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Université Echahid Hamma Lakhdar d'El-Oued

FACULTE DE TECHNOLOGIE  
DEPARTEMENT DE GENIE CIVIL

Mémoire de fin d'étude

Présentée pour l'obtention du diplôme de

**MASTER ACADEMIQUE**

Domaine : Sciences et Technologies

Filière : Génie civil

Spécialité : Génie civil

**Thème**

**Etude comparative entre une chambre en brick rouge et  
en polystyrène**

Devant le jury composé de :

Dr. Fouzi Masmoudi	Examineur	Présentée par les étudiants : - Bassou Karima - Khatraoui Seif Eddine - Labidi Sara
Dr. Rafika Hachem	Examineur	
Dr. Abderrahmane Khechekhouche	Encadreur	

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## Dedication

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روح أبي الطاهرة رحمه الله وأسكنه فسيح جناته, الذي نحت على صدري معاني الكد والإجتهد وحقق بين ضلوعي حب العلم والعمل كان لي خير سند في كل خطوة اخطوها لم يبخل عليا بحبه وعطاءه وحنانه .  
من أضاءت مذكرتي بنوري عينيها رمز الحب والعطاء أجمل ما أهداني رب السموات والأراضي, إلى حضن الأمان ومنبع الحنان وتحت قدميها جنان الرحمان.

أمي الغالية حفظها الله

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رفقائي في المذكرة: (سارة لعبيدي, سيف الدين خطر اوي) .

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إلى كل طلبة دفعة جوان 2021

كريمة باسو

# اهداء

بسم الله الرحمن الرحيم

وَقُلِ اعْمَلُوا فَسَيَرَى اللَّهُ عَمَلَكُمْ وَرَسُولُهُ وَالْمُؤْمِنُونَ " "

صدق الله العظيم

الهي لا يطيب الليل إلا بشرك ولا يطيب النهار إلا بطاعتك ولا تطيب اللحظات إلا بذكرك ولا تطيب الجنة إلا برويتك

إلى من بلغ الرسالة و أدى الأمانة إلى نبي الرحمة ونور العالمين سيدنا محمد صلى الله عليه و سلم  
إلى من جرع كاس فارغا ليسقيني قطرة حب إلى من حصد الأشواك عن دربي ليمهد لي طريق العلم  
إلى القلب الكبير

إلى السراج الذي لا ينطفى نوره أبدا والذي بذل جهد السنين من اجل أن اعتلي سلالم النجاح والذي  
العزير

" كمال الدين "

إلى منبع الحنان والتفاؤل و الأمل إلى كل من في الوجود بعد الله ورسوله إلى ملاكي وبسمة في  
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# General Introduction

## **Introduction**

The construction sector used a lot of natural resources and was also responsible for a lot of energy use. This is likely to rise further as the economy develops, resulting in an increase in the number of people in need of decent accommodation. As a result, any building material that uses natural resources sparingly or recycles trash to some level could have a promising future. This study looked at a new wall technology that employs recycled expanded polystyrene (EPS) to make lightweight aerated concrete panels. A comparison study of a polystyrene wall and a red brick wall found that the prefabricated polystyrene panel can be a good competitor and so has the potential to become a common wall material.

The objective of our work is to prove that the polystyrene material can compete with other construction materials and that this material can solve many construction problems in the region of El Oued south-eastern Algeria.

The region of El Oued south-eastern Algeria is a very hot zone in the summer and cold in the winter. The question arises, is polystyrene good for this region?

The region of El Oued is sandy and vertical construction is unlimited. Can polystyrene solve this problem since this material is light.

In this study there are 3 chapters:

- The first chapter is devoted to different materials and different construction methods referred with some scientific studies.
- in the second chapter, we proposed the preparation of the samples in red brick and in polystyrene in the civil engineering laboratory of the University of El Oued.
- in the third chapter, we present our experimental results on the samples i.e. the results of thermal test and mechanical tests.
- Finally, we will end this dissertation with a general conclusion which summarizes the results obtained and sets out some research perspectives envisaged.

# Chapter I

Different building materials of houses

## I.1. Introduction

The most common types of building materials used in construction are wood, cement, aggregate, metals, bricks, concrete and clay as shown in Figure I.1.

The selection of these depends on their effectiveness and cost appropriate to the projects.

Many man-made products are used, some more and less synthetic.

Building materials manufacturing is a well-established industry in many countries and its use is usually divided into specific specialized occupations, such as carpentry, plumbing, roofing and insulation.

This reference deals with structures and structures including homes.



Figure I.1.Types of bonding building materials

## I.2. Most famous types of house

When searching for your new place, the first thing you must do to narrow your search is to know what type of house structure you are looking for. Here are the most popular types you'll talk about

### I.2.1. Cement house

A cement house is a home that is built with concrete as its primary structural element, specifically with concrete bearing walls as shown in Figure I.2. Cement walls can be exposed or faced with other materials. The foundation and floors would be made of concrete and even the roof structure of a cement house can be concrete. A study done in 2014 which speaks about the history of cement [1,2]. Table I.1 summarizes the advantages and disadvantages of this type of construction.



Figure I.2. Cement brick house

Table.I.1. Advantages and disadvantages of cement houses

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• The opportunity to build at any time of the year,</li> <li>• Variety of layout options,</li> <li>• Possibility of exterior decoration of houses with any material,</li> <li>• Fire protection</li> <li>• Lower material cost</li> </ul>	<ul style="list-style-type: none"> <li>• Weak heat insulation.</li> <li>• Low noise isolation</li> <li>• Heavy weight plates</li> </ul>

### I.2.2. Clay house

The clay houses as shown in Figure I.3., are considered one of the most important houses in the Iraqi groups and are also found in the mountainous provinces of Vietnam and Algeria. They have the advantage of the technical side, the bridge stone wall, the patchwork wooden frame method, the houses have earthen and wood floors and a high section to suit the environmental conditions. Until now studies are done on clay house [3, 4]. Table I.2 summarizes the advantages and disadvantages of this type of construction.



Figure. I.3. Building a Clay mosque

Table. I.2. Advantages and disadvantages of clay houses

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• Ease of preparation and construction operations with this material, using a minimum of simple machines and tools</li> <li>• The presence of this substance in most of the implementation sites, which contributes to the building permits in them</li> <li>• Diversity of construction method</li> </ul>	<ul style="list-style-type: none"> <li>• Weakness of the clay material to resist the impact of water badly resulting from rain and torrents or rising from floors and bases through the capillary property,</li> <li>• The relative weakness of the clay material makes it unsuitable for supporting heavy roofs</li> <li>• Significant erosion of clay material surfaces; As a result of various environmental influences; Rain and winds loaded with sand, which contribute to the weakness of the durability of this material, and requires constant repair and maintenance.</li> </ul>

### I.2.3. Gypsum house

Gypsum board is mainly used as a final coating for walls and ceilings, and is known in construction as drywall, wall panels or slate sheets. Gypsum blocks are used like concrete blocks in building construction as shown in Figure I.4. Gypsum remains an important building material until now and research teams around the world are interested in this material [5-7]. Table I.3 summarizes the advantages and disadvantages of this type of construction.



Figure I.4. Gypsum housing

Table. I.3. Advantages and disadvantages of Gypsum housing

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• The speed of its implementation, and ease of disassembly and use.</li> <li>• Low financial cost and light weight compared to other alternatives.</li> <li>• Safe, flame retardant, fireproof and moisture proof decor.</li> <li>• Durable and sturdy panels.</li> <li>• It controls the height of the ceilings, and it does not leave any impurities and dirt like normal gypsum</li> </ul>	<ul style="list-style-type: none"> <li>• Votes are allowed to run out.</li> <li>• Lack of stability compared to a normal ceiling.</li> <li>• One of the main disadvantages of gypsum board suspended ceilings is that they are sometimes subject to wear and tear</li> </ul>

## I.2.4. Container house

The use of container houses as an alternative to traditional houses, as they are low in cost, fast to accomplish and prepare, but in terms of aesthetics, there is a deficiency in this, and with the passage of time the interest in the aesthetic view became very strong. The original container homes were DIY projects by proprietary builders. Containers and container houses have become a new fashion for construction and many locals are designed with this type of construction. Scientific studies support this type of construction [8-11].

### House from a large container

From a large 40 or 45 feet container, you can build a tiny home. However, we must bear in mind that its interior, excluding finishing, will be 31.55 m<sup>2</sup> and 27.95 m<sup>2</sup>, respectively. Such a design is more suitable for a summer residence, as a guest option. Single people, families without children, and retirees will be able to live there permanently



Figure I.5. House room a large container

**home from a small bowl**

By installing on your site 20, 30-foot blocks, you can get a small residence of 13.67 sq.m and 20.81 sq.m. To organize the living space in this case is much more difficult. We will have to save everything as shown in Figure I.6.



Figure I.6. House from a small container

### Country house for containers

It has been used for several functions including storing garden equipment, its area is 10.67 sq.m., 19.81 sq.m. Very comfortable in summer. It is characterized by a great abundance of jobs and good fields in construction as shown in Figure I.7.



