Energy and Buildings 43 (2011) 2414–2421

Contents lists available at ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Introduction to control of solar gain and internal temperatures by thermal insulation, proper orientation and eaves

S.M.A. Bekkouche [a,*], T. Benouaz [b], M.R. Yaiche [c], M.K. Cherier [a], M. Hamdani [a], F. Chellali [a]

[a] Applied Research Unit on Renewable Energies, URAER, B.P. 88, ZI, Gart. Taam, Ghardaïa, Algeria
[b] Laboratory of Electronic Physics and Modeling, University Abou Bakr Belkaïd, Tlemcen, Algeria
[c] Development Center of Energies Renewable (CDER), B.P 62, 16340, Route de l'Observatoire, Bouzaréah, Algiers, Algeria

ARTICLE INFO

Article history:
Received 14 July 2010
Received in revised form 24 May 2011
Accepted 30 May 2011

Keywords:
Temperature
Solar gain
Thermal inertia
Orientation
Thermal insulation
Eaves

ABSTRACT

In desert regions, the orientation of buildings, thermal insulation and eaves have an important influence in the inside air temperature. The main objective of the current work is to minimize interior temperatures by these three techniques. This study aims at assessing also the geographic parameter enhancing or damping the role of thermal inertia, providing a variety of results.

As result, this work proves that stones play a contradictory role on thermal comfort; it has been found that changing orientations of building is not beneficial in terms of thermal comfort particularly in the hot season in case of a building without insulation. Consequently, the insertion of the eaves is recommended to achieve a better thermal comfort in arid and semi arid regions and the habitation will have to be situated in south flan of a hill to satisfy the two strategies (hot and cold).

1. Introduction

The seventies housing crisis had inspired the interest in bioclimatic architecture. As the most nowadays built houses are intact and combustible energy reserves are exhausted. Decline towards the bioclimatic architecture becomes an issue. This principle of architecture requires first an adequate choice of house location and orientation and then warmth and cold requirements. Numerical methods that predict the thermal behavior of the housing envelop have been elaborated. These models allow the evaluation of internal temperatures in terms of thermal comfort to be achieved [1,2].

However, it is not appropriate to consider air conditioning, or heating systems without tacking into account the outside temperature fluctuations, building orientations, and the strength of the insulating material to be used, internal charges and construction materials used. Classical methods used to compute the energy consumption and energy demand [3–7] are not adequate since the effect of interaction of different basic building constituents and the suggested solution are not dealt with [8].

Ghardaïa region (32.4°N, 3.8°E) is located 600 km from the coast, at an altitude of 450 m above sea level. It is influenced by a dry climate, characterized by very low precipitations (160 mm/year), very high temperatures in summer and low temperatures in winter (frosty from December to mid-February). The climate is hot and dry in the summer with temperatures variation between a maximum of around 45 °C and a minimum of 20 °C, thus giving a large diurnal temperature swing. Winter temperatures vary between a maximum of 24 °C and a minimum of 0 °C. Its normal temperature in January is 10.4 °C, it is 36.3 °C in July. And the average annual range is about 12.2° amplitudes of monthly average temperatures. They are more moderate in winter than in summer (average 11° in winter cons 13.5° in summer). The monthly maximum amplitudes are larger in summer than in winter fluctuates around 20 °C. Solar radiation is intense throughout the year with a maximum of 700 Wm^{-2} in winter and 1000 Wm^{-2} in summer, measured on the horizontal surface. This Saharan climate result that insulation is necessary, some requirements have been identified by Fezzioui et al. [9]. Chelghoum et al. [10] paper discusses adaptation for climate change through a local adaptation strategy at a variety of scales, showing how to manage high temperatures.

With the present studies, we can aim the optimal advantage of the sun for passive solar heating and cooling. The orientation effect of a non-air-conditioned building on its thermal performance has been analysed in terms of temperature index for hot-dry climates. The evaluation is derived from a series of computer simulations. At the end of study, we will give some solutions that can provide positive improvements.

* Corresponding author. Tel.: +213 661317629; fax: +213 29 87 01 52.
E-mail addresses: smabekkouche@yahoo.com, smabekkouche@yahoo.fr (S.M.A. Bekkouche).

0378-7788/$ – see front matter © 2011 Published by Elsevier B.V.
doi:10.1016/j.enbuild.2011.05.018

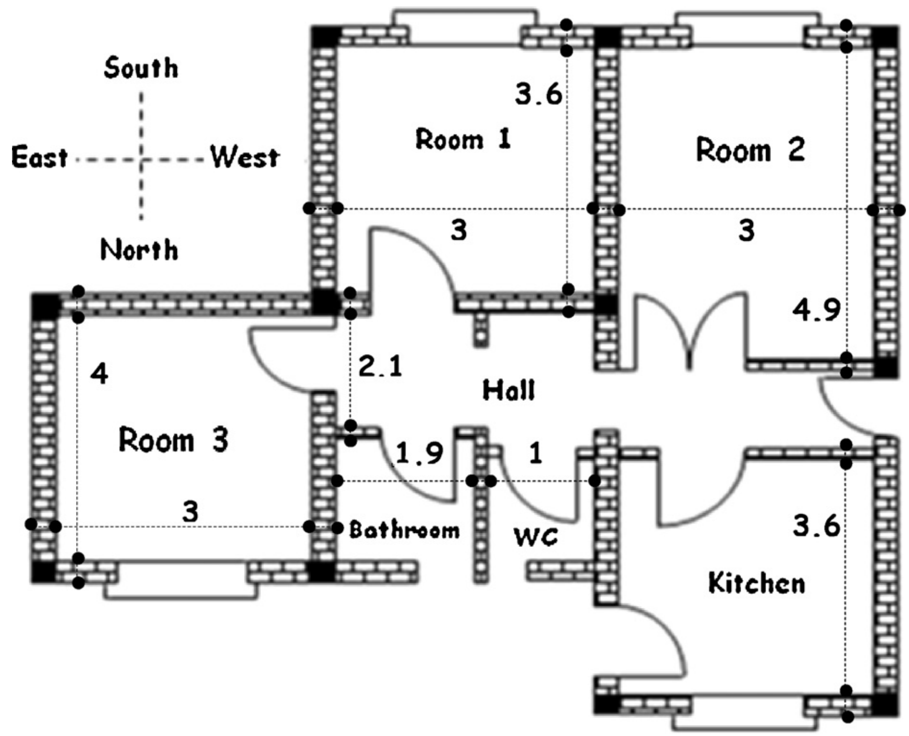

Fig. 1. Associated descriptive plan, the dimensions are given by m.

