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Glazed Transitional Space as a Passive Heating System
(Case Study: Glazed Loggias in Semi-Arid Climate)

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ABSTRACT: The environmental concern, ensuring comfort for occupants, pushed us to search for the impact of glazed loggia on thermal comfort of adjacent space in Constantine climate, having strong climatic constraints. An experimental study is undertaken and described in this paper. Analysis of the in situ results is also discussed. This work shows that in winter glazed loggia benefit largely from solar gains. In summer, it is a thermal regulating space, delaying diurnal peak of temperature towards the end of the day. Overheating can be avoided with natural ventilation and a good use of the relation glazed loggia-adjacent space. This result leads to the possibility of retrofitting glazed loggias in hard climates, such as in Constantine (Algeria). To define criteria being able to return this addition, favourable and adapted to the winter and the aestival thermal comfort of adjacent space, a simulation is carried. But the only investigation is discussed in this paper.

Keywords: *Buffer space, Sunspace, Passive solar, Overheating*

INTRODUCTION

The control of energy constitutes a solution for environmental, economic and social problems. The residential sector offers significant possibilities in order to reduce the power consumption (Nadine, 2001), and its environmental impact. However, if we want to control energy; a detailed attention must be given to the outer envelope of the building.

The creation of buffer spaces, supports the conditions of thermal comfort by insulating this envelope. Sun spaces are an example of this type of spaces, which in addition to their thermal regulating role, contribute positively to the habitation heating by collecting solar energy, which became increasingly significant, attractive and profitable. However, great glazed surfaces are the point of passage of significant solar contributions in causing summer overheating.

Durable construction starts very upstream with a preliminary preoccupation with a regional planning. Unfortunately, in residential projects in many towns, spaces are conceived according to professional prospects' for the rather than on comprehension of the life ways of the inhabitants (Deshmukh & Deshmukh, 2008). In Algeria," Glazing the balconies" is becoming a common practice of inhabitants aiming to better adapt their residences to their needs without reflexion on its impact on comfort situations, nor about the consumption of energy following these practices. However, these new requirements must fall under a durable step of development. A few of them know that a balcony behaves like a complementary heat insulation, decreases the losses of heat in the winter and protects the interior of the solar radiation in summer, and that glazed spaces harm the comfort of the occupants and involve a waste of energy, in particular the phenomenon of frequent overheating in summer (Acfas, 2000; Saleh, 2015).

Local Climate

Constantine is an internal city of Algeria, located at 36°, 17 of Northern latitude. Its hard climate is characterized by strong daily and seasonal thermal fluctuations, dry air and clear skies with intense solar radiation. Average air temperature presents a value of 25.5°C at the hottest months of the year: July and August. 34°C is the maximum average reached for these two

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months. Diurnal temperature variation is significant, great daily temperature fluctuations are also a character determining in the area. Concerning relative humidity, the minimal average value of 48% corresponds to August. the maximum average value of 7.64% it is recorded in January. (Fig.1)

The average intensity of solar radiation in this city is significant, as it is about 4230 W/m² / day on a horizontal surface according to the National office of weather data. Total solar radiation on a horizontal surface reaches its maximum value of 337 W/h/m² in July. (Fig.2)

MATERIALS AND METHODS

Sun spaces can take varied forms which depend on the possibilities offered. The optimal configuration of sun space in a climate characterized by cold winters and hot summers is the glazed loggia. In this paper, the impact of glazed loggia on thermal comfort of adjacent space is presented by a comparative study between a cell of multifamily apartment with loggia completely closed by glazing, to compare with a similar one, but having kept its initial configuration (opening of the loggia on outside), these last will be used as a pilot cell. The intervention of inhabitant made that the volume of the loggia is supplemented by a simple clear glazing assembled on a steel structure.

Building Description

In situ measurements were conducted in the most widespread typology of the habitat in Algeria. Multifamily apartment, built in contemporary architectural style, according to a concept with prefabricated modules, allows a comparative study and the analysis of two samples having initially the same characteristics.

