IMPACT OF THE BUILDING ENVELOPE ON HEAT TRANSFER IN A HOT AND DRY CLIMATE, CASE OF INDIVIDUAL HOUSING IN LAGHOUAT (ALGERIA)

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Axe 3

Titre de l'axe : Exemples d'études intégrées sur la recherche écologique

Communication : Orale ☐* Poster ☐

Abstract

Nowadays, the integration of energy components into the architectural design process is aimed at improving thermal comfort, and developing an adequate architecture.

In Algeria, houses do not meet the requirements of thermal conditions, especially in summer, when it is very hot. The objective of this research is to study the insulating house's envelope and its components against climatic conditions in Laghouat, a city where the maximum temperatures can reach 50 ° C during summer days.

The work is carried out by measurements taken on site, and the use of the Energy + software allows us the improving indoor comfort conditions by simulating the characteristics of the envelope, in order to satisfy the well-being of the occupants to the least cost.

Keywords : Houses, Hot and dry climate, Envelope, Thermal comfort, Energy +.

Introduction

Today, humanity is facing an unprecedented energy problem: meeting the needs of 6.7 billion people with global energy consumption is expected to increase by 40% by 2030. (WEC (World Energy Council), which will affect consequently the environment.

In Algeria; houses do not meet the requirements of thermal comfort, due to the lack of several criteria, namely; an architectural design that adapts to the hot and dry climate; Thermal insulation of the outer envelope of the building and finally a thermal inertia stabilizing the ambient inside the building. In summer, this building is confronted with problems of discomfort related to the phenomenon of overheating and thus, an irrational consumption and abuse of electricity for the air conditioning. Indeed, the thermal environment in buildings is an important factor for the comfort of the occupants, because extreme temperatures, hot or cold, can cause inconvenient effects on the occupants (Potier M, (2014)).

The city of Laghouat, which is characterized by a hot and arid climate, illustrates one of this phenomenon. The built environment produced in this city is indifferent to the climatic conditions, which lead to high energy consumption in the use of air conditioning.

The objective of this study is to evaluate the thermal impact of the structural and constructive elements of the envelope as they occur in self-produced houses in Laghouat city. The ultimate goal of our research is to improve the thermal performance of the architectural envelope of this type of houses and thus reduce energy consumption through passive solutions.

Figure1: Geographical location of the case study (Station météorologique de la ville de Laghouat).

Rethinking the building envelope is now a priority, it is among the urgent solutions in the building of houses. The energy performance of a house depends primarily on the materials used in its construction. The built-up envelope is no longer simply regarded as the frontier of the habitable domain, it becomes a flexible

element to transform a fluctuating and uncomfortable exterior climate into a pleasant indoor sensations.

The envelope must be able to create a comfortable interior independently on the climatologically conditions prevailing outside. (Kaoula, D and al 2009).

The one who builds his final habitat is faced with major challenges in the choice of materials: given the high cost of modern building materials, often imported, and the improvement of comfort conditions they can allow.

1. Presentation of the case study

Laghouat is a medium city in southern Algeria, at 33° 47 latitude North and 2° 52 longitude East [4]. Figure 1.

It is characterized by a Saharan climate (hot and dry). Our choice was made to evaluate the heat of a single house, in that Saharan climate, which is characterized by two seasons: a hot and dry season (from April to September) and another, temperate (from October to March). The temperature is marked by large amplitude between day and night during both summer and winter times, the maximum temperature is around 38 ° C during the summer, and the winter is very severe, where the temperature decreases to 2.38 °C in December (Rapport Technique, (2011) .Figure 2.

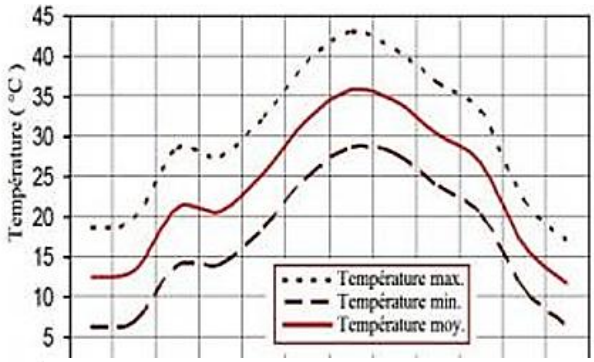

Figure2 : Monthly temperature changes

(Station météorologique de la ville de Laghouat.