2. Description of typical house plan

In Ghardaïa region, stones are the most used construction materials. It is has been used for centuries (since the foundation of the town at 1200J) due to their availability and also due the lack of other construction materials such as wood (Vegetation are low due to the climate). A typical most commonly used construction in the region had been chosen. Fig. 1 is a schematic outline of real apartment building situated whether at the ground or at the first floor of two storey building. The house has an area of 88 m^2, wall heights are equal to 2.8 m while the other dimensions are shown in detail in Fig. 1.

This apartment includes the following elements:

- Building envelops or outer wall consisting of a heavy structure generally constituted of stones jointed and surrounded by two layers having thickness of 1.5 cm of mortar cement. The most inner face is coated with 1 cm thick plaster layer. The inner face of these walls may have a thermal insulating structure composed of an insulating polystyrene layer of thickness in the order of 6 cm and an air layer of 1 cm.
- The inner walls (or splitting walls) whose sides are in contact only with the internal ambient are considered to be of heavy structure constructed of stones of 15 cm width jointed and surrounded by two mortar cement layer of 1.5 cm thick and two layers of 1 cm thick of plaster.
- The flooring is placed on plan ground to lodge the ground floor. The concrete of the flooring is directly poured on the ground thus minimizing losses. Floor tiles are inter-imposed, it is an end coating resisting to corrosion and chemical agents.
- The roof is composed of cement slabs and concrete slab made so that it handles the load and be economical. A roof sloping of 5° allowed water evacuation through several openings. Until now the flat roofs are considered as nest infiltration and as architectural solution.
- Windows and doors contribute significantly to the energetic balance. Their contribution however depends on several parameters as: local climate, orientation, frame, relative surface (window-flooring), and concealment performance during night and sunny days. In this case focus is made particularly on windows and doors dimensions and all are made of woods [11,12].

3. Solar radiation for buildings

Heat transfer through walls and openings depends on site location of the building, receiving surfaces and orientation. For this reason the incident solar radiation for a vertical plane facing north, east, south, and west was determined using numerical models. In this regard, solar maps of Algeria for a totally clear sky have been made by the Liu and Jordan model [13,14]. The objective is to have an idea on the received energy by each façade to control the incident solar flux following the season and the orientation building.

Fig. 2 shows two solar maps of Algeria that provide the sum of all daily global solar radiation on a vertical south plane respectively in the two seasons, winter and summer.

From these maps, we notice that the sum of the daily Global solar radiation on a vertical south plane exceeds the value of 19 kWh/m^2 in winter season. In other hand, this value is less than 11 kWh/m^2 in summer in Ghardaïa zone. Similarly, we can appreciate the incident solar energy on other façade. It is legitimate to find that the energy intercepted by the north facade is clearly the least important. The results indicate that in winter the obtained value is between 0.94 and 0.99 kWh/m^2. But in summer season this value is between 3 and 4 kWh/m^2. With regard to the sum of daily global solar radiation on a vertical east and west plane, the results indicate that in winter the obtained value is between 9 and 10 kWh/m^2. But in summer season this value exceeds 11 kWh/m^2.

Consequently, solar radiation intensity on a major part of the Algerian territory requires most of the time the use of installations of air conditioning, to improve the internal conditions of comfort. The collected data indicate that Ghardaïa has a strong potential for

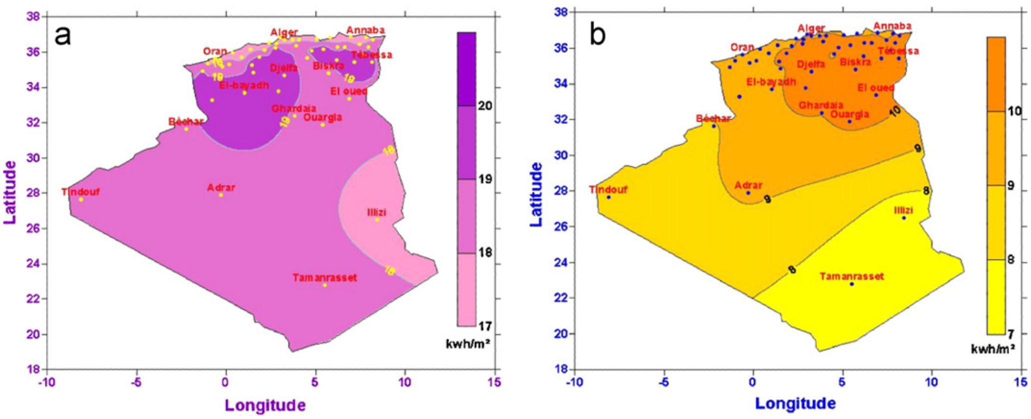

Fig. 2. solar maps of Algeria for a totally clear sky, sum of all daily Global solar radiation on a vertical south plane: (a) winter and (b) summer.

solar energy applications. For this reason, two solutions for example can be envisaged:

- The warm and dry climate imposes mostly to have closed façades, with openings of small dimensions and introverted towards the courtyard.
- The exploitation of effects of the shape and building orientation, this solution will allow sometimes to avoid (or at least limiting) appeal to the solutions of artificial air conditioning, with all that it implies of running costs and maintaining problems.