The case studied loggia is towards the south with depth 1,25m, area 3.9 m². Its adjacent space is 12,6 m² arranged in family living. The connection between the two spaces is ensured by a window located in the central part of the connecting wall living-loggia (Fig.3). The windows in the two apartments (cells) as well as in the glazed loggia are all single glass panels assembled on a steel structure. The situation of selected cells in an intermediate floor allows them a protection of distant or environmental masks.

The building envelope is built in reinforced concrete panels,

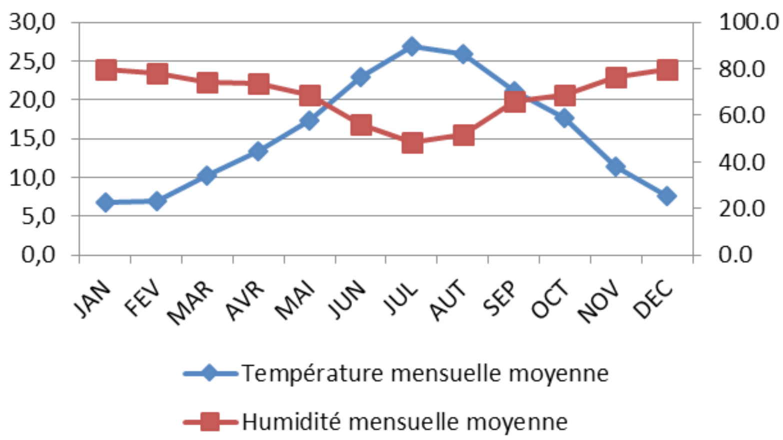

Fig.1: Monthly average temperature in Constantine– Period 2000-2010, National weather office: O.N.M.

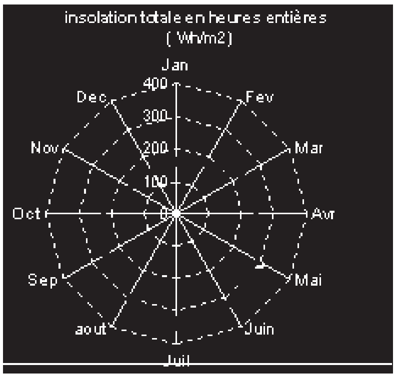

Fig .2: Average insulation for the period of 2000-2010, Office National weather, O.N.M.

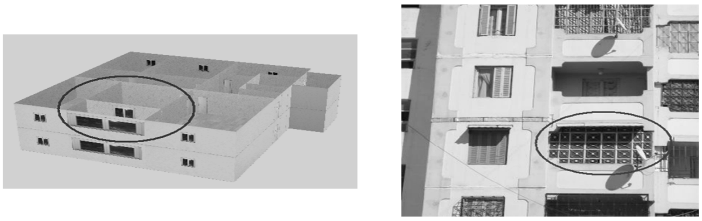

Fig .3: The monitored building with the glazed loggia (cell 2).

the partition walls of 10 and 15 cm thickness are also built of concrete, and the floors are in flat flagstones. The presence of this thermal mass is significant for the thermal performance of sunspace systems (Kesik & Simpson, 2002).

Measurement

The series of measurement was held over two periods of 3 days, each one, representative of cold and hot seasons. Measurements are recorded each 2 hours by the power station weather "OTIO and THERMOTECH" model 94030. The power station allows the taking away of air temperature like its relative humidity in space living, and receives the values of air temperature recorded in the loggia, by a transmitting thermometer (Fig.4). All measurement points have been situated at a height of 120 cm above the floor level. Continuous time variations of the outdoor temperature and relative humidity are given by meteorological station (ONM).

In order to allow a better comparison between the results: the two selected cells present the same number of occupants and similar indoor activities. Concerning indoor control, there is no heating or cooling system working in measurement periods. The only way to control indoor conditions is by natural ventilation.

RESULTS AND DISCUSSION

Cold Investigation

Note: In this paper, cell1 indicates the apartment with pilot loggia open on the exterior, and cell 2 indicates the apartment with glazed loggia.

Measurement of air temperatures and air moisture were done under a clear sky with cloudy passage in living space and its extension (loggia). The collected data allows us to calculate the air temperature variation between interior and outside in order to evaluate the performance of glazed loggia. Moreover, it gives a first estimate air condition in the contiguous living.