Figure I.7. Country house compact container

#### I.2.4.1. Stages of construction of a container house

- The construction of houses from containers is no different from the usual construction as shown in Figure I.8



Figure I.8 Container house from the inside

Home building starts with the foundation. In this regard, the construction of houses from containers does not differ from the usual construction

Preparing the foundation and Container installation

### **Preparing the foundation:**

This is the foundation in Figure I.9, on which the construction is being built and the strength and durability of the building depends on the quality of the building. Foundation construction is high price. For container houses, a strong foundation is not required due to the small weight of the structure. For a one-story building, it is enough to use foundation blocks and lower them into the ground. But design designs and multi-storey buildings require a well-tape reinforced base



Figure I.9. Preparing the foundation

### **Container installation**

The pit is prepared for the installation of the foundation according to the design data. Formwork and reinforcing cage are installed, concrete mixture is poured. When forming the foundation, concrete is compacted with special equipment. Then the technological pause begins, and the time is given to complete freeze completely, it is not less than 22 days



Figure I.10. Container installation

**Thermal insulation of the Container house (Internal or external )**



Figure I.11. Example of wall insulation with foam plasti

Work on insulation of the container is no different from the usual warming of the house. Initially, a cage is installed and filled with a heater. Heater, mineral wool, foam and other materials are used. When creating this type of housing, especially if it is supposed to spend a large part of time, you should not save on warming, it is better to achieve it with a certain stock



Figure I.12. Use of mineral wool to insulate the exterior walls of the house

The facade can be finished with decorative bricks, plastered and painted, covered with natural stone. When using paint and varnishes, special paints are used that are resistant to high and low temperatures and their differences. By using siding panels or siding to cover the building from the outside, you can also insulate the buildings. The materials available in the trade network can be painted in different colors and differ in quality. These qualities make it possible to choose the materials perfectly so that the building blends well with the landscape design and matches the style chosen by the architect

**Internal insulation :**

For interior decoration, you use drywall, plywood, USB boards. to be more correct to install them coating you , you use stretch ceilings, plasterboard paint the wood. The paint on the walls also uses the same materials you used in ordinary homes: wallpaper and gypsum. The floor is covered with linoleum, parquet, tiles.

**External insulation :**

Great way to protect against penetrating damp, creating a new weatherproof layer outside of the building, and slowing the movement of heat through the walls. advantage of solid wall insulation is that it will cause the temperature to rise. This means if there is lots of water vapour in the air this will no longer condense on these walls. Table I.4 summarizes the advantages and disadvantages of this type of construction.

Isolation d'une façon générale est l'objet de recherche de plusieurs laboratoires dans le monde. Beaucoup des recherche sont concentrés sur ce sujet [13]. Table I.4 summarizes the advantages and disadvantages of this type of construction.

Table I.4. Advantages and disadvantages of Container house

Advantages	Disadvantages
<p><b>Strength and durability:</b> Shipping containers are designed to be stacked in tall columns, carrying heavy loads. They are also designed to withstand harsh environments, such as on ocean-going vessels or sprayed with road salt when transported on roads.</p> <p><b>Modular :</b>Due to the modular design of the containers, additional construction is as easy as stacking more containers. They can be stacked up to 12 units high when empty.</p> <p><b>Labor:</b> Welding and cutting steel is considered a skilled labor and can increase construction expenses, but overall it is still lower than in conventional construction. Unlike wood frame construction, the fasteners have to be welded or drilled into the outer skin, which takes longer and requires different jobsite equipment.</p> <p><b>Transport:</b> Because they already conform to standard shipping sizes, prefabricated modules can be easily transported by boat, truck, or train.</p> <p>AvailabilityDue to their widespread use, new and used shipping containers are available worldwide.</p> <p><b>Free:</b> One of the main advantages of buying container homes is that they are quite affordable. Depending on the requirements and the materials used, a container house will cost you less than traditional houses [1]</p> <p><b>Respectful of nature:</b> A 40ft shipping container weighs over 3,500 kg. When upgrading shipping containers, thousands of kilograms of steel are saved. In addition, when building with containers, the amount of traditional building materials needed reduced.</p>	<p><b>Temperature</b></p> <p>Steel conducts heat very well; containers used for human occupancy in an environment with extreme temperature variations will normally have to be better insulated than most brick, block or wood structures.</p> <p><b>Humidity</b></p> <p>As noted above, single wall steel conducts heat. In temperate climates, moist interior air condenses against the steel, becoming clammy. Rust will form unless the steel is well sealed and insulated.</p> <p><b>Construction site</b></p> <p>The size and weight of the containers will, in most cases, require them to be placed by a crane or forklift. Traditional brick, block and lumber construction materials can often be moved by hand, even to upper stories.</p>

### **I.2.5. Wooden house**

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 as shown in Figure I.13. 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 in the thermal side or in the mechanical side. [14-16]. Table I.5 summarizes the advantages and disadvantages of this type of construction.



Figure I.13. Simple log cabin in elegant classic design

#### **Stages of construction of a wooden house**

The construction phase includes the steps in which the main and clear parts of the house are raised, namely:

**Walls:** The walls of wooden houses are built by stacking wood on top of each other and aligning their corners and arranging them so that the wall rises straight in a straight line, some wood may arise in the wall due to its weight and load on it. Wood must be chosen so that it can bear the weight in addition to lining the walls correctly .

**Roof:** Wooden ceilings have many shapes. To protect the house from various environmental elements, the classic log house often consists of a low sloping roof with sharp edges that rise to the end of the projection, as its design resembles the head of a triangle.

**Entrances and windows:** doors and windows are installed after finishing the walls so that their openings are installed in the walls in the previous step, then put the windows and doors in their correct place, taking in to account some important factors when choosing their locations, including the direction of the sun's rays. , In addition to passive solar heating due to its temperature. Wind direction and intensity according to the nature of the climate in the place in winter. Anticipate the possibility of the roof collapsing or falling in to the openings.

Table I.5 .Advantages and disadvantages of Wooden house

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• Flexural strength and</li> <li>• Resistance to tensile forces</li> <li>• Tear resistant               <ul style="list-style-type: none"> <li>• A great strength of tenacity.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Rotting of the wood, and therefore</li> <li>• Short durability of the structures</li> <li>• Fire safety</li> </ul>

### I.2.6. Prefabricated house

Prefabricated house is rather recognized for its robust material, solid and easy to combine. Also, it is also appreciated for its aesthetic result and its guarantee of comfort. In addition, the construction guarantees thermal and bioclimatic comfort, also allowing significant energy savings as shown in Figure I.14. This type of construction is of interest to many builders and many researchers as well. He is very abandon in all the countries of the world [17-19].



Figure I.14. Assembling a prefabricated wooden house

### **I.2.6.1. Stages of building a prefab house**

Prefabricated house is rather recognized for its robust material, solid and easy to combine as shown in Figure I.15. Also, it is also appreciated for its aesthetic result and its guarantee of comfort. In addition, the construction guarantees thermal and bioclimatic comfort, also allowing significant energy savings.



Figure I.15. Prefab house with sandwich panels

**Steel structure:**

The iron structure is built on a concrete base with different thicknesses ranging from 10 cm thickness to 40 cm thickness supported by steel reinforcement to maintain its durability and solidity.

**External wall:**

After the construction of the iron structure, the wall panels are built and installed as shown in Figure I.16, which are usually panels of insulation covered with an outer layer of resistance to rain and moisture from aluminum material or a cement board material or high-resistance plastic and the exterior decoration is carried out accordingly.



Figure I.16. Installation of precast concrete walls

**Roof:**

After installing the exterior wall, the ceiling of the prefab house or the prefab room is installed, and the appropriate design and shape for the exterior ceiling can be chosen, where aluminum panels can be installed with high resistance to environmental factors, or a high-quality ceiling can be installed such as Spanish or Italian tiles, which gives the decoration an aesthetic view.

**Interior finishing:**

The internal finishing works are started by installing high-strength gypsum board panels for interior walls and walls, and their thickness ranges from 12 mm to 20 mm.

**Finishing stage:**

After that, the interior foundation is made and the interior decoration is painted in accordance with the proposed design .

-After that, the building's floor decorations are established and installed according to the required specifications, and floors can be installed.

-Parquet wooden or porcelain tile flooring or ceramic upon request, and installed with the finest materials. Table I.6 summarizes the advantages and disadvantages of this type of construction.