We will be forced to choose an efficient numerical model to estimate the incident global irradiation on the walls. The chosen method is Capderou model that utilizes the atmospheric Linke turbidity factor in order to compute direct and diffuse components of solar irradiation. Absorption and diffusion caused by atmospherical particles are expressed in terms of the Linke turbidity factors. From these factors direct and diffuse irradiation are determined in case of clear sky model [15–19]. We are interested in determining the incident irradiation on the roof (horizontal) and the vertical surface of external walls. Fig. 3 presents instantaneous variations of solar irradiation incidents upon the roof and wall of the flat for different orientations. These values correspond to the days of June 02nd under clear sky condition.

Whereas Fig. 4 represents instantaneous variation of solar irradiation incident upon different surfaces of the flat for second day of June with the following orientations: South East ($\alpha = -45^\circ$), South West ($\alpha = 45^\circ$), North East ($\alpha = 135^\circ$) and North West ($\alpha = -135^\circ$).

Solar radiation is intense throughout the year with a maximum of 700 Wm^{-2} in winter and 1000 Wm^{-2} in summer, measured on the horizontal surface. The desert Sahara has a huge potential of solar energy, which would permit solar power generation.

4. Experimental data and thermal inertia properties

Energy conscious building design consists in controlling the thermophysical characteristics of the building envelope such as, firstly, thermal inertia or thermal transmittance. In heat transfer, a higher value of the volumetric heat capacity means a longer time for the system to reach equilibrium. In a similar way, thermal inertia is the term used when a material has the ability to store heat and retards the transfer of heat loss or gain [20,21].

Several works have been performed in this field. Dornelles et al. [22] suggested that constructive systems with high thermal inertia provide more comfortable environment and buildings with low energy consumption. For example, Noren et al. [23] showed that thermal inertia has an influence on the annual energy requirement for the heating of a house located in a country with a northern climate. The lowest specific energy requirement is obtained with an extremely heavy concrete construction. Also, it has been proved in a more cold climate (Belgium, for example) [24], that thermal inertia is essential for absorbing solar and internal gains during the day to reduce temperature rise inside. Only the innermost layers of the building mass play an active role in the control of the indoor temperature fluctuation over a daily cycle. This section discusses

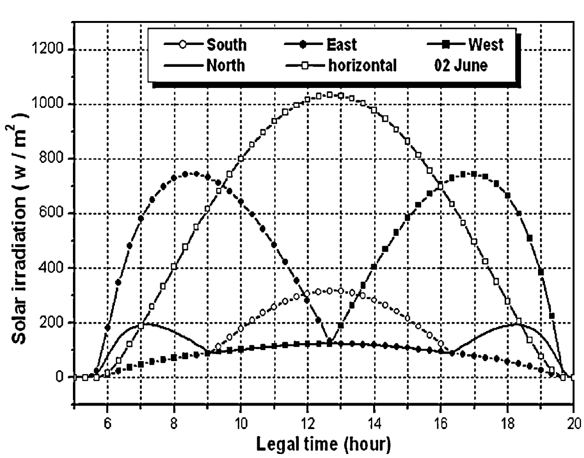

Fig. 3. Incident solar irradiation on walls, 02 June.

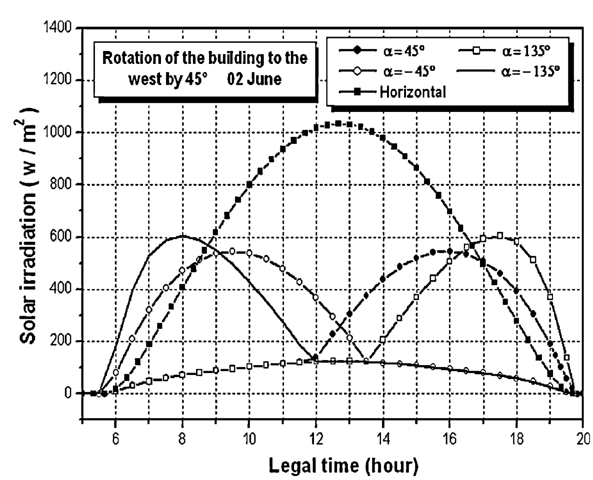

Fig. 4. Incident solar irradiation on walls, West rotation by 45°, 02 June.

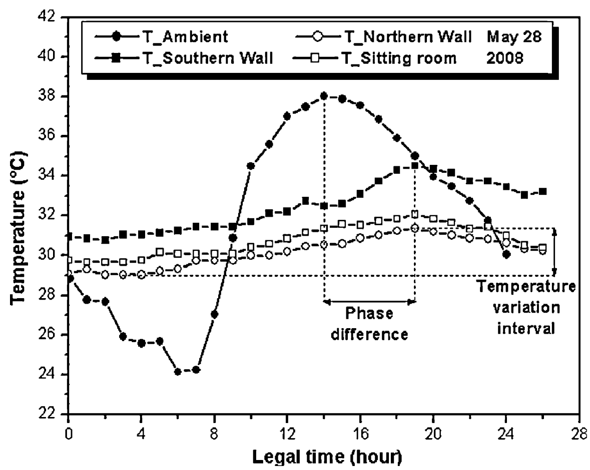

Fig. 5. Indoor and outdoor temperatures, May 28, 2008.

thermal inertia effect on measured indoor air temperatures in a building in an arid region of Algeria.