An amplitude air temperature of 6.8°C is observed in the glazed loggia, while the temperature fluctuation in the living space (5°C) is less significant; the weather station temperature knew a broader field of fluctuations of 12.9°C in the same period of measurement. (Fig.5)

Fig. 4: measure equipment used in the investigation.

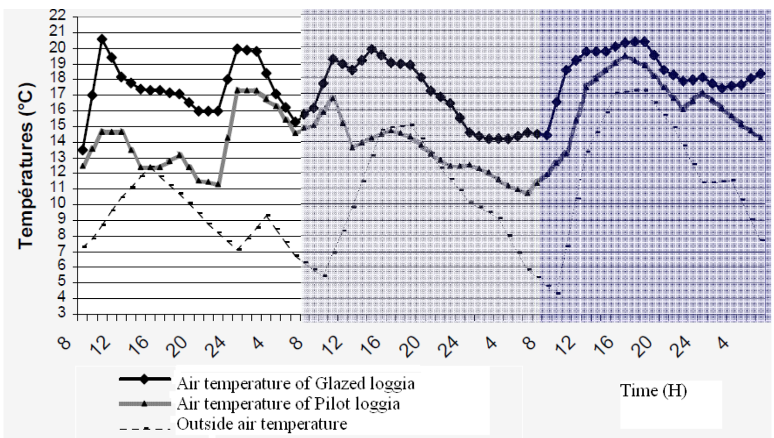

Fig. 5: Variance of air temperature between loggia (cell 1) and glazed loggia (cell 2). In Cold period.

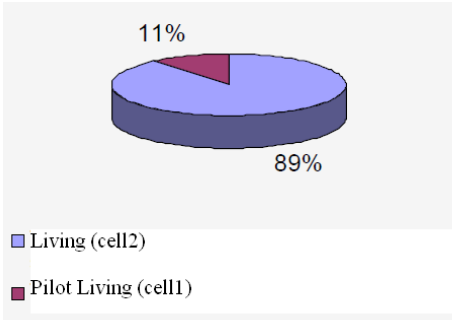

Fig. 6: Percentage of time when air temperature of living related to the glazed loggia in (cell 2) is higher than that of the controlled living (cell 1), with respect to the total duration of the investigation.

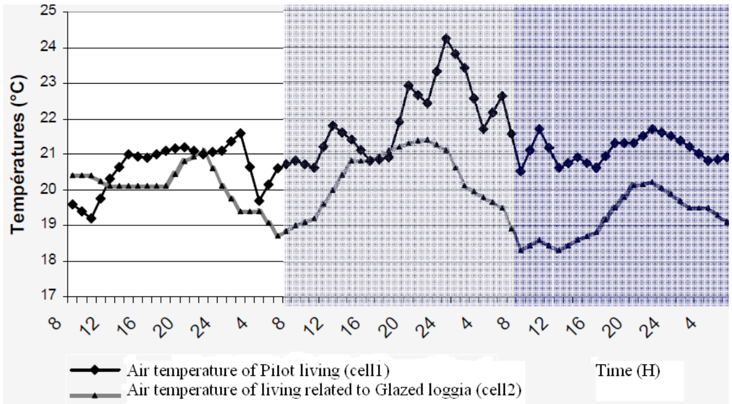

Fig. 7: Variance of air temperature enters the two livings, witness and related to the glazed loggia. Cold period.

Average air temperature (18.14°C) recorded in the not heated glazed loggia, compared with external average temperature, which was about 10.28°C, does not have any physical significance in the absence of internal gains (Connection between the two spaces is closed), other than thermal inertia. Because, the larger is the stored quantity of solar gains, smaller will be overheating and larger will be the availability of this energy after the sun (Pasupathy et al., 2008). Indeed this buffer space, is built out of prefabricated concrete so dense and having a good heat conduction.

It is in the living space adjacent to glazed loggia that we can see better the regulating character of the glazed loggia induced by the inertia. In fact, recorded air temperature values present fewer fluctuations, and reveal a thermal comfort situation for occupants, by exceeding neutral temperature 188,8% of total investigation time.