Table I.6. Advantages and disadvantages of Prefabricated house

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• <b><u>Costs</u></b>: Prefab homes are less expensive than a regular home, for example prefabricated concrete houses cost 50% less than the cost of building a brick house.</li> <li>• <b><u>Speed</u></b>: The speed of building prefabricated houses in some countries takes between (3 to 6) weeks, while brick houses take approximately 90 days.</li> <li>• <b><u>Maintenance</u></b>: In the case of wooden installations, immediate maintenance must be continued in order not to rot, but houses that are not made of wood need maintenance every 5 years, like traditional brick houses.</li> <li>• <b><u>Solidity</u></b>: Prefab houses are distinguished by their strength and durability to various climate factors, and they do not collapse in the event of earthquakes like traditional homes, it is possible for an earthquake to shake or displace them without demolishing them.</li> </ul>	<ul style="list-style-type: none"> <li>• The presence of joints between the wall units, and this is the most important problem facing the pre-fabricated building system.</li> <li>• Not suitable for buildings whose exterior appearance requires non-repetition.</li> <li>• As for the unit size used in prefab construction.</li> </ul>

### I.2.7. Polystyrene house

Houses built of polystyrene blocks fitted together like 'Lego' with space in between to pour concrete have been around since the 1970s. ... ' Beeny opted for the polystyrene block method – known as Insulated Concrete Formwork (ICF) - to build her new eco-mansion as shown in Figure I.17. This type of construction is very recent it is starting to attract the attention of construction companies and is also looking for them [20].



Figure I.17. Stages of building a Polystyrene house

## Stages of building a Polystyrene house

Stage 1. Tools, materials. The work will require:

- foam blocks;
- finishing material;
- sand;
- wires, pipes;
- metal fittings o12 mm;
- steel wire for bundles;
- cement "six hundred" grade;
- water;crushed stone;
- concrete mixer.

Table I.7 summarizes the advantages and disadvantages of this type of construction.

Table I.7. Advantages and disadvantages of Polystyrene house

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• <b>Cheapness:</b> This method of construction is one of the most budgetary;</li> <li>• <b>Speed:</b> It is possible to build houses from polystyrene foam and finish it in a week, without taking into account the construction of the foundation;</li> <li>• <b>Earthquake resistance:</b> As tests have shown, no earthquakes are afraid of the dome structure;</li> <li>• <b>Easy assembly:</b> Build a house with your own strength for every beginner.</li> <li>• <b>Minimum heating costs:</b> Due to the low thermal conductivity of the material, such houses turn out to be very “warm” and energy-saving;</li> <li>• <b>The possibility of expanding the are:</b> .If necessary, you can finish building outbuildings.</li> </ul>	<ul style="list-style-type: none"> <li>• <b>Suitable only for temporary residence:</b> Foam houses can only be considered as housing for temporary residence;</li> <li>• <b>Low strength:</b> Styrofoam walls, even reinforced ones, are not able to fully protect housing from intruders.</li> </ul> <p>A foam house can be used in agriculture, for example, as a vegetable store, hangar, greenhouse, etc.</p>

### **I.3. Conclusion**

In this chapter we have represented the different building materials and the different old and recent methods of building houses. We have also shown some scientific and academic studies concerning each method. In the following chapters, we will focus on the construction method based on polystyrene.

# Chapter II

## **Methodology**






## II.1.Introduction

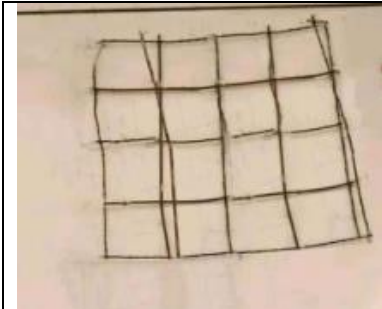
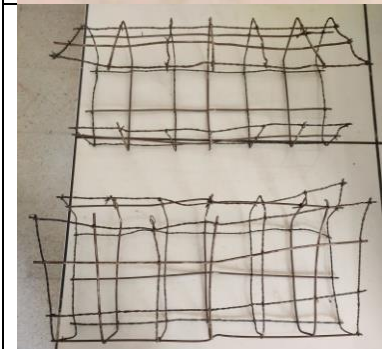
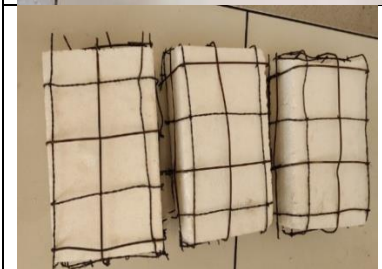



In this chapter we will deal with the construction materials first used in our study. Polystyrene samples will be prepared that have the same dimension as the brick blog. Both samples will be prepared to build a 3 x 3 meter wall. This section will also talk about measurement and control equipment are neglected their operation in the field of civil engineering.




## II.2. Preparation of samples

In Table II.1, where are all the steps to build our samples. All the steps so that we were done at the level of the civil engineering laboratory of the University of El Oued.

Table II.1. Construction stages

		<p>Preparation of used samples is as follows:</p> <p>Polyester sheet with dimensions (10 * 20 * 90)cm</p> <p>Three bricks with dimensions (10 * 20 *30) cm</p>
		<p>Stage 2:</p> <p>The polyester sheet is cut to the same dimensions as the bricks in a regular and flat manner by a hand saw.</p>
		<p>Stage 3:</p> <p>We take samples of polystyrene, after cutting, so that they take the form of bricks</p>

		<p>We prepare an iron grid with a diameter of 6 mm, where the dimensions of the squares are (5 x 5) cm</p>
		<p>We need 3 pieces of the network according to the samples To be studied and folded with a machine, and care must be taken to preserve its dimensions.</p>
		<p>After the net is folded, the polyester samples are then placed inside the net and fixed well tightly</p>
		<p>We weigh the samples on the grid before coating, and find the following weights of reinforced polyester: Sample 1: 394 g Sample 2: 381 g Sample 3: 384 g Brick weight: 3470 g</p>
		<p>Weigh the necessary quantities of cement, sand and water: Sand weight: 1992 g Cement weight 1329 g Water volume: 600 cm<sup>3</sup></p>
		<p>Tools used: Mixing bowl Electronic balance Spoon for mixing Included bowl Gloves</p>

		<p>We put the ingredients in the bowl and then mix them homogeneously</p>
		<p>Regular coating of samples (polyester + brick) from all sides with smooth surfaces Samples shall be kept after plating in a place where the humidity is not less than 90% and the temperature ranges between (15-20) degrees Celsius for a period of 24 hours.</p>
		<p>After hardening the samples we weigh it</p>

## II.3. Mesuring Equipments

### II.3.1. Sclerometer

It is a device as shown in Figure II.1, it is used to measure the properties of elasticity or strength in concrete or rocks, mainly surface hardness and penetration elasticity. It was invented by the Swiss engineer "Ernst Schmidt" so that referring to the conversion diagram, the value of the rebound can be used to determine the compressive strength.



Figure II.1. Sclerometer

### II.3.1.1.Principle of Sclerometer

The work of the device is based on the theory that the recoil force of an elastic mass depends on the strength of the surface on which it collides. The operating steps of this measuring device are as follows

1. By lightly pressing the device button, the plunger head comes out.
2. The device is placed perpendicular to the place to be tested and then pressed, the head slips into the device and before it disappears, the hammer is loosened and a knock on the head occurs (shock).
3. When a shock occurs, the device must be completely perpendicular to the tested surface and not touch the Button on the device.
4. Upon impact, the hammer will rebound in proportion to the hardness of the surface being tested, and drive a pointer that moves on a scale to set the value of the recoil.
5. The device is moved to another point and the process is repeated.
6. After work is completed, the device is returned to its original position by placing the head inside the device.
7. The part to be tested is determined and the points are located on it, then an area of 30 cm \* 30 cm is determined for each point.
8. Smoothen the area 30 cm \* 30 cm, and take 12 readings within the male area at least.
9. For each point, we calculate the average number of its retracement after removing the anomaly from it (the anomaly is more or less than the mean by 5 degrees).
10. Bounce number - a number that appears on the screen of a hammer that depends on the strength and hardness of the surface and thus determines its resistance.
11. After that, the rebound number of each point is converted into compression resistance using special tables, then the average pressure resistance of all points is calculated.

### II.3.1.2. Reading of Sclerometer

To get an idea on how to read the values of Sclerometer. The values found experimentally on the measuring device are projected on Figure II.2 to find the corresponding values in mega Pascal.

