

Table 2 brings together the results of our study, it shows that:

(i) Polystyrene is more insulating than brick.
(ii) Polystyrene is more stable in temperature discharge than brick.
(iii) The polystyrene withstood 50 hits without this breakage and without showing any sign of breaking, but the brick did not resist on the 10th hit.

Table 2. Result comparisons.

Materials	Temperature Stability of The Room in Charge	Temperature Stability of The Room in Discharge	Mechanical Impact
Polystyrene	25 – 27°C	Stable	Not broken at the 50th hits
Brick	35 – 37°C	disable	Broken in 10th hits

4. CONCLUSION

The objective of our work is to show that polystyrene material is a good material for construction in the region of El Oued south-eastern Algeria. It can also be a good competitor for other materials used in construction such as brick. The results obtained in our work are very encouraging either in the thermal field or in the mechanical field:

(i) With a temperature difference of 10°C, the polystyrene wall is more insulating than the brick wall.
(ii) The impact resistance of polystyrene is more than 5 times greater than brick.

Based on the results found in this work, we can say that polystyrene is a construction material of choice for the region of El Oued, and it is a very good competitor to other materials such as bricks from the point of view of thermal and mechanical resistance.

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5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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