In order to accomplish the measurement phase, a data acquisition unit of type Fluke Hydra Series II which in spite of its high accuracy, it accumulates some errors, not really considerable. Type K thermocouples were used to measure temperatures, their measuring principle is based on Seebeck effect. For recording the temperatures of south and north walls, five thermocouples were placed in different locations of walls. Also, the temperatures of the internal ambient air were registered by placing other five thermocouples in different points. The plotted temperatures experimental values are those corresponding to the average of the registered ones. We introduced the thermocouples so that:

- First is located in the center of the sitting room.
- The second and the third are placed on the middle axis of the horizontal plane at 1.4 m in height so that each thermocouple is at 20 cm of the southern wall and the Northern wall.
- The others thermocouples were inserted into the normal line which passes through the first thermocouple, they were implanted in such way the distance between the thermocouples and the walls (the roof and floor) will be about 10 cm.

Indeed, we judged that five thermocouples are largely sufficient because the temperature gradients are not really significant. According to the measurements in summer and for any position of the vertical plane, the maximum difference between air temperature at a point near the roof and another point on the same normal and at proximity to the ground does not exceed the value of 0.85 °C. Similarly, for any height, the maximum variation in temperature is about 1 °C between two points, one near the southern wall and the other near the northern wall, which lie along the same axis and same horizontal plane. Then to measure the temperatures of the walls, we introduced the five thermocouples on surfaces of the walls by respecting the same distances. The first will be at the center, the second and the third will be on the vertical line which passes by the center and the last thermocouples will be on the horizontal line which passes by the center. However, the experimental temperatures obtained in May 28, 2008 for air and some sitting room walls are given in Fig. 5.

The house interior is usually warmer than the outside for most of the evening hours from 23:15, with the interior air temperature being lower than the outside air during the exterior interval of time. The higher interior air temperature during the evening hours is caused by the thermal storage. Thermal storage or thermal inertia of any wall can be defined as the maximum minus minimum surface temperature (temperature variation interval). The temperature of a material with low thermal inertia changes significantly during the day, while the temperature of a material with high thermal inertia does not change as drastically. It can be also characterized by the difference between time of maximum outside air temperature and time of maximum inside air temperature (phase difference); a material with high thermal inertia dephases significantly. In our case, this average difference is about four hours. Whereas, the difference in temperature between nighttime and daytime is not larger in summer, all these characteristics are consistent with the scenarios described above. In other terms, the temperature variations are more apparent in buildings with low thermal inertia than in the buildings with high thermal inertia.

5. Orientation effect

Generally, in the south of Algeria, the building policy is the same as its homologue in the North. However, such policy has been failed due to the difference in their climates. The northern regions are characterized by a Mediterranean climate (wet winter and dry summer) while the southern regions are characterized by a very rough Saharan climate (very low precipitations and heavy sandy winds). The used building architecture is not efficient in terms of electrical demand. Due to the climatic specifications of the regions, the electrical consumption of the heating as well as the cooling systems is very high. In addition to that, the arbitrary orientation of building results a direct expose of solar constraint.

In this sense, the main objective of this part is to study the impact of orientation on the internal temperature of the building. This is carried out by evaluating the building energetic demand for different orientations using thermal insulation. Indeed the traced curves of temperature profiles governing room 1, living room and room 2 show clearly the enhancement that can be made to thermal comfort. To make these studies, we developed in Refs. [11,12] a mathematical models based on thermodynamic first principle were elaborated to obtain different air temperatures of the inside parts. However these models took into account only thermal exchanges thus air stratification, whereas wind influence on air infiltration and water diffusion into walls body were not considered. Also states changes are not considered therefore storage of latent heat and moisture effects were neglected. Implementing the general law of building energy conservation, we arrive to a non stand alone system governed by hundred and twelve non linear ordinary differential equations. However, the computing of temperatures and also the perception of dynamic aspect of thermal transfer are of paramount importance. Subsequently, it is essential to implement numerical methods that compute these temperatures. Designed to solve such problems, Runge–Kutta fourth order numerical method was used to apprehend thermal behavior of walls and air subjected to varied solicitations. The elaborated interactive programs allowed a better understanding heat transfer phenomenon of walls and air under dynamic regime.

By varying the building orientation by 45° towards the West or 45° towards the East, a slight change of internal air temperature has been observed. It should be noted here that internal air temperature change depends on the used construction material and the wall surfaces. Therefore, we propose to vary the orientation angle by 90°.

Figs. 6 and 7 present the simulated temperature profiles of the sitting room for different orientations during June the 02nd and 03rd 2008 while the ambient temperature varies from 20 to 36 °C. Parallel study was carried out on ground room and another of the first floor without implementing the technique of thermal insulation. It has been found that the temperatures values in the first floor are the highest. This may be explained by the fact that the

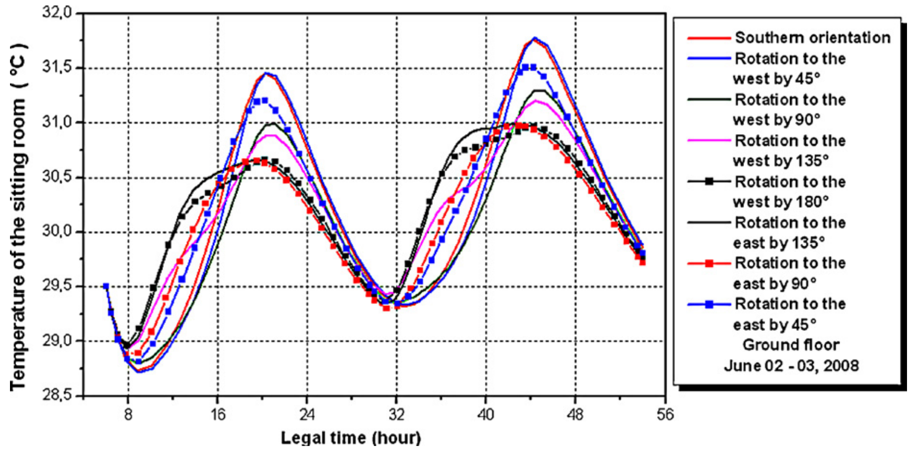

Fig. 6. Influence of the orientation on temperatures of the sitting room without thermal insulation (ground floor).

total exposed surface to the Sun and consequently the amount of absorbed thermal energy by the first floor is more important than that of ground floors. The rotation of the Building by 90° to the West direction induces to a reduction of cooling demand. In fact, it has been found that this reduction of cooling demand is significant before 18:30. Whereas the orientation of the Building by 90° towards the East will allow a reduction of cooling need after 18:30.