Note that there are two lines in the Figure, one for horizontal measurements ( $\alpha = 0$  degree) and another for vertical measurements ( $\alpha = 90$  degree)

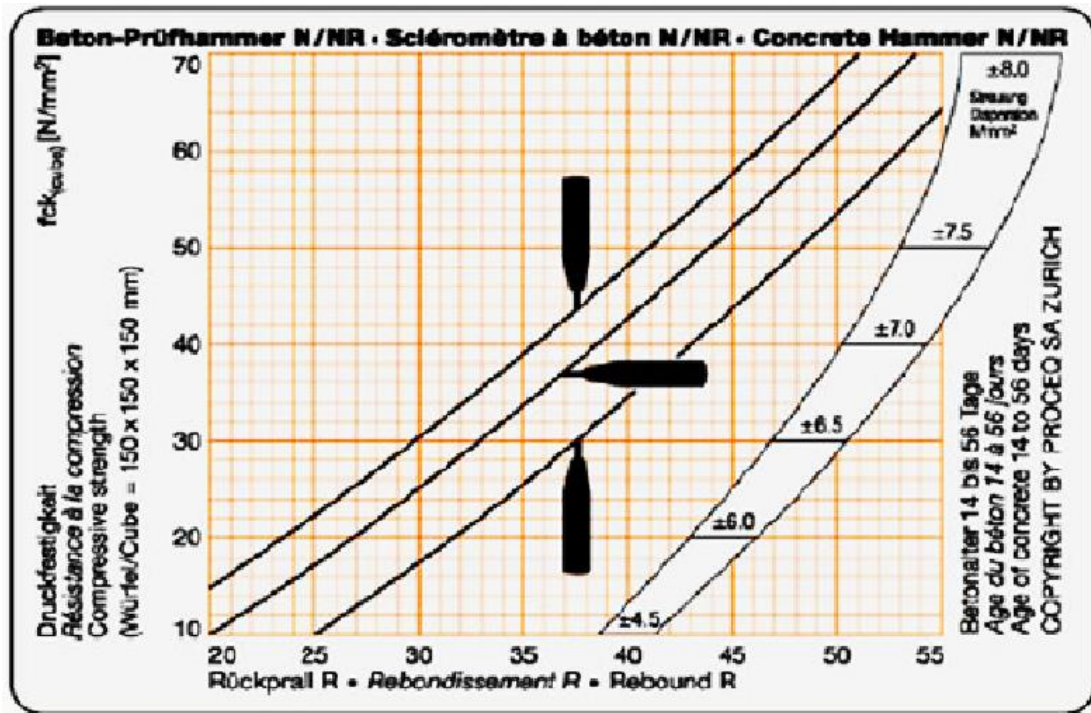


Figure II.2. Reading of Sclerometer

### II.3.1.3. Experiment with Sclerometer

Figure II.3 shows part of our test. The first step in our preparation was as follows

- The two samples were traced with a marker pen to form a mesh on the test surface.
- We have to lay the S horizontally on several points of this mesh.
- We had several values from this test. The highest and lowest measurement are eliminated.
- An average value was taken and projected on the graph to have the pressure in mega Pascal.



Figure II.3. Sample test

## II.3.2. Pressing Machine

### II.3.2.1. Pressing Machine description

The pressing Machine determines the compression test behavior of materials under crushing loads. The specimen is compressed and deformation at various loads is recorded. and preformed parts which are made of concrete, steel fiber concrete and reinforced concrete. Figure II.4 et Table II.2 show the Pressing machine components and its description.

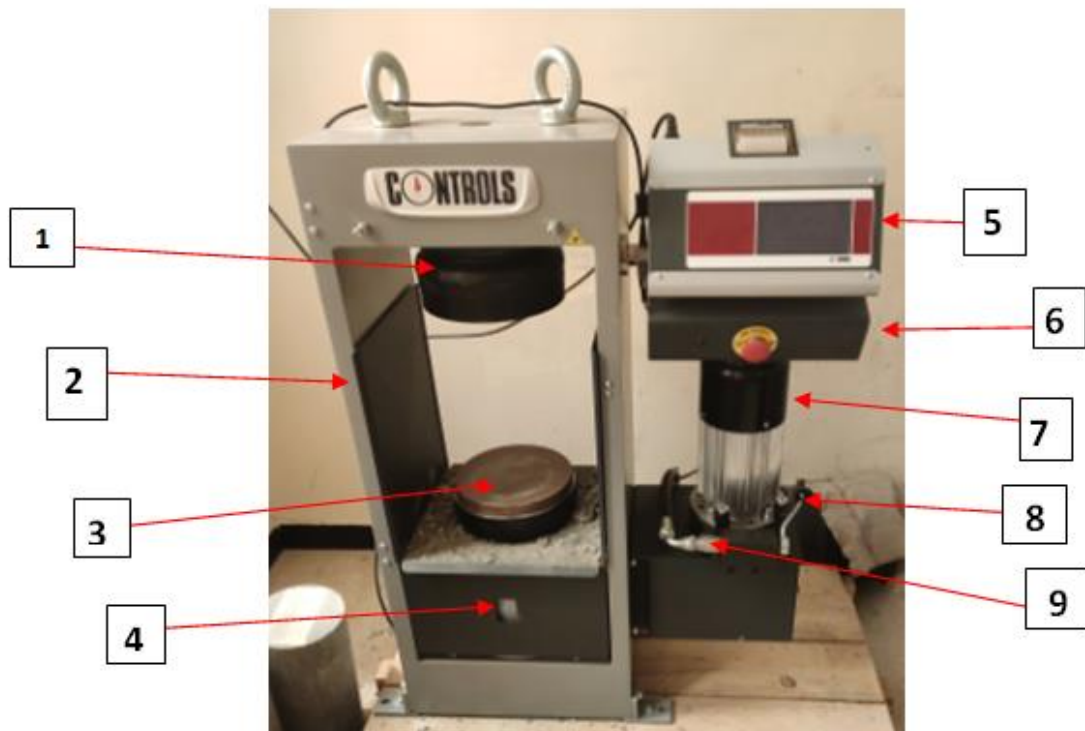


Figure II.4. Pressing Machine components

Table II.2. Pressing Machine Description

Ref.	Description
1	Upper platen with spherical seat
2	Front guard
3	Lower platen
4	Piston travel indicator
5	Control unit with touch screen display
6	Power unit with emergency button
7	DC motor hydraulic pump
8	ON/OFF hydraulic valve
9	Frame selector lever ( optional, lever UP=Frame #1, lever DOWN=Frame#2)

### II.3.2.2 .Machine Characteristics

- Speed rate control from 0.01 kN / s to 100 kN / s (depends on sample hardness)
- Additional channels for displacement transducers, expansion meters, etc. are integrated into the system as auxiliary frame for the load cell (pressure transducer) or displacement transducer
- 240 x 320 pixels LCD digital display, touch operation panel, it can control two frames
- Pregnancy, displacement or strain control tests can be performed.
- Multilingual support
- Machine principle:
- A compression testing machine is a very common test method used to determine the compressive strength or crushing resistance of a material and the ability of a material to recover after applying a specific compressive force and even retain it over a specified period of time by measuring basic parameters such as strain, tension and deformation.
- There are many models and capabilities available for this compression testing machine designed to meet the need for reliable and consistent testing of concrete samples.

### II.3.2.3. Experiment with pressing machine experiment

The sample (brick or polyester) is placed between the upper platen with spherical seat ) and the Lower platen as shown in Figure II.5. Then the pressure machine is started to test the pressure resistance. As soon as the sample bursts, the machine is stopped and the value of the pressure in mega Pascal is taken.



Figure II.5. Pressing Machine components

### **II.3.3. Ultrasonic pulse velocity tester**

#### **II.3.3.1. Pressing Machine Description**

With an ultrasonic pulse velocity tester as shown in Figure II.6, it is possible to detect pulses that have travelled through the concrete in some other direction. It is therefore possible to make measurements of pulse velocity by placing the two transducers on either opposite face (direct transmission), or on adjacent faces (semi-direct transmission), or the same face (indirect or surface transmission)



Figure II.6. Ultrasonic pulse velocity tester

### II.3.3.2. Experiment with ultrasound

Figure II.7 shows the use of in the civil engineering laboratory at the University of El Oued. The method used is the direct method.



Figure II.7. Ultrasound test

For direct transmission ,the path length is the distance between the transducers and when possible, the accrue of measurement of the path length should be  $\pm 1\%$  and the accury shall be recorded .The accuracy of estimating of path length is dependent upon the size of the transducer compared with the center to center distance and it shall be estimated.

For direct and semi-direct transmission the pulse velocity shall be calculated from the formula :

$$V = \frac{L}{T} \quad (\text{II.1})$$

**where :**

**V**= pulse velocity, in Km/s

**L**= path length, in mm

**T**= time taken by the pulse to transverse the length, in ms .

The resultant determination of the pulse velocity shall be expressed to the nearest 0,01 km/s or to three significant figure.

from measurement of ultrasonic waves velocity it is possible to calculated the elastic dynamic modulus ED as follow :

$$E_D = V^2 Q \frac{(1+n)(1-2n)}{1-n} \quad (\text{II.2})$$

**where :**

**V**=velocity in Km/s

**Q** =concrete density in Kg/ m<sup>3</sup>

**n**= poisson's ratio (for high strength concrete n = 0.15; for low strength concrete n=0.30 )

**ED** =Dynamic elastic modulus MN/m<sup>2</sup>

### II.3.4. Shock instrument

#### II.3.4.1. Shock tester description

Impact resistance is a very important parameter in the construction of houses, which is why our samples were impact tested. Due to the unavailability of this instrument in our laboratory, we were forced to construct an impact test voucher as shown in Figure II.8. This test bench has given impressive results.