Comparison of the two livings Indicates that air temperature of the living adjacent to glazed loggia (cell 2) is higher than that recorded in the pilot living with a percentage of time of 89% of the total investigation duration. (Fig. 6)

Fig.7 shows the curves of the temperatures recorded simultaneously in the two livings and indicates a positive average difference (2.2°C) in favour of the glazed loggia. 3.1°C is the highest difference between the two livings. This value is of great importance with respect to winter comfort, and reduction of energy consumption. The situation would be better with a good proportioning of thermal mass. The great thermal mass of glazed loggia deprived the living of several calories, because according to R.D. Seifert (Seifert, 2009), in the case of a great thermal mass employed in the sun space, the great majority of solar heat will be worn in the sun space, and never reaches the house. The absence of insulation worsens this deficit. However the thermal role of buffer balances this deficiency during the night, and delays the cooling of the interior structure of adjacent space.

The surplus of temperature established by a closing loggia by glazing, is obtained with a bad management of connection glazed loggia- living (the inhabitants of cell 2 allow themselves to open the window by ignorance of the management of this connection). It is evident that a good behaviour of occupants will improve the thermal comfort in the adjacent space to glazed loggia. Other results of the in situ temperature measurements are resumed in Table 1.

Hot Measurement Period

The same cells were the subject of an investigation in hot periods. The values of air temperature measured in glazed loggia indicate fluctuations of about 5.1°C. The glazed loggia gains only a small portion of solar radiation, because of its advantageous orientation. The adjacent living space, maintaining the connection with glazed loggia through the open window all the period of investigation, is consequently

Table1: Results of the experimental measures relating to the cold season.

	Loggia cell 1(Tc 1)	Glazed Loggia Cell 2 (Tc 2)	external air (Tex)
Temperature min (°C)	10.7	13.5	4.3
Temperature max(°C)	19.4	20.3	17.2
Amplitude of temperature in space (°C)	8.7	6.8	12.9
Average air temperatures (°C)	10.28	18.14	10.3
Average gain of temperature on all period of the investigation (°C)	0	2.2	
3.1°C is the maximum valor of the variation enters the two livings (°C)	- 3.1	+ 3.1	

strongly influenced by outside air temperatures. The behaviour of occupants is dictated by a preoccupation with an evacuation of heat excess cumulated in the living, accompanied by an ignorance of the best management of connection).

Glazed loggia attenuates temperature peaks, observed at the same time in the pilot loggia, by acting on the maximum and minimum temperatures, by crushing mainly the maximum ones (Seifert, 2009). The sun space has a role of damping of external effect of extreme temperatures (SOL.A.R. architects engineers, 1988). The temperature amplitude of glazed loggia is less significant than that of the pilot loggia, however, its natural ventilation rate is reduced, its close volume constantly maintained a temperature with the top of 23,8°C. (Fig.8)

When taking 25.16 °C as limiting value of an aestival comfort[1], we carry out the existence of overheating and this glazed space becomes uncomfortable 91.66% of the time of the whole investigation period.

Fig.9 shows the curves of the temperatures recorded simultaneously in the two livings and indicates an average temperature difference enters the two livings around 0.6°C obtained by a bad management of the relation living- glazed loggia.

The interior temperature of the living related to the glazed loggia Ti is higher than that equivalent in cell1(pilot cell) to a percentage of 55% of the total investigation time (Fig.10). More precise calculations resulting from this comparison show that air temperature of living related to the glazed loggia are higher than that of the pilot living with a percentage 36% of the diurnal time of the investigation period. Three deductions can be deduced from this report:

The air temperature of the living related to the glazed loggia (cell 2) is strongly influenced by his extension temperature, since the connection between the two spaces, is maintained.

A night ventilation problem arises. The opening area of glazed loggia constitutes 20% of the glazed area. This area is not sufficient for a good ventilation rate. For the climates with cold winters and hot summer, it is necessary to envisage an area of opening at least equal to the 1/3 area of the veranda (ENERTECH, 2005).

The single skin facade configuration in semi - arid areas is a major contributor towards influencing thermal comfort in the buildings.