Thus it is evident that the orientation would have a more pronounced effect if the roof is not exposed to sun irradiation and the number of wall exposed to sun rays would be no more than two.

From Fig. 8, it is evident that the models fit adequately to describe the effect of the building orientation on the inside temperatures. The superposition of the obtained curves showed that their profiles are similar to those plotted in previous figures. The results of the simulation procedure showed that the sitting room temperature margin was 1 °C. This can be attributed to the impact of thermal insulation. The temperature difference obtained between full South facing building and other orientations does not exceed 0.5 °C.

In the following section we propose an example of thermal behavior of room 1 by varying orientation without and with thermal insulation. Thus Figs. 9 and 10 give the computed temperatures values for four orientations in such way that ambient temperature varies from 3 to 16 °C. As can be seen from these figures, the same scenario is repeated (same as curves forms during hot periods).

In the case of room 1, the air temperature oscillates between 14 and 16.6 °C. Whereas, the isolated air temperatures oscillate between 17.4 and 18.5 °C. The thermal insulation allowed reduction of air heat losses through the side walls. It is worth mentioning that these results concern the current state in thermal building view point. In Saharan region, this type of construction will have to respect at least technical of thermal insulation to improve the energetic performances in winter period. Also the obtained results show that the temperature value is high if the building is South or West facing.

6. Control of solar gain

Tighter building regulation requirements have focussed attention on preventing the overheating of buildings. This principally requires a reduction in solar gain from incoming solar radiation. However, the answer is not simply to use smaller areas of glazing as there is a need for daylighting and views out, and the appearance of the building has to be considered. In this situation we will require to change the orientation of the building to determine the direction that favors minimizing solar gain. They are calculated by the following equation:

$$Q_s = 24 \sum I_{sj} S_{sj} \tag{1}$$

Q_s is the solar gain (Wh), the sum is over all directions j; I_{sj} is the solar irradiation for orientation j, it is expressed in W/m^2; S_{sj} is the receiving surface of j orientation (m^2), is computed as follows:

$$S_{sj} = ASFs \tag{2}$$

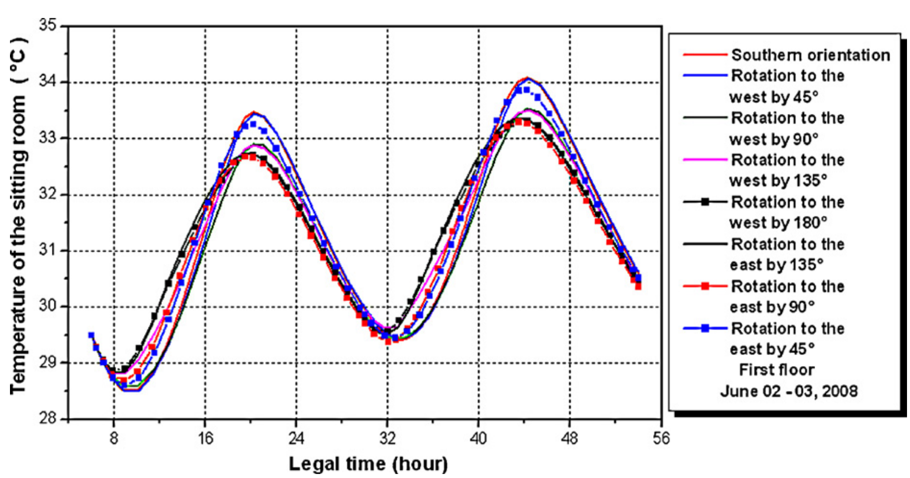

Fig. 7. Influence of the orientation on temperatures of the sitting room without thermal insulation (first floor).

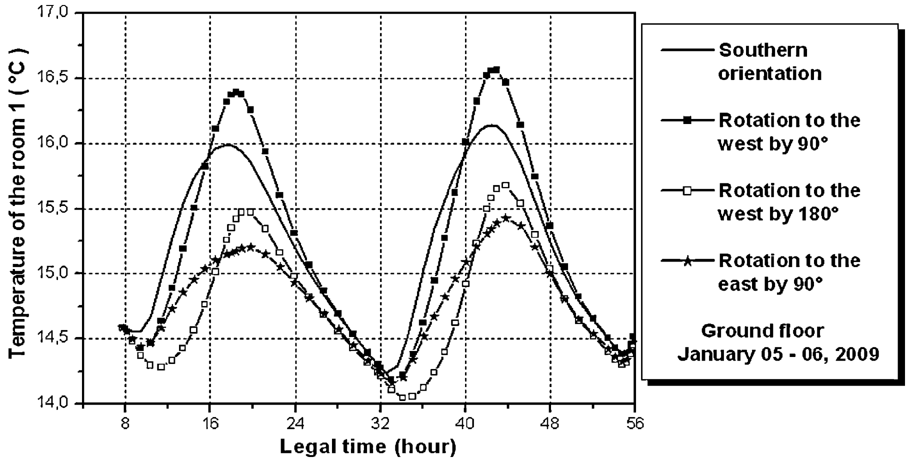

Fig. 8. Influence of the orientation on temperatures of the sitting room with thermal insulation (ground floor).