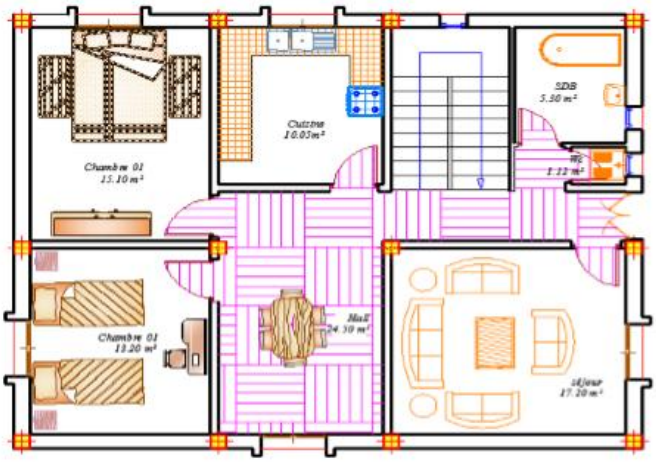

Figure 3: Plan view of the studied house

2- The case study house

The house that we are studying is of the detached individual three rooms' type; it is a small rectangular single house with an area of 143 m2 and a height of 3.00 m. And whose envelope characteristics, and its building materials are taken into account. Figure 3.

3. Methodology

In order to evaluate the thermal balance of this house, the work is based on an analytical approach, by means of a manual calculation followed by a simulation to confirm the results and to deduce the possibilities for improvements:

1-It is a calculation of the thermal balance manually of an individual three rooms' house type, isolated which allows us the calculation of the thermal balance which is also a verification tool. Indeed, it is necessary to try to limit the loss of the building as far as possible (by choosing the use of double glazing and the addition of polystyrene insulation between two walls of the exterior envelope), and therefore to limit wastage of energy to compensate for these losses. The calculation of the thermal balance will also allow us to have access to the calculation of energy consumption, these being proportional to it, and thus will allow us to verify that these consumptions remain reasonable.

2- Our work is to study the heat transfer through the envelope: We estimate the energy losses of a single individual dwelling, through a manual calculation. Initially we use a single glazing for the windows, then we replace it with double glazing and the addition of a layer of polystyrene in place of the air space in the exterior walls. At the end of this study, we compare the results obtained to conclude on the effect of double glazing and the effect of polystyrene.

3- The simulation of the temperatures using the Energy + software will be used for the same operation already carried out manually to validate the results.

4. Simulation by the Energy + software

The case study is always a unit of three rooms' type isolated individual house.

Our work consists in verifying the results obtained during the first part by computer tool called Energy +, on the effect of double glazing and the addition of an insulating product (polystyrene) between the two walls, making up the external wall, in considering the temperature values, in both cases, winter and summer. So we simulated the data in the optimum cases that of 21st December for winter and 21st August for summer, reminding that in the initial case, the simulation was carried out without any improvement and in the second case, we have used a double glazing and a layer of polystyrene in the exterior walls instead of a simple air layer between the parts of the wall.

5. Results of the simulation:

5. 1.Winter period

During the winter period, when it is cold and dry, the external temperature vary from 6°C minimum to14,5°C whereas the interior temperature goes from 11,5°C to 13°C. Figure 4.

The graph shows this variation which we can say is important compared to the indoor temperature variation which is almost 2°C, that is from 11,5°C to around 13°C, and in this case we need some heating in spite of the stability of the inside temperature.