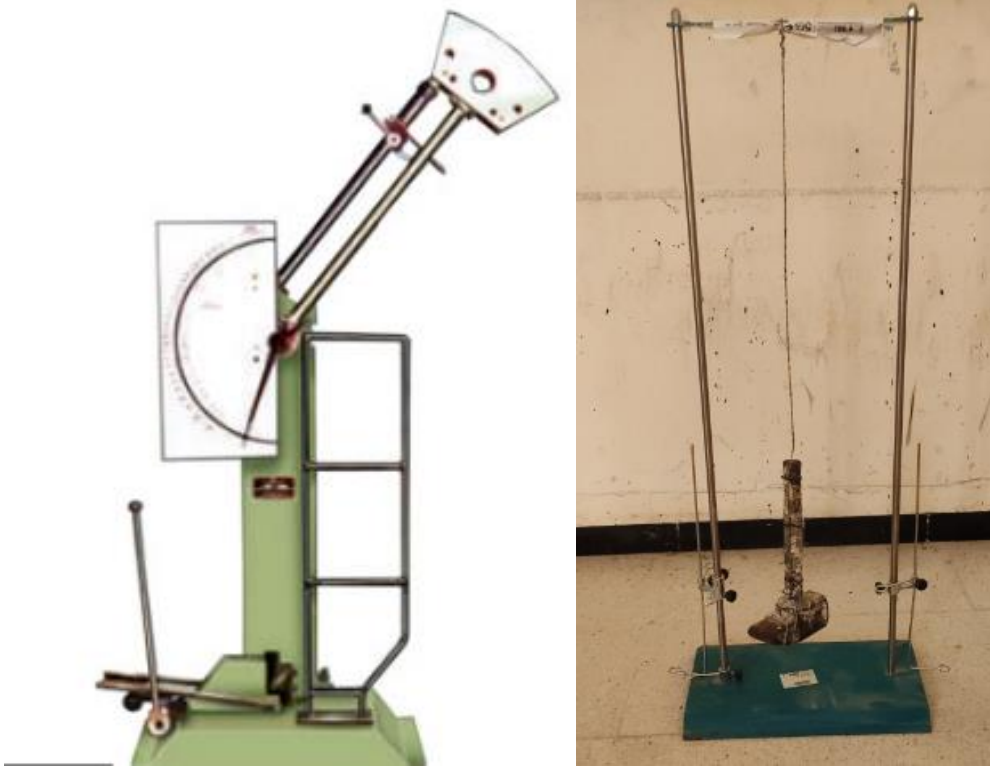


Figure II.8. Shock tester

### II.3.4.2. Experiment with Shock tester

The principle of operation of this type of test is based on mechanical energy  $E_m$ .

mechanical energy = kinetic energy + potential energy

$$E_m = E_c + E_p$$

$$E_m = \frac{1}{2}mv^2 + mgh$$

(II.3)

### II.3.5. Thermal tester

#### II.3.5.1. Thermal tester description

We have created a system with 2 rooms separated by our sample (brick wall and a polystyrene wall) as shown in Figure II.9. Chamber 1 contains an electrical resistance which heats this chamber. Considering the temperature difference between the two chambers, a heat transfer is created. The aim of this experiment is to know the resistance to heat transfer by our sample and to have a result which conforms which of the two samples is more resistant to heat transfer.



The rate of heat flow  $Q$  [W] over the area  $A$  [m<sup>2</sup>] and through a laminar films of thickness  $x_1$  and  $x_2$  [m] respectively may be written as:

$$\begin{aligned}
 Q &= k \cdot A \cdot (T_1 - T_2) \\
 &= \alpha_1 \cdot A \cdot (T_1 - T_{w_1}) \\
 &= \frac{\lambda}{w} \cdot A \cdot (T_{w_1} - T_{w_2}) \\
 &= \alpha_2 \cdot A \cdot (T_{w_2} - T_2)
 \end{aligned}
 \tag{II.4}$$

where  $\lambda$  [W/m·K] is the wall thermal conductivity,  $\alpha_1$  and  $\alpha_2$  [W/m<sup>2</sup>·K] are the respective individual heat transfer coefficients and  $k$  [W/m<sup>2</sup>·K] is the overall heat transfer coefficient.

## II.4. Conclusion

In this chapter we have explained the operating principle of each equipment used in our study. We have also exposed the protocol of each experiment as Sclerometer, pressing machine, ultrasonic pulse velocity tester, shock tester and thermal tester, with the aim of facilitating the understanding of the results obtained in the following chapter.

# Chapter III

Results and discussion

### III.1. Introduction

In this chapter we will do three studies on the samples designed in chapter II. We start with a thermal study to see the thermal resistance of our samples. Then we will do a second mechanical study to see the different resistances such as resistance to pressure, resistance to shock, ..etc. The last goes to the economic side and that to get an idea on the cost of our study.

### III.2. Thermal study

The thermal study, that is to say the heat transfer via a brick wall or a polystyrene wall. This study is done in order to see the thermal resistance of the two walls and then to make a comparison. The first transfer step is when the heat passes through the walls and there is an accumulation of heat in the wall i.e. loading and when the heat comes out of the wall and the wall begins to cool i.e. unloading. Both cases will be studied in our experience.

Figure III.1 represents 2 rooms separated by a wall. Room 1 has a radiator that heats this room and the other room 2 stays at room temperature. Since there is a temperature difference between the two chambers, then there will be heat transfer.

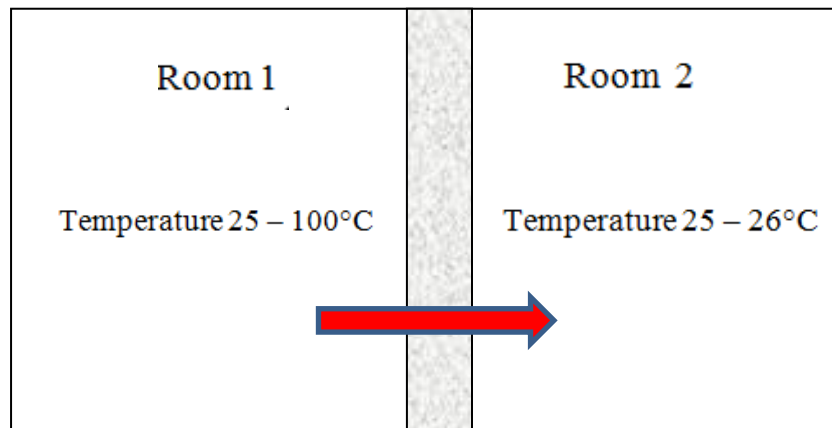


Figure III.1. Thermal test schema

#### III.2.1. Thermal load in the brick wall

Figure III.2 shows the variations in the temperature of the outer chamber which contains the radiator and the variation in temperature on either side of the walls, as a function of time. Temperature measurements are made every 30 minutes, during a period which varies between 9:00h until 14:30h.

We notice that the temperature of the chamber and of the brick wall increases during the duration of the experiment while reaching a maximum at 14:30h in the value is almost at 99 ° C, while the temperature of the wall of the outer chamber increases slowly between 9:00h and 11:30h then we notice that there is a stability between noon and 14:30h, the corresponding temperatures of which vary between 36 and 37 ° C.