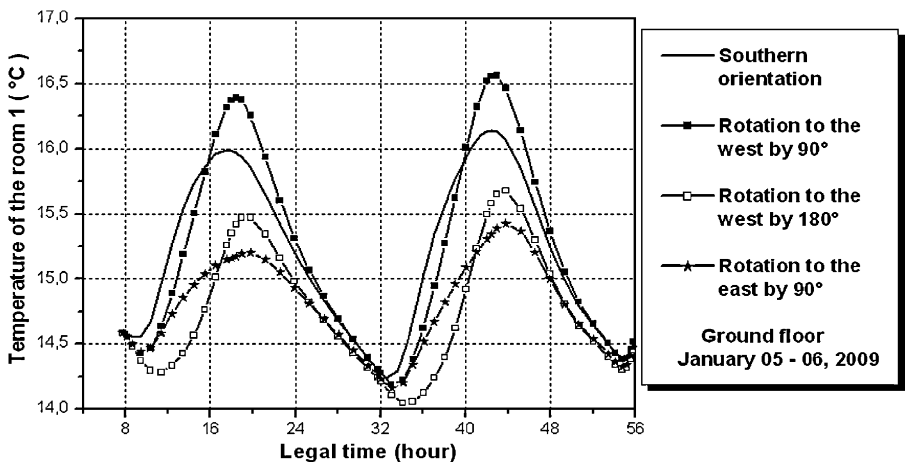

Fig. 9. Influence of the orientation on temperatures of the room 1 without thermal insulation (ground floor).

A is the surface openings (m^2); *Fs* is the correction factor for shading: for Northern $Fs = 0.89$, for the South $Fs = 0.72$ and finally for the East and West $Fs = 0.67$; *S* is the solar factor; is the ratio of the total solar energy flux entering the premises through the glass to the incident solar energy flux. For the carpentry wood $S = 0.44$, it is all just the contribution of a window to the heating of the room. Surface openings, South side $A = 3.36\,m^2$; surface openings, North side $A = 3.36\,m^2$; surface openings, East side $A = 2.068\,m^2$; surface openings, West side $A = 2.5080\,m^2$.

Then we deduce S_{sj}: $S_{s\_South} = 1.0644\,m^2$, $S_{s\_North} = 1.3158\,m^2$, $S_{s\_East} = 0.6096\,m^2$ and $S_{s\_West} = 0.7394\,m^2$.

So we can write:

$$Q_s = I_{s\_South}S_{s\_South} + I_{s\_North}S_{s\_North} + I_{s\_East}S_{s\_East} + I_{s\_West}S_{s\_West} \quad (3)$$

I_s is the daily irradiation incident on the considered direction (Wh/m^2).

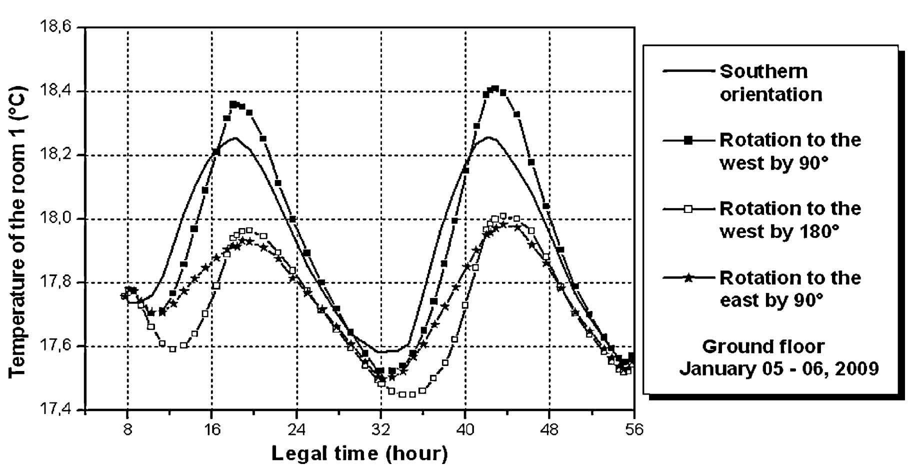

Fig. 10. Influence of the orientation on temperatures of the room 1 with thermal insulation (ground floor).

Table 1
Average daily irradiation (Wh m^{-2}).

	January	February	March	April	May	June	July	August	September	October	November	December
Vertical South	6764	6576	5492	3929	2695	2153	2350	3198	4470	5649	6313	6478
Vertical North	260	307	382	689	1423	2084	1751	978	528	402	312	258
Vertical East and West	2653	3269	3773	4216	4256	4240	4106	3942	3616	3158	2690	2323

The following table gives the average values of daily irradiation calculated for each month and for the four possible orientations (Table 1) [13,14].

The obtained Fig. 11 presents the variation of the average daily solar gain calculated by Eq. (3) according to the four classical orientations: South, North, East and West. In the fifth curve (black color), we illustrate the average daily solar gain of the habitat oriented in full South but with considering that there are not openings in the Northern façade.

Calculations showed that to protect itself from the summer overheating caused by the solar gain, it is recommended to choose the Southern orientation between Mars and September and the Western orientation for October. On the other hand, to benefit from this solar gain, it is preferably to choose the Eastern orientation for February and Southern orientation between November and January. However, we can say that the prevailing orientation is South. Even if we refer to February and October remarks, we can see that the difference in solar gain is not considerable compared to the Southern orientation. We can also draw from this study that closing openings of North facade reduces the solar gain in hot weather. Consequently, this initial study shows that to effect significant energy savings, specialist forms of shading are needed, combining low solar transmittance in summer with useful solar gain in winter.