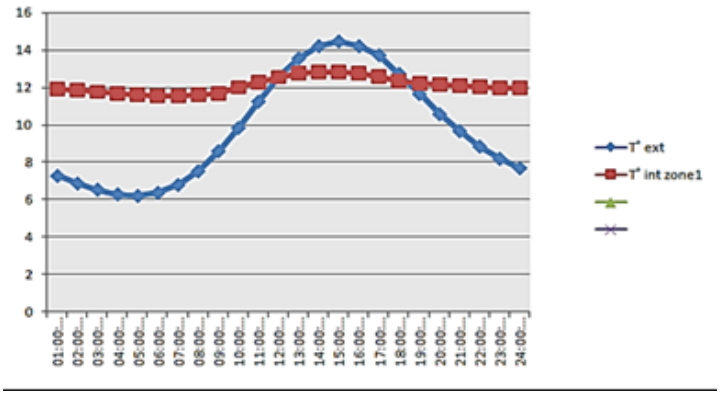

Figure 4: The graph of the initial case simulation data; Author 2019

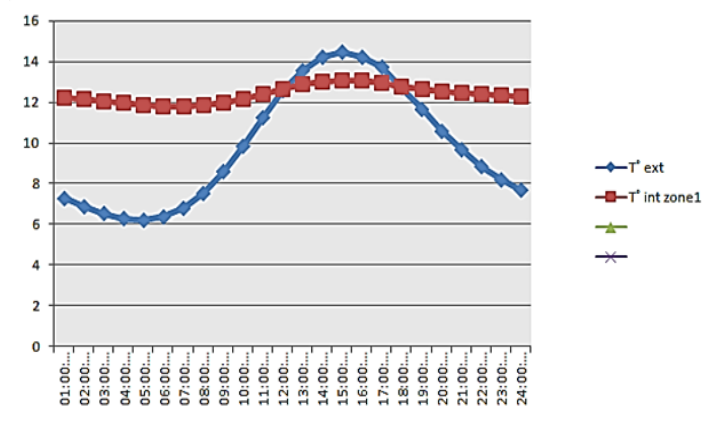

Figure 5: The graph of the case simulation data improved.

Author 2019

After application of the improvements, that is, the use of double glazing and the addition of an insulating product (polystyrene) between the two parts of the external wall, in this case, we get a slightly higher temperature compared to the initial case. Figure 5.

The same Remarque can be applied in this case too, that is, the almost stability of the internal temperature in spite of the relatively high variation of the exterior temperatures, the shape of the two graphs is nearly the same, however, with slightly less difference in value and therefore less heating needed than in the initial case. (Figure 6.)

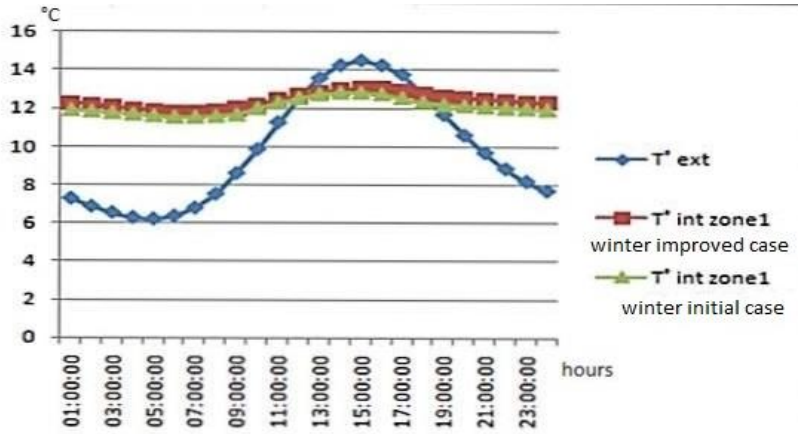

Figure 6: Comparison between winter initial case and improved winter case.

5. 2. Summer period:

During summer time, when it is very hot, as the outside temperature overtake the 50°C, in our case, it reaches 43°C, our house in the initial case behave as in the winter and we can notice that, although, the outside temperature vary from 16°C in the early morning to 43°C in the afternoon (around 3h.00 pm) whereas the interior temperature vary from 33°C to 37°C. Figure 7.

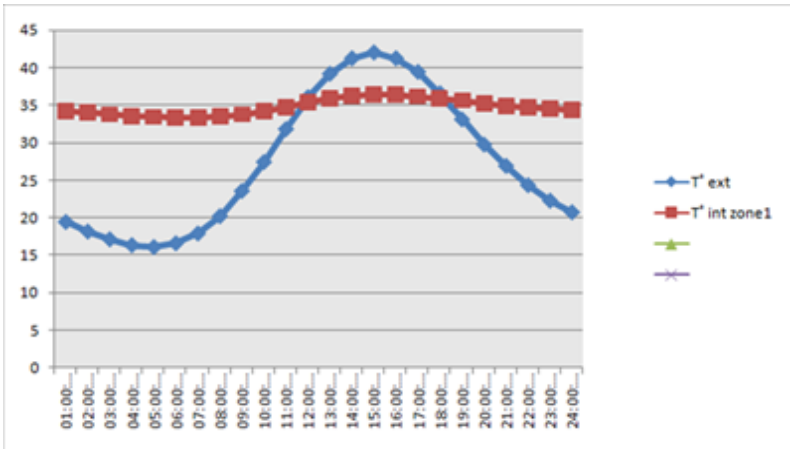

Figure 7: Graph of the initial case simulation data; Author 2016

In the figure, we can read, through the shape of the graphs, the insulation behaviour, where it keeps the little variation of the indoor temperature,

which is around 4°C, in this case some air conditioning is needed especially, from 12h00 to 18h00.

