

Technical Note

**BIOCLIMATIC APPROACH OF BUILDING DESIGN IN HOT
CLIMATE: AN EXAMPLE OF BISKRA**

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ABSTRACT

The primary purpose of building design is the creation of an indoor thermal environment, offering adequate living and working conditions for occupants. Thus, the objective is to consider local climatic conditions in the way of designing buildings for regions of the southern Algeria, where the hot and arid climate affects architecture and building materials.

Keywords: Thermal comfort, bioclimatic architecture, hot and dry climate, thermal inertia

1. LOCATION AND CLIMATE

The territory is divided from the North to the South into climatic zones, as shown in the map of climatic zones of Algeria, Figure 1, Ref. [1].

Biskra, a city of south Algeria, is characterized with the following geographic coordinates:

City	Biskra
Latitude	34.48 °N
Longitude	5.44 °E
Altitude	81m

There are high differences in annual and diurnal temperature ranges, and maximum temperatures may exceed 44 °C in summer; annual rainfall is very low.

Winters have sunny and pleasant days with cold nights. Solar radiation is very intense in summer, being able to reach for the warmest month (in this case July), a daily average of 5962 Wh/m² for a horizontal surface [2].

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Annual climatic data for Biskra are summarized with Figures 2 and 3.

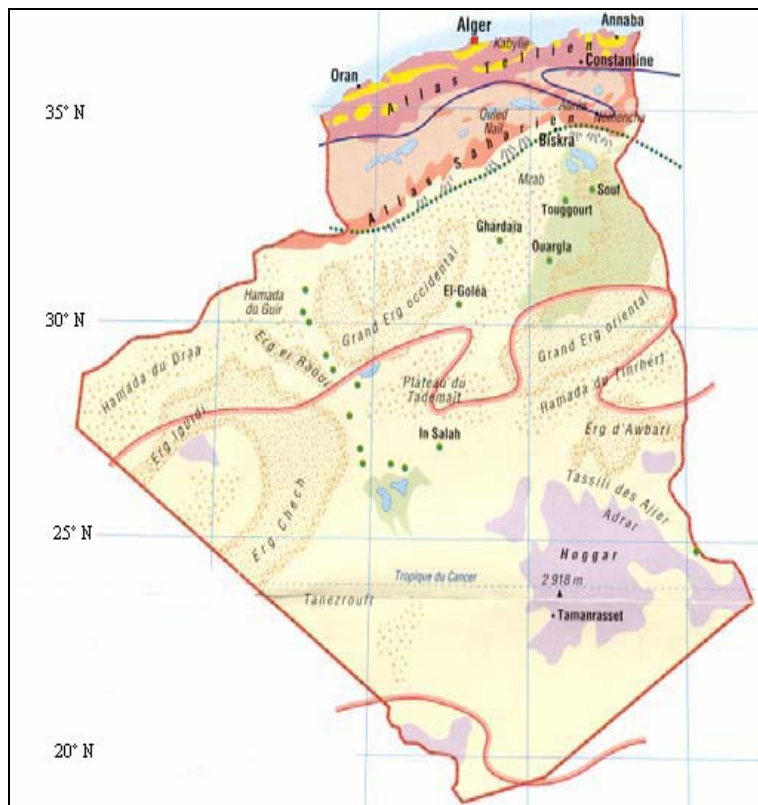


Figure 1. Map of Algeria

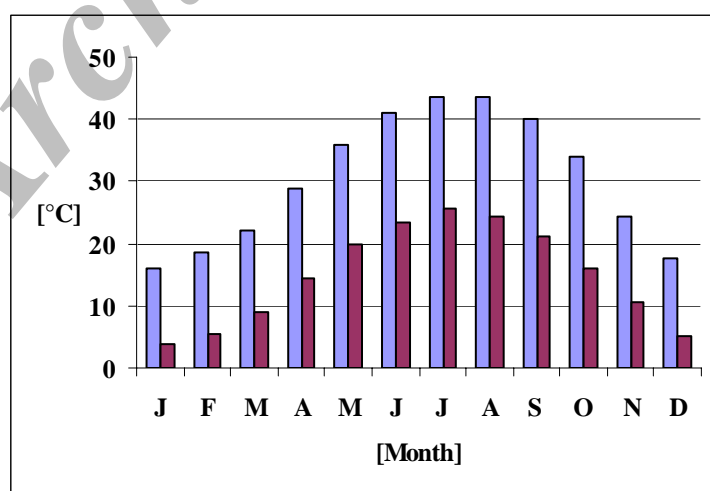


Figure 2. Maximal and minimal monthly temperatures

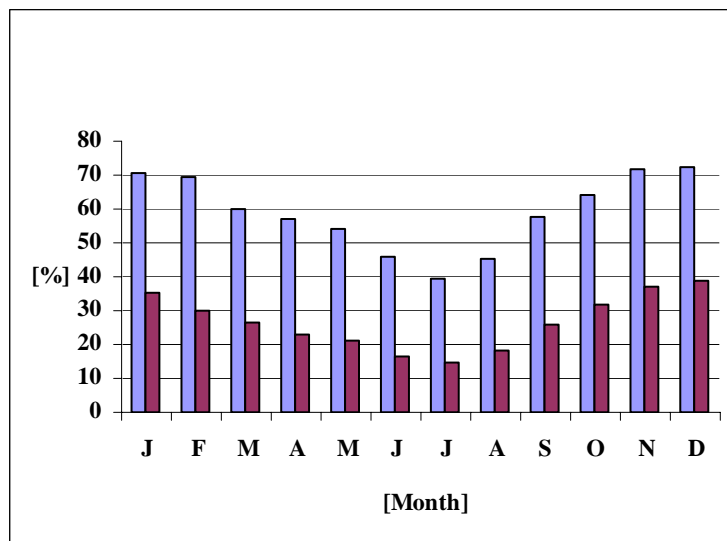


Figure 3. Maximal and minimal monthly humidities

2. LIMITS OF COMFORT

According to Auliciems, they are limits such as 80 % or 90 % of the persons feel at ease, [3].

The limits of comfort so that 90 % of the persons feel at ease are such as

$$T_n \pm 2.$$

Where T_n = temperature of thermal neutrality in [$^{\circ}\text{C}$].

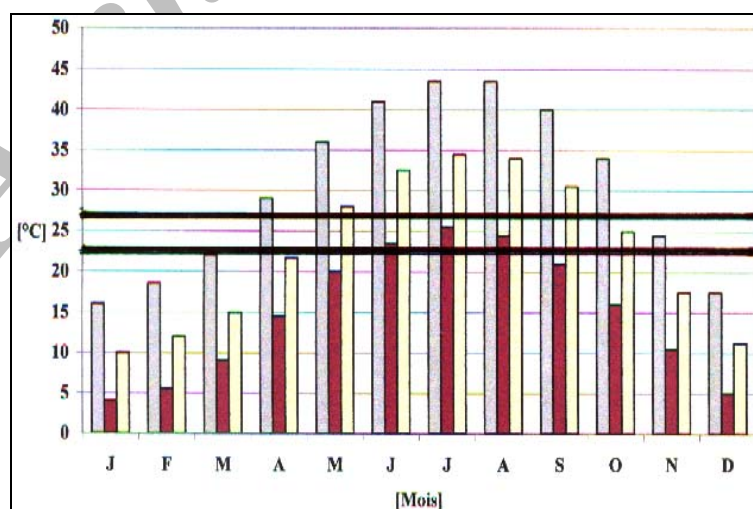


Figure 4. Limits of comfort (comfort for 90 % of the persons)

Observing comfort's limits from Figure 4, one notices that according to these limits, this one is practically possible naturally only during three months of the year (April, May and October).

3. GIVONI'S CHART

The report of these annual climatic data on Givoni's bioclimatic chart is given in Figure 5.