These situations lead us to think about the integration of eaves. In winter the angle between the rays and the horizontal is less important in summer many winter rays pass under the eaves and reach the façade. While some summer rays reach the façade; they are stopped by eaves.

7. Integration of eaves

The eaves of a roof are its lower edges, usually projecting beyond the walls of the building to provide weather protection. The eaves can be designed to control the amount of the solar gain and heat crossing the windows and walls respectively. The use of eaves can reduce overheating by creating shade. Automatically, we eliminate the direct irradiation incident on the south wall. This means that calculations and simulation programs, do not take into consideration the diffuse irradiation incident on the south facade. Fig. 12 is a descriptive diagram showing the position and height of the sun in summer and winter.

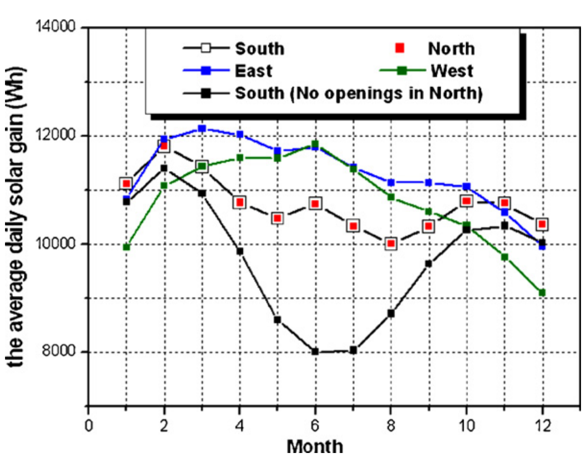

Fig. 11. Average daily solar gain for each month.

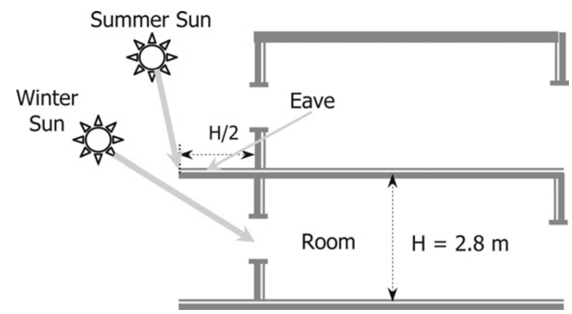

Fig. 12. Descriptive diagram shows an example of integration of eaves.

To show the advantage of eaves we chose the days of 08 and 09 July 2009, these days correspond to a completely clear sky and an ambient temperature between 30 and 45 °C. Running the program for several solicitations allows us to obtain Fig. 13. It represents the change in temperature inside the sitting room for three different cases: if the habitat is in its original state, if the habitat is with eaves in the south side and finally if the habitat is well insulated and with eaves of the south side. The interior thermal insulation has been made by introducing an air layer of 1 cm and a polystyrene layer of 8 cm.

The present study demonstrates that the inclusion of eaves slightly reduced the temperature of sitting room; the difference maximum (1 °C) is at 19:45. Consequently, we can say that the integration of this architectural technique does not achieve thermal comfort. Even if we consider that the habitat is well insulated, it can not achieve the desired comfort temperature (27 °C). So it is necessary to increase the thermal resistance of the outer envelope and insert other architectural techniques such as the attic space.

8. Discussion of principal results

In the arid and semis-arid region, the problem of energy consumption is of great importance due to the air-conditioning cost. Several results have been obtained, we summarize them as follows:

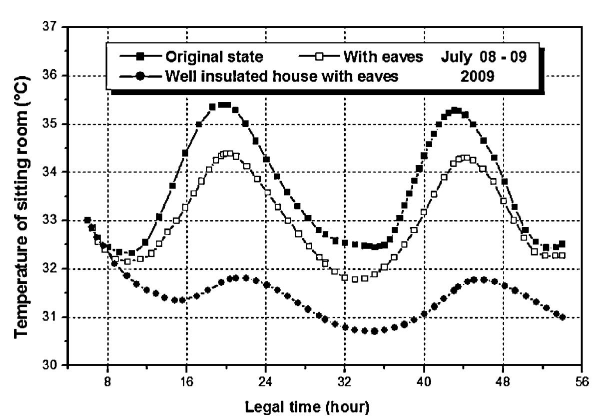

Fig. 13. Temperature of sitting room, July 08–09, 2009.

- Measurements of temperature indicate that thermal inertia is the key property in controlling temperature oscillations. The correct use and application of thermal mass depends on the prevailing climate. The thermal insulation in this case is insufficient due to the fact that several walls are exposed to the sun radiations. In addition to that, stones are an ideal material for thermal mass (with high specific heat capacity and high density). In other words, in hot season of Saharan climates, the use of high thermal inertia walls in buildings can not avoid outdoor heat to come indoor during 24 h. We can retain that the walls thermal inertia in these situations, play a contradictory role because the nights are not fresh. So even in the presence of a high thermal inertia, reduction of energy consumption in buildings is a major aim and is a particular challenge in desert climate.
- For the region of Ghardaïa, it has been found that changing orientations of building is not beneficial in terms of thermal comfort particularly in the hot season because they conduce to overheating. The influence of orientation changing depends on the floors and exterior walls constructing materials, the insulation levels and application of the inseparable rules of the bioclimatic design.
- In the case of thermal insulation, it has been found that the changing of building orientation has a low effect on its internal temperature.

9. Conclusion

The objective of this paper is to address the envelope impact on the interior temperature of a building in Saharan climates. In this work, we analyze features considered to have an impact on the building such as the building orientation, thermal inertia and thermal insulation. According to these studies, we concluded that heat gains through walls and openings are certainly the main cause of overheating in these habitat types. But the sun protection should cover all the outer walls of housing: roof, walls and windows. This is an important step in bioclimatic design. Consequently, the achievement of effective sun protection is the second phase of the fundamental design of thermally and energy efficient homes.