After applying improvements, also in this case, the use of double glazing in addition to an insulation element (Polystyrene) instead of a simple air layer between the two parts of the wall.

At this moment one can notice the slightly decreasing temperature inside the house, which is around 2°C to 3°C compared to the initial case , given that double glazing are protected from direct sun heating. (Figure 8)

In figure 9, one can see the slightly difference between the initial case and the improved one, with almost the same shape for both cases, all through the day.

The values of the improved case are lesser, however, we still need some air conditioning, but for a short time, to make the house more comfortable.

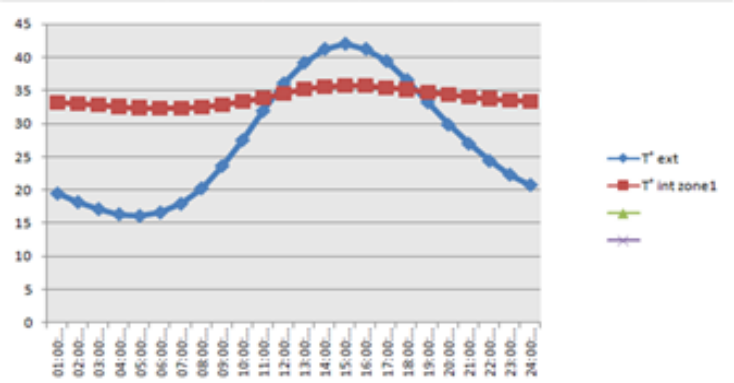

Figure 8: Graph of the Simulation Case Data improved; Author 2016

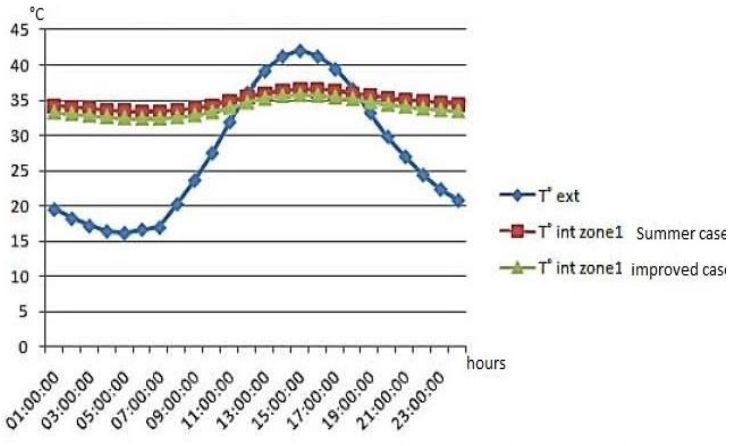

Figure 9: Comparison between the summer initial case and the improved summer case.

Conclusion:

The local identity of the Saharan cities is intimately linked to the use of building materials vis-à-vis their thermal efficiencies against Saharan climatic specificities.

The design of housing in particular has a very important role in energy consumption. This can be achieved by minimizing energy consumption; several solutions are possible in some cases and can

play an important role in improving the thermal behaviour and energy performance of the building, gg from **10, 43% to 06, 25%.**

- The higher the insulating glazing (high coefficient K), the lower the heat loss through the surface in the winter and the higher the supply of the sun by greenhouse effect. It can provide heating savings of around **5%** and greatly improves the comfort conditions, however to avoid problems of overheating during summer time, it is preferable to use an appropriate sun protection.

The double glazing is one of the solutions, indeed (two glasses trapping an air space) proves to be more efficient than simple glazing:

- It reduces thermal losses through the windows.
- It can allow heating savings and greatly improves comfort conditions.
- In fact, it makes the effect of cold wall disappear.

- The introduction of the polyester layer allows a substantial improvement of the thermal insulation compared to the simple air layer and consequently allows a better thermal comfort. It indicates an equivalent gain of **14, 99W/k**

Roof insulating (the 5th façade) is also to consider making the house even more comfortable.

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