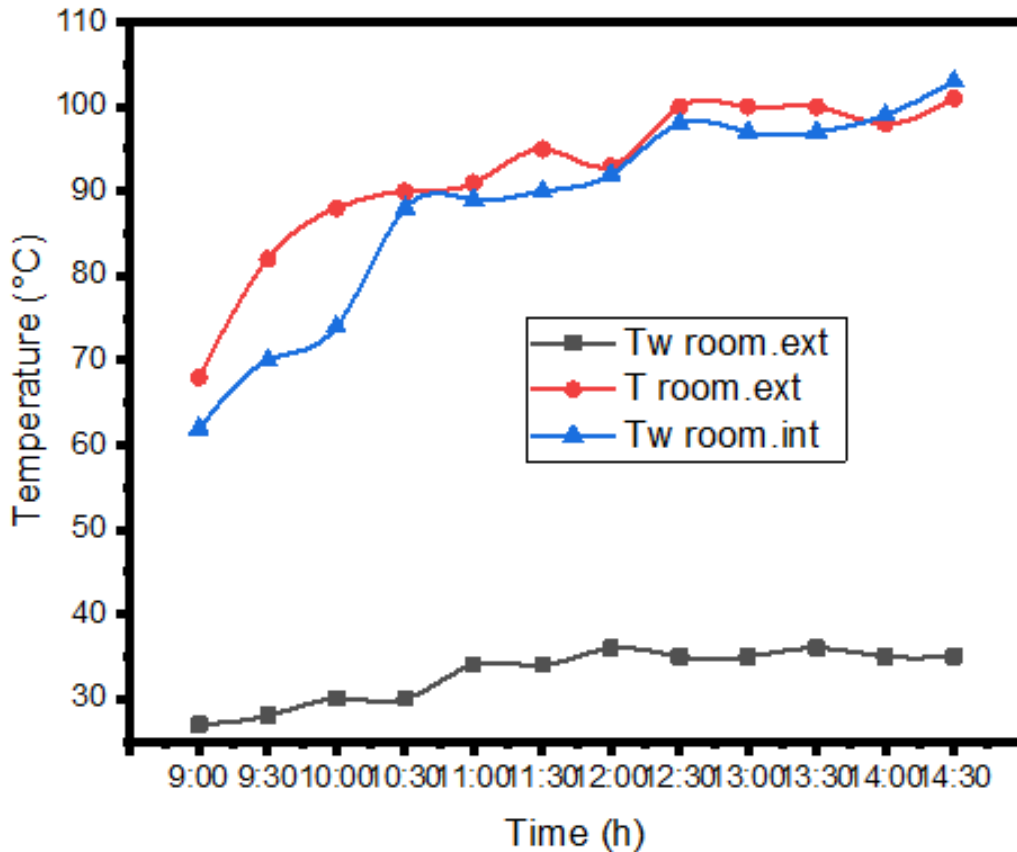


Figure III.2. Temperature evolution via brick wall

### III.2.1 Thermal load in the polystyrene wall

Figure III.3 shows the evolution of the temperature of the outer chamber and the wall as a function of time. We notice that the two temperatures increase rapidly until reaching a maximum of 100 ° C and that around the stroke of 14:30 h. While we notice an almost perfect stability of the temperature of the polystyrene which varies between 25 and 27 ° C and that between 9h until noon. Between noon and 14:30 h, we notice perfect stability with a temperature of 27 ° C.

## Result

If we compare the heat transfer via the brick wall and via the polystyrene wall we notice that the temperature of the polystyrene wall varies between 25 and 27 °C although the temperature in the other side of the wall is 100 °C.

The heat transfer in the brick wall is the same but the temperature of the brick walls varies between 35 and 37 °C, which means a difference of 10 degrees between the two materials. What favors in this study the polystyrene wall.

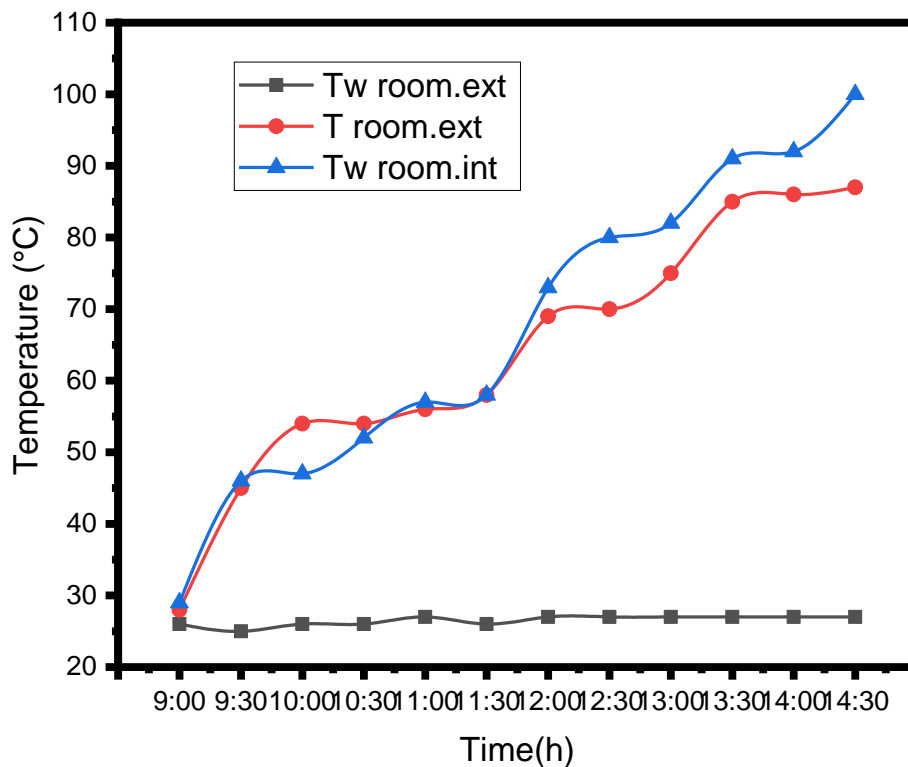


Figure III.3. Temperature evolution of the outer chamber and the wall

### III.2.2. Thermal unloaded

Figure III.4 represents the evolution 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 °C to 35 °C in a period that varies between 15:00h and 16:00h. we also notice that the temperature of the exterior wall is stable and varies between 25 and 27°C. Figure III.5 represents the variation 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 of the face of the wall in the warm side while the variation in temperature is small in the side where the wall is exposed to the ambient temperature. we notice that the temperature variation is between 35 and 37 °C.

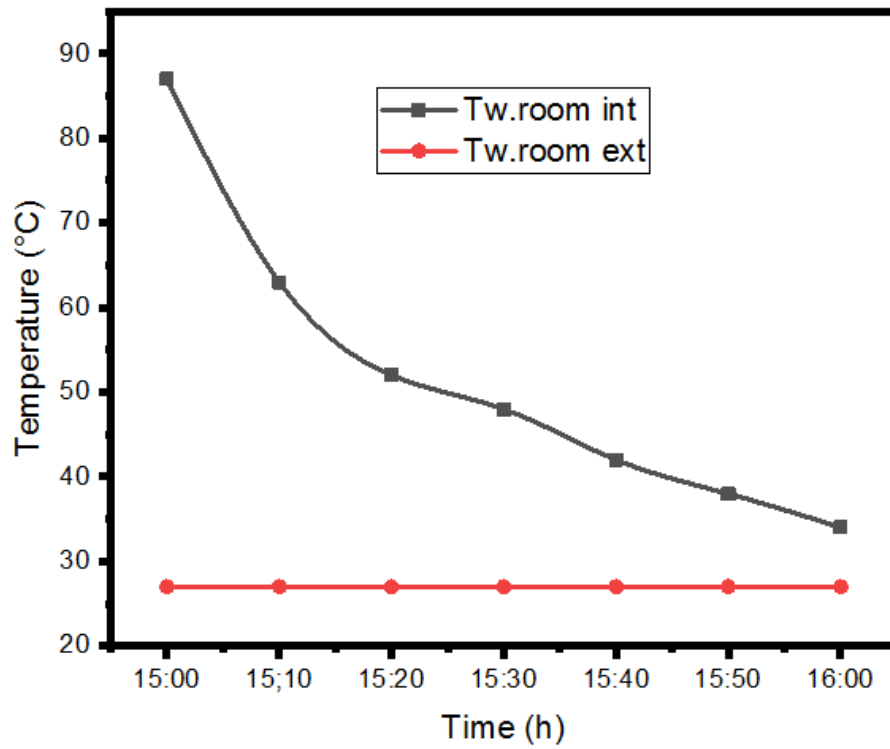


Figure III.4. Temperature evolution of either side of the polystyrene wall

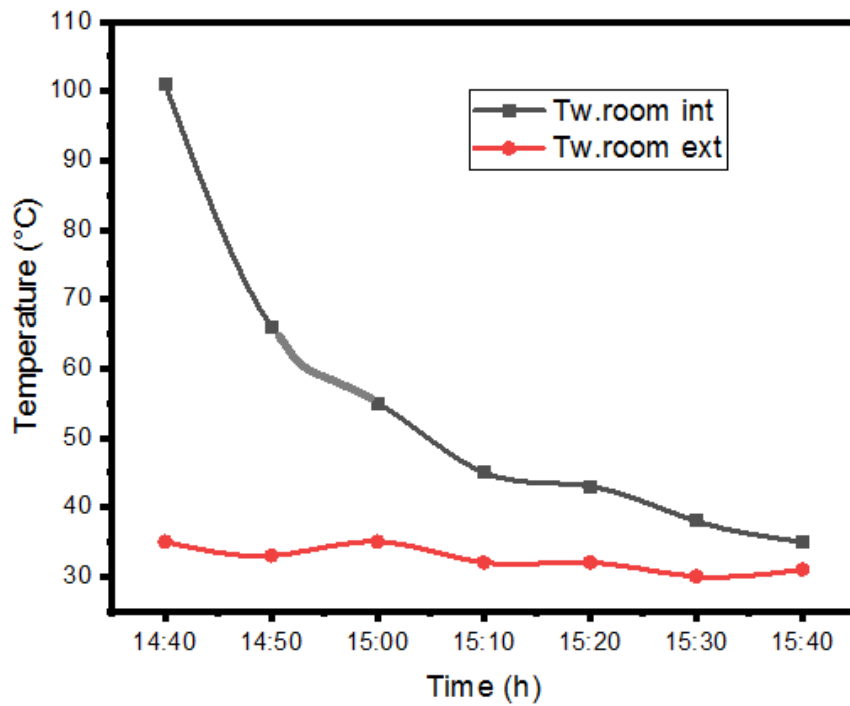


Figure III.5. Temperature evolution of either side of the brick wall

## Result

In the cooling stage, the brick wall slowly cools down over time. The temperature deteriorates from 37 ° C to a temperature of 34 ° C. While the polystyrene wall remains almost stable because the wall has not really been heated, which is why the cooling is not really sharp and clear in the figure. We notice that the temperature is almost stable and it is 27 °C. We compare the two results, we can say that the polystyrene wall is very favorable compared to the brick wall.