The optimum house design in the Ghardaïa is South facing, but in order to avoid the excess of heat during summer, one must create up eaves. These results are strongly coincided with those found by Fezzioui et al. [9] and Chelghoum et al. [10]. The difference is that these authors consider that the walls are built in hollow concrete. But they have almost the same thermal resistance compared to the stone walls resistance in our studies.

The design of passive houses in an arid region is based on several points, we quote as an indication: the calculation and the control of solar gains, knowledge with precision the impact of thermal mass on indoor temperatures, the correct choice of building materials and the strengthening of the thermal insulation, the building orientation and the optimal uptake of solar energy through the roof and eaves.

References

[1] A. Mingozzi, S. Bottiglioni, M. Medola, Passive cooling of a bioclimatic building in the continental climate of the padan plain: analysing the role of thermal mass with dynamic simulations, International Journal of Sustainable Energy 28 (March (1–3)) (2009) 141–156.
[2] A. Mingozzi, S. Bottiglioni, Bioclimatic architecture, the case study of the sustainable residential settlement in pieve Di cento, in: 2nd PALENC Conference and 28th AIVC Conference on Building Low Energy Cooling and Advanced Ventilation Technologies in the 21st Century, September 2007, Crete Island, Greece, 2007.
[3] L. Wang, J. Gwilliam, P. Jones, Case study of zero energy house design in UK, Energy and Buildings 41 (2009) 1215–1222.
[4] J. Yu, C. Yang, L. Tian, Low-energy envelope design of residential building in hot summer and cold winter zone in China, Energy and Buildings 40 (2008) 1536–1546.
[5] A.F. Tzikopoulos, M.C. Karatza, J.A. Paravantis, Modeling energy efficiency of bioclimatic buildings, Energy and Buildings 37 (2005) 529–544.
[6] F.F. Al-Ajmi, V.I. Hanby, Simulation of energy consumption for Kuwaiti domestic buildings, Energy and Buildings 36 (2004) 710–719.
[7] E. Gratia, A.D. Herde, Greenhouse effect in double-skin facade, Energy and Buildings 39 (2007) 199–211.
[8] L. Buzzoni, R. Dall Olio, M. Spigab, Energy analysis of a passive solar system, Revue Générale de Thermique 37 (1998) 411–416 (Elsevier, Paris).
[9] N. Fezzioui1, B. Droui, M. Benyamine et, S. Larbi, Influence des caractéristiques dynamiques de l'enveloppe d'un batiment sur le confort thermique au Sud Algérien, Revue des Energies Renouvelables 11 (1) (2008) 25–34.
[10] Z. Chelghoum et, A. Belhamri, Habitat a bas profil énergétique, Revue des Energies Renouvelables, Journées de Thermique (2001) 59–64.
[11] S.M.A. Bekkouche, T. Benouaz, A. Cheknane, Simulation and experimental studies of an internal thermal insulation of tow pieces of rooms located in Ghardaia (Algeria), IJACE International Journal of Advanced Computer Engineering 2 (June (1)) (2009).
[12] S.M.A. Bekkouche, T. Benouaz, A. Cheknane, A modelling approach of thermal insulation applied to a Saharan building, Thermal Science 13 (4) (2009) 233–244.
[13] M.R. Yaïche et, S.M.A. Bekkouche, Conception et validation d'un programme sous Excel pour l'estimation du rayonnement solaire incident en Algérie, cas d'un ciel totalement clair, Revue des Energies Renouvelables 11 (3) (2008) 423–436.
[14] M.R. Yaïche et, S.M.A. Bekkouche, Conception et validation d'un programme sous Excel pour la modélisation d'une station radiométrique en Algérie, cas d'un ciel totalement clair, Revue des Energies Renouvelables 12 (N°4) (2009) 677–688.
[15] M. Capderou, Modeles théoriques et expérimentaux, Atlas solaire de l'Algérie, Office des Publications Universitaires, Algérie, Tome 1 Vol 1 et 2, 1987.
[16] A. Mefti, M.Y. Bouroubi et, A. Khellaf, Analyse critique du modèle de l'atlas solaire de l'Algérie, Revue des Energies Renouvelables 2 (2) (1999) 69–85.
[17] F. Kasten, A.T. Young, Revised optical air mass tables and approximation formula, Applied Optics 28 (22) (1989) 4735–4738.
[18] F. Kasten, A simple parameterization of two pyrheliometric formulae for determining the Linke turbidity factor, Meteorology Rdsch 33 (1980) 124–127.
[19] F. Kasten, The Linke turbidity factor based on improved values of the integral Rayleigh optical thickness, Solar Energy 56 (3) (1996) 239–244.
[20] J.A. Orosa, T. Carpente, Thermal inertia effect in old buildings, European Journal of Scientific Research 27 (2) (2009) 228–233.
[21] S.V.G. Goulart, Thermal inertia and natural ventilation—optimisation of thermal storage as a cooling technique for residential buildings in southern Brazil, A Thesis Submitted in Partial Fulfillment of the Requirements of the Open University for the Degree of Doctor of Philosophy, October 2004.
[22] K.A. Dornelles, M. Roriz, Thermal inertia, comfort and energy consumption in buildings: a case study in Sao Paulo state-Brasil, International Journal for Housing Science and its Applications 28 (part 2) (2004) 153–162.
[23] A Noren, J. Akander, E. Isfält, O. Söderström, The effect of thermal inertia on energy requirements in a Swedish building-results obtained with three calculation Swedish building results obtained with three calculation models, International Journal of Low Energy and Sustainable Buildings (1999), 1.1999.
[24] E. Gratia, A.D. Herde, Design of low energy office buildings, Energy and Buildings 35 (2003) 473–491.