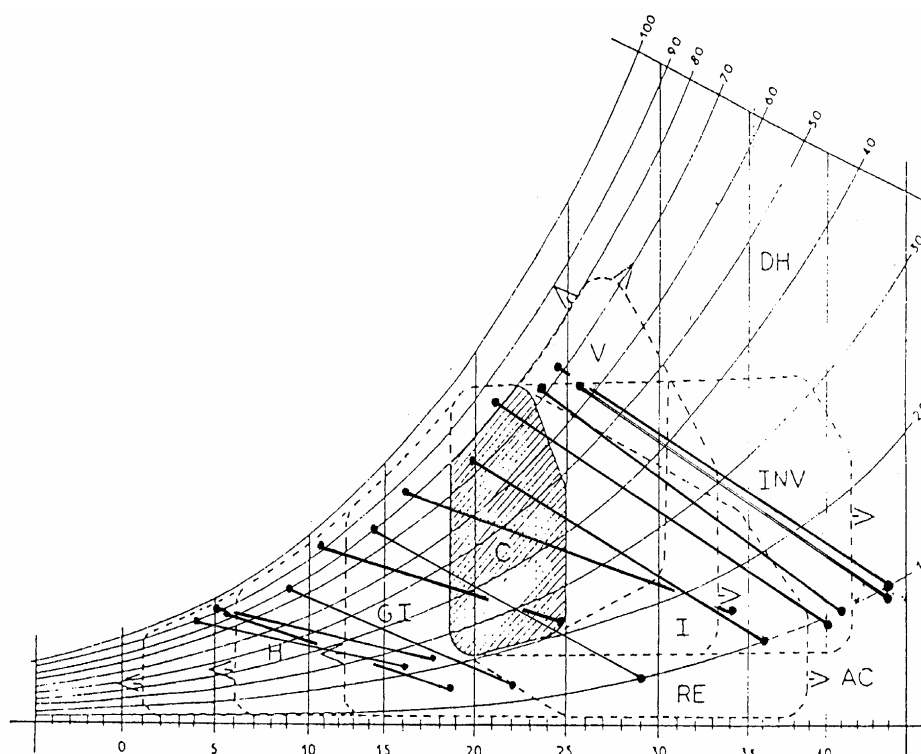


Figure 5. Givoni's bioclimatic chart for the city of Biskra

From Givoni's chart, one retains especially an active system of air conditioning and a night-ventilation for warmest summer months. For the cold winter months, a thermal inertia associated to good exploitation of solar gains (with a system of active conventional or solar heating for the cold winter nights).

So, main interventions to be retained to improve indoor climate within comfort zone, will be a high inertia (for all the year), a good use of solar gains in winter (and to minimize solar gains in summer), as well as an effective night-ventilation in summer.

4. CONCEPTION IN HOT AND DRY CLIMATE

In summer, possibilities of adopting for achieving the indoor thermal comfort are generally:

a) Shape

Both of orientation and building shape have a great influence on thermal conditions and the needed energy for cooling indoor space.

The use of compact forms with central courtyards is a general characteristic of the architectural conception for all the Sahara, and around the central courtyard, different rooms are arranged. The openings are of small size and introverted towards the courtyard. The courtyards act as a ventilator for the building [4].

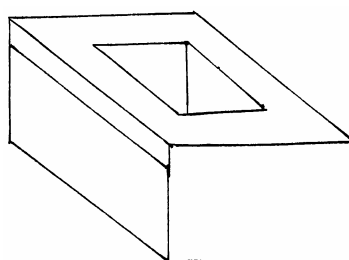


Figure 6. Use of central courtyard

To note also the use of central courtyards in the conception of houses, allowing a better protection of internal spaces from solar radiation, by reducing at least exposition to the summer sun and the heat losses in winter.

b) Thermal mass

The thermal mass can be obtained with walls with high inertia realized in natural stones, in concrete blocks or by sun-dried clay bricks.

The thick walls absorb the heat of the sun during the day, preventing it from affecting the inside of the building. During the night, in presence of a clear sky, the building must be opened to the cool night-air for the refreshment of walls and roof.

Cooling effect is increased with the wind and the radiation towards the night sky. The external walls are realized according to the various possibilities as shown in Table 1.

Table 1. type of external walls

Type of external wall	Time lag ϕ [h]	Decrement factor μ
Concrete blocks (0.20 m)	4	0.044
Stone (0.20 m)	4	0.095
Stone (0.30 m)	6	0.056
Clay bricks (0.20 m)	9	0.0052

A clear night-sky allows nocturnal night sky radiation between the building and the sky.

c) Building's colour and reflectivity

It will be of light colours to reduce the amount of the solar radiation (for example a whitewash). A white wall absorbs about 20 % of the incident solar radiation, what reduces very appreciably the quantity of heat entering the building and simplifies the task of refreshment to be realized.

d) Reduction of solar gain by shading openings

Thoughtful shading devices must be applied to windows and other glazed surfaces, to decrease the entries of heat while.