## III.3. Mechanical study

In the mechanical study there are 4 tests to do, the pressure test, the hardness test, the ultrasonic impact test et the shock test,.

### III.3.1. Pressure test

The pressure test of the polystyrene block and the brick aims to study the resistance to pressure  $F$  of the two materials. In place our sample on the press, the contact surface must be perfect with the surface of the metal mold head of the machine, and then we apply a pressure force  $F$ .

## Result

- The brick sample is compressed until it fractures, a force is recorded:  $F = 36$  KN. For the polystyrene sample, the force was  $F = 16$  KN. Brick resists pressure 2.25 times better than polystyrene.
- From the stress point of view  $\sigma$ ,

$$\sigma_{\text{brick}} = F_b / S \text{ and } \sigma_{\text{polystyrene}} = F_p / S$$

since the surface of the contacts the same then we conclude that  $\sigma_{\text{brick}}$  and larger  $\sigma_{\text{polystyrene}}$  is what to say that the brick is subjected to high stresses, that is why it is breaking. So the stress on the polystyrene is 2.25 times lower than the brick and cala is due to its elasticity. that's why it doesn't break like brick does.

### III.3.2. Hardness test

By performing the hardness test (Sclerometer) in two directions at the angles ( $0^\circ$  and  $90^\circ$ ) on the polystyrene sample where ( $\alpha = 0$ ), it is found that the maximum frequency is 13.80 Mpa as shown in Table III.1.

Table III.1. Pressure resistance

Pressure resistance (MPa)				Step number
Red brick		Polystyrene		
$\alpha = 90^\circ$	$\alpha = 0$	$\alpha = 90^\circ$	$\alpha = 0$	
18	16	11	11.5	1
20	21	13	13.80	2
14.5	18	12	11.90	3

At the angle ( $0^\circ$ ) we find  $R = 13$  Mpa. We conclude that the durability of polystyrene is low because the sample contains an iron mesh and when the hammer hits the surface of the sample, the force of the blows is distributed over the surface.

When a Schmidt hammer strikes the surface of the sample at several points, the highest rebound  $R = 21$  Mpa is recorded

### Result

Compared to polystyrene, we say brick has high surface hardness resistance compared to polystyrene and therefore its strength is good.

### III.3.3. Ultrasound test

We performed ultrasonic testing on the brick and polystyrene samples using an ultrasonic device. The results were recorded in a Table III.2.

Table III.2. Ultrasonic testing

	Brick (Hertz)	Polystyrene (Hertz)
1	55.4	22.6
2	90	/
3	92	/
4	96	/
5	105	/
6	108	/
Average values	91.06	

It was noted that by measuring the pulse velocity of the red brick sample, the waves propagate at an upward velocity of (55.4 to 108), and this depends on the density and properties of the material being tested.

For polystyrene, we had difficulty transmitting the waves due to the presence of the iron grid in the sample, so several points were selected on the surface of the sample. A narrowing has been observed in the transmission of waves (22.6- / - /).

### **Result**

We conclude that the steel reinforcement has a significant effect on the transmission of waves.

### **III.3.4 Shock results**

Figure III.6 represents behavior of the material tested by shock depending on the blow of a pendulum hammer. A mass was taken on the sample in a pendulum fashion for the purpose of testing impact resistance.

For the red brick block we noticed after the 3rd shot that the brick starts to break and that on the 10th shot it is completely taken.

For the polystyrene block we noticed that there is a small hole on its surface and that after 50 strokes.

### **Results**

It is the concentration of stresses in a small space on the sample that breaks it. In the polystyrene block, the stresses are not concentrated in a small space, it is on the contrary, they are dispersed over the entire surface of the block due to the iron mesh.

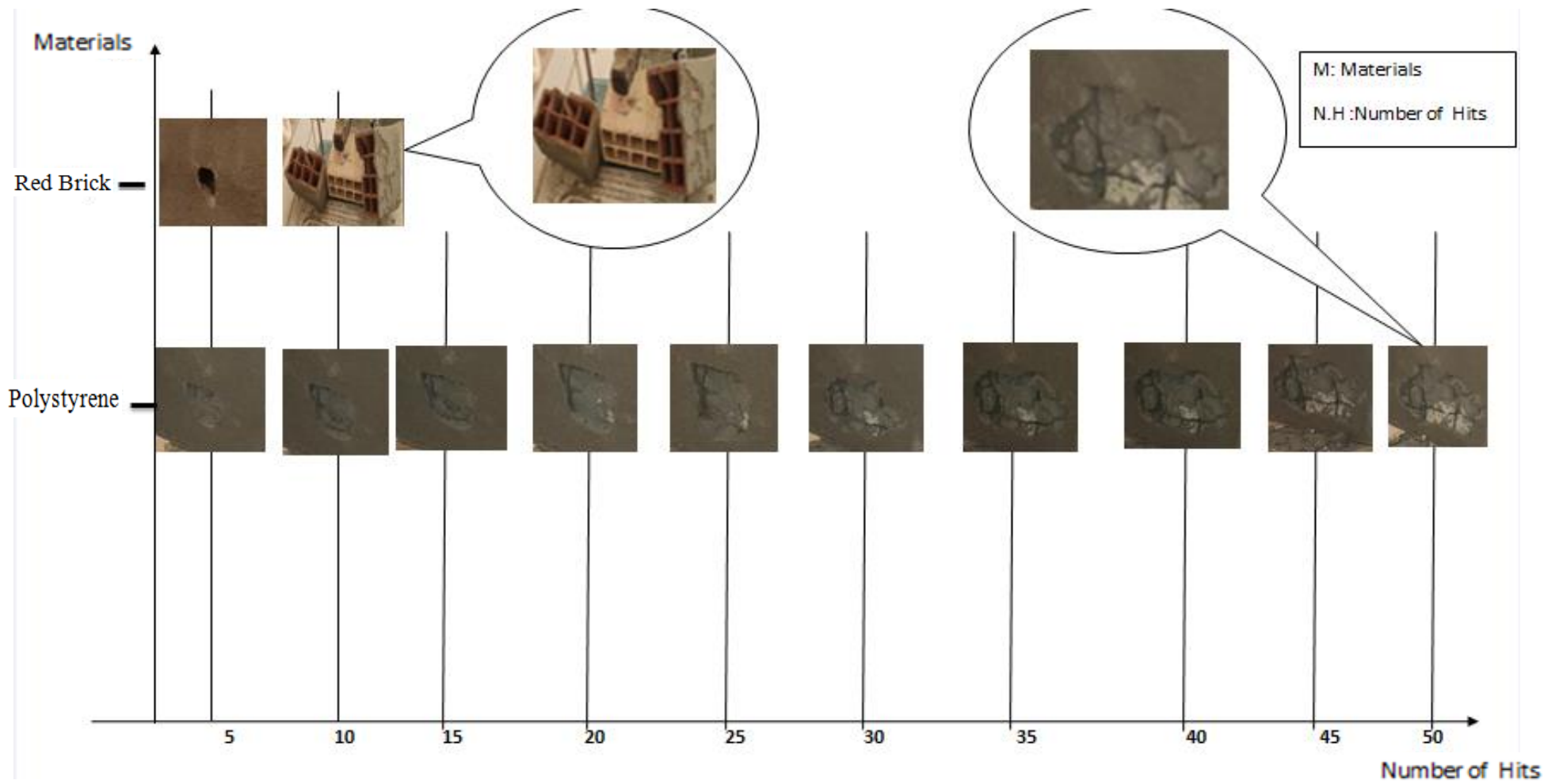


Figure III.6. Behavior of the material tested by shock

### III.4. Wall physical load test

#### III.4.1. Polystyrene wall

Polystyrene weight 124 g

Iron weight both sides 262 g

After the process of strengthening the polystyrene, the weight becomes 386 g

A wall 3 meters long and 3 meters high consumes 150 polystyrene grains, which means that the weight of a polystyrene wall is as follows

Reinforced polystyrene wall =  $150 \times 386 = 57900 \text{ g} = 57.9 \text{ kg}$

Reinforced polystyrene wall weight = 57.9 kg

A wall measuring 3 x 3 meters, starting from both sides: 100 kg of cement and 300 kg of sand

This means that the wall after coating with mortar becomes as follows:

$$457.9 = 57.9 + 100 + 300 = \text{weight of a wall after cladding kg}$$

kg 457.9 = Weight of a wall after cladding.