The analysis of measurement data indicates that glazed loggia is a thermal regulating space, delaying diurnal peak of temperature towards the end of the day. Overheating arises especially at night, in the living related to the glazed loggia, and can be avoided with good night time ventilation and a good use of the relation living-glazed loggia.

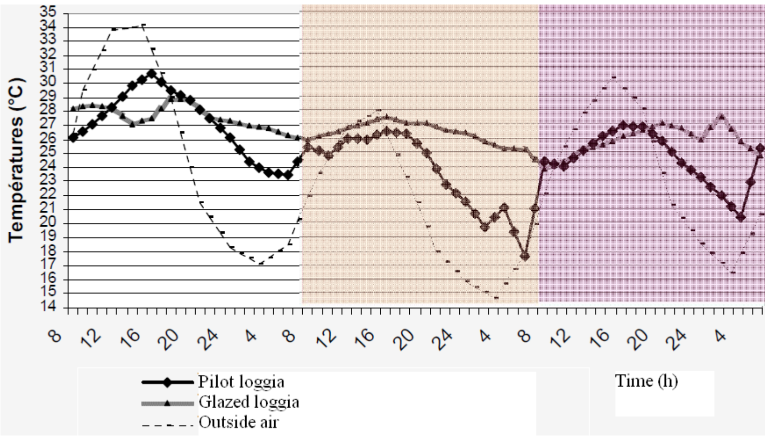

Fig. 8: Variance of air temperature between pilot loggia and glazed loggia. Hot period.

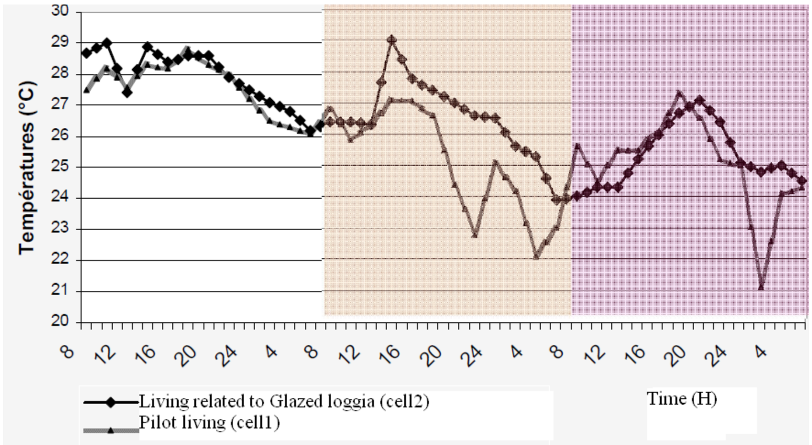

Fig. 9: Variation in air temperature of living related to the glazed loggia and pilot living. Hot period.

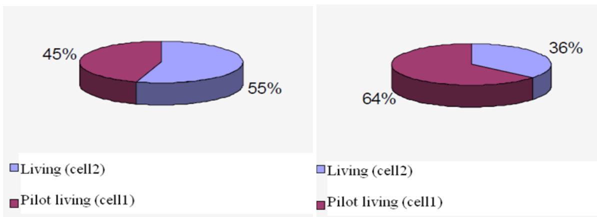

Fig. 10: Percentage of time when living temperature of cell 2 is higher than that of the pilot living cell 1, with respect to the total investigation duration on the left, with respect to the diurnal period on the right.

CONCLUSION

Glazed loggia is a solar collector in cold season. It is also a buffer space, which protects interior space, controls its temperature and realise an economy in energy consumption.

To avoid overheating of adjacent space in the hot season, it is imperative to conceive glazed loggias for an optimal performance for the whole year, especially when there are contrasted climatic conditions (cold winters and hot summers). Leaving a permanent opening between the glazed loggia and the adjacent space, in the absence of solar profits, increases the losses, and reduces the buffer effect. In summer, management must be reversed, it is imperative to thermically isolate the adjacent space from glazed loggia during the day and to encourage night ventilation in order to dissipate heat and to cool the structure.

It is particularly crucial to give councils and information to the occupants about the thermal operation of glazed balconies, or any passive strategy to improve their behavior.

ENDNOTES

1. Neutral temperature for the season of cold calculated from Auliciems formula.

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