To realize a good solar radiation in winter, one should direct the building southward (weak solar altitude in this period and good solar radiation).

The values of solar altitude at noon solar time and of global daily irradiation for cold and warm periods, for a south oriented surface, are given in Tables 2 and 3.

Table 2. Daily global irradiation during cold season for a south surface

Period	h at noon solar time	Daily irradiation [Wh/m^2]
November 21	35° 32'	4776
December 21	32°	5018
January 21	35° 42'	5258
February 21	43° 47'	5450

Table 3. Daily global irradiation during hot season for a south surface

Period	h at noon solar time	Daily irradiation [Wh/m^2]
June 21	79°	2510
July 21	76°	2710
August 21	67° 31'	3378

The windows following this orientation should contain solar shading devices, in order to reduce the thermal loads in summer, while maintaining an acceptable level of natural lighting.

By considering a window of dimension 0.90 m x 1.20 m, southward oriented, with an overhang of width 0.30 m, the rate of sunny window in summer and in winter will be given

with Figures 7 and 8.

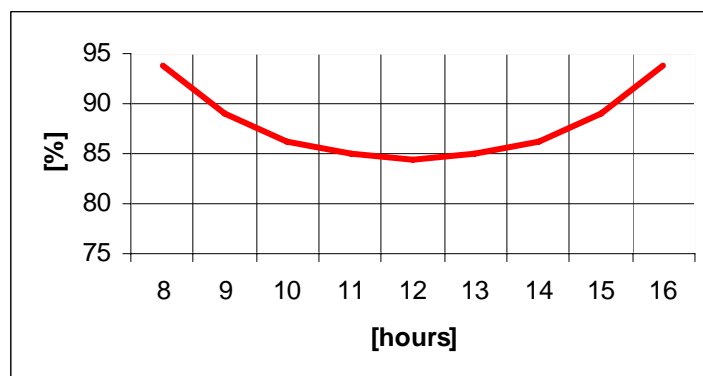


Figure 7. percentage of sunny window in December.

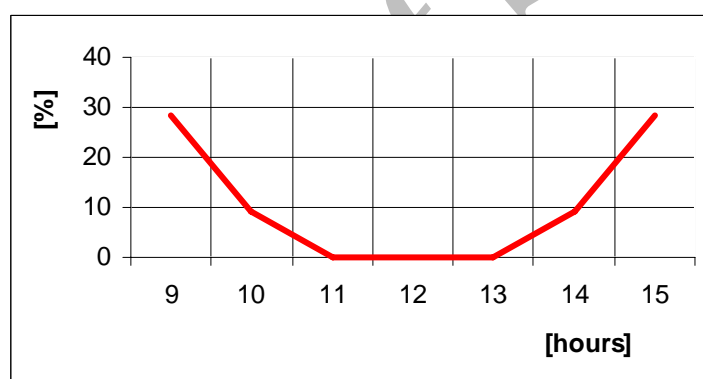


Figure 8. Percentage of sunny window in June

East and west-facing windows are the most difficult to shade, because early morning and late afternoon sun rays are approaching perpendicular to these windows, causing excessive heat gain and visual glare.

So, we have to minimize use of east and west-facing windows. When these windows cannot be avoided, use a combination of horizontal overhangs and vertical fins to shade these windows as much as possible.

e) Night-ventilation

Night ventilation takes advantage of the cooling potential of the outside air at night and the thermal storage capacity of the building. It can be realized by using the exterior windows and interior doors.

Ventilation will be efficient with high located windows in spaces, to release hot air and sometimes can be augmented with air movement from ceiling fans.

5. CONCLUSION

Passive refreshment is not and will not probably be in the close future, as efficient as the conventional techniques of cooling (electric and mechanical systems). However for persons in hot and uncomfortable climate for whom such an equipment of refreshment is out of reach, passive cooling design can be a step towards the comfort with low cost.

Financial motivations, associated to educational programs for the consumers, the entrepreneurs, and the other speakers in the field of the building, can stimulate conception and realization of energy-efficient construction.

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