#### III.4.2. Red brick wall

Red brick weight: 3454 g

The weight of the cement needed to fix the red bricks to the wall: 75 g

Weight of sand needed to fix the red bricks to the wall: 225 g

A wall 3 meters long and 3 meters high consumes 150 red bricks, that is, I have weighed a red brick wall as follows:

Red brick wall =  $(150 \times 3.454) + 75 + 225 = 818 \text{ 100 g} = 818.1 \text{ kg}$

Red brick wall = 818.1 kg

A wall measuring 3 x 3 meters, starting from both sides: 100 kg of cement and 300 kg of sand

This means that the wall after coating with mortar becomes as follows:

$$\text{kg}1218.1 = 818.1 + 100 + 300 = \text{weight of the wall after cladding}$$

$$\text{kg}1218.1 = \text{weight of the wall after cladding}$$

### Result

Comparing the results, we find that a red brick wall is approximately three times the weight of a polystyrene wall. Red brick wall = 2.66 heavier than polystyrene wall. Figure III.7 summarizes the Wall physical load test.

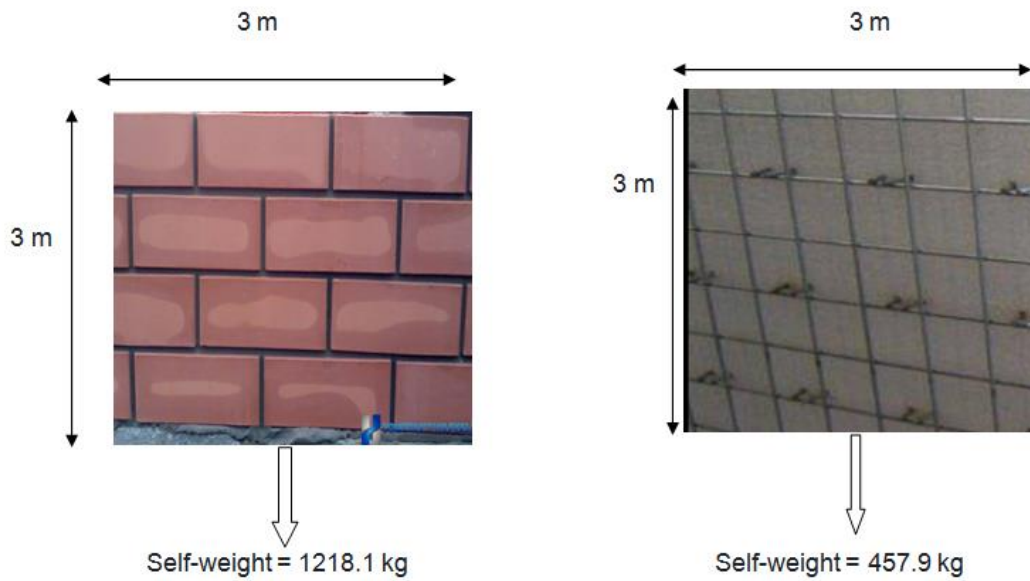


Figure III.7. Wall physical load

### III.5. Economic study

Estimates and financial costs in construction projects are one of the most important activities required for design work. The significant impact on its progress, because the estimates and financial costs represent an important pillar of the project implementation process. These estimates are based on correct practical foundations and prepared according to proven scientific methods which contribute to the output of the project from satisfactory implementation. The cost of building a Red brick and Polystyrene walls are 3 meters long and 3 meters wide. These values are taken on 05/27/2021 as shown in Table III.3 and Table III.4.

Table III.3. Materials Price for Polystyrene

Materials	Quantity	Price per	The price of all quantities
Polystyrene	3Dimensions 1/3	3900 da	11700 da
the sand	149.887 kg		
Cement (durable)	2 bags of 50 kg	410 da	820 da
The iron mesh with a diameter of 6 mm has a dimensions of 10/10 cm	9m <sup>2</sup>	500 da	4500 da

Table III.4. Materials Price for brick

Materials	Quantity	Price per	The price of all quantities
Polystyrene	3Dimensions 1/3	3900 da	11700 da
the sand	149.887 kg		
Cement (durable)	2 bags of 50 kg	410 da	820 da
The iron mesh with a diameter of 6 mm has a dimensions of 10/10 cm	9m <sup>2</sup>	500 da	4500 da

We have discussed the detailed costs of building materials used in this study, to make a comparison in terms of profit or material loss, between a brick wall and a polystyrene wall. Our research is a wall study of dimension (3 x 3 m).

- We calculated the quantities of raw materials that we need in the construction of this wall (red bricks, polystyrene, sand, iron mesh, water, cement .....). With the addition of the calculation of the cost of labor to the cost of the project.

### **Result**

Carrying out the economic study of materials, it was concluded that the cost of the project carried out with polystyrene is two times cheaper than the cost of red bricks. Polystyrene helps us to develop considerably in various fields of construction.

### **III.6. Conclusion**

All the tests made on the two samples either the thermal tests or the mechanical tests show that the polystyrene material can conquer with force the red brick material.

The polystyrene material can be a good competitor from an economic point of view because its handling is not expensive even if the material itself is a little expensive and not available in an abandoned way in the markets of the region of El Oued, south-eastern Algeria.

# General conclusion

## **Conclusion**

Building materials are the materials that are used in the field of construction these materials must have the property of resisting against significant forces and stresses applied to the construction during its life. The discovery of new materials has led to real revolutions in the history of technology. The great periods of prehistory are also defined by the materials mastered, Stone Age, Bronze Age, Iron Age. It shows the importance of materials in people's lives. Today the number of new materials is constantly increasing, such as polystyrene.

The objective of our work is to show that the 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 red brick.

The results obtained in our work are very encouraging either in the thermal field or in the mechanical field:

- Polystyrene and more insulating red brick.
- Polystyrene wall (3 x 3 m) is 2.6 times lighter than a brick wall.
- The impact resistance of polystyrene is greater than red brick.
- The price of both materials and their labor is almost the same, which favors use of polystyrene instead of red brick.

Based on the results found in this thesis, we can say that polystyrene is a construction material of choice for the region of El oued southeast of Algeria that it is a very good competitor to other materials such as that the red bricks, despite this unavailability in the markets of the region.

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## Abstract

Today the number of new materials is constantly increasing, such as polystyrene. 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 red brick. The results obtained in our work are very encouraging either in the thermal field or in the mechanical field. Polystyrene and more insulating red brick, polystyrene wall (3 x 3 m) is 2.6 times lighter than a brick wall, the impact resistance of polystyrene is greater than red brick and the price of both materials and their labor is almost the same, which favors use of polystyrene instead of red brick. Polystyrene is a very good competitor to other materials such as that red bricks, despite this unavailability in the markets of the region.

**Key words:** polystyrene, red brick, construction material, wall, mechanical test.

## Résumé

Aujourd'hui, le nombre de nouveaux matériaux est en constante augmentation, comme le polystyrène. L'objectif de notre travail est de montrer que le matériau polystyrène est un bon matériau pour la construction dans la région d'El Oued au sud-est de l'Algérie. Il peut également être un bon concurrent pour d'autres matériaux utilisés dans la construction comme la brique rouge. Les résultats obtenus dans nos travaux sont très encourageants que ce soit dans le domaine thermique ou dans le domaine mécanique. Polystyrène et brique rouge plus isolante, le mur en polystyrène (3 x 3 m) est 2,6 fois plus léger qu'un mur en brique, la résistance aux chocs du polystyrène est supérieure à celle de la brique rouge et le prix des deux matériaux et leur main d'oeuvre est quasiment le même, ce qui favorise utilisation de polystyrène au lieu de brique rouge. Le polystyrène est un très bon concurrent d'autres matériaux comme celui des briques rouges, malgré cette indisponibilité sur les marchés de la région.

**Mots clés :** polystyrène, brique rouge, matériau de construction, mur, essai mécanique.

## المخلص

اليوم ، يتزايد عدد مواد البناء الجديدة باستمرار ، مثل البوليسترين. الهدف من عملنا هو إظهار أن مادة البوليسترين هي مادة جيدة للبناء صالحه للبناء في منطقة الوادي جنوب شرق الجزائر. يمكن أن يكون أيضاً منافساً جيداً للمواد الأخرى المستخدمة في البناء مثل الطوب الأحمر. النتائج التي تم الحصول عليها في عملنا مشجعة للغاية، سواء في المجال الحراري أو في المجال الميكانيكي. وجدنا ان البوليسترين أكثر عزلاً من الطوب الأحمر ، وجدار البوليسترين (3 × 3 م) أخف بمقدار 2.6 مرة من جدار الطوب، ومقاومة تأثير الصدمة للبوليسترين أعلى من تلك الموجودة في الطوب الأحمر وسعر كل من المادتين مع البناء هو نفسه تقريباً وهذا يجعل الافضلية لاستخدام البوليسترين بدلاً من الطوب الأحمر. يعتبر البوليسترين منافساً جيداً جداً للمواد الأخرى مثل الطوب الأحمر ، على الرغم من عدم توفره في أسواق المنطقة.

**الكلمات المفتاحية:** البوليسترين ، الطوب الأحمر ، مواد البناء ، الجدار ، الاختبار الميكانيكي.