Proceedings of 3rd Conference: *People and Buildings* held at Westminster University, School of Architecture and the Built Environment, London, UK, 20th September 2013. Network for Comfort and Energy Use in Buildings: http://www.nceub.org.uk

Thermal Impact of Glazed Balconies in Lebanon: a Case Study

Philip H. Saleh[1]

1 MSc Sustainable Environmental Design; Architecture Association, London, UK.
philippe.saleh@aaschool.ac.uk

ABSTRACT: The research aims to analyze the thermal performance of what is becoming a very common practice of glazing up balconies in Lebanon. Two apartments in one residential building, one with a glazed balcony the other with a shaded one are monitored for four full days in late June. Then the building is modelled and calibrated using the EDSL TAS [1] thermal simulation software, and overall cooling and heating loads for different parametric factors including orientation, shading devices, different window to floor area ratio, shade location as well as usage are analyzed.
The aim of the paper is to try to reach much lower than the recommended cooling benchmark set recently by the Lebanon Thermal standard (2010) [2] and to come up with practical recommendations that allows this to happen.

Keywords: Balconies, Glazed Balconies, Thermal mass, Lebanon, Orientation, Cooling loads

1-INTRODUCTION

The paper is studying the environmental impact of a practice that is becoming very common in the built-up fabric in Lebanon: that is glazing balconies.
Although not more than 60km at the widest Lebanon has four distinct climatic zones [2]. The paper will deal with the coastal zone which has warm and short winters, hot and humid summers.
The overwhelming construction type in Lebanon is of exposed concrete, masonry block walls, and an optional natural stone finishing. All those materials are labelled thermal mass referring to both their combined heavy weight as well as their capacity to absorb, store and release heat with a time lag [4;5]. The paper will monitor 2 apartments in one building in the Zouk area for 5 days in late June. One of the balconies is glazed and the other has curtains. Following the monitoring, the building is modelled and calibrated using EDSL TAS [1]. Once this is done simulation runs can start manipulating different orientation, as well as miscellaneous parametric runs which would give an overview of the thermal performance of those balconies in relation to the internal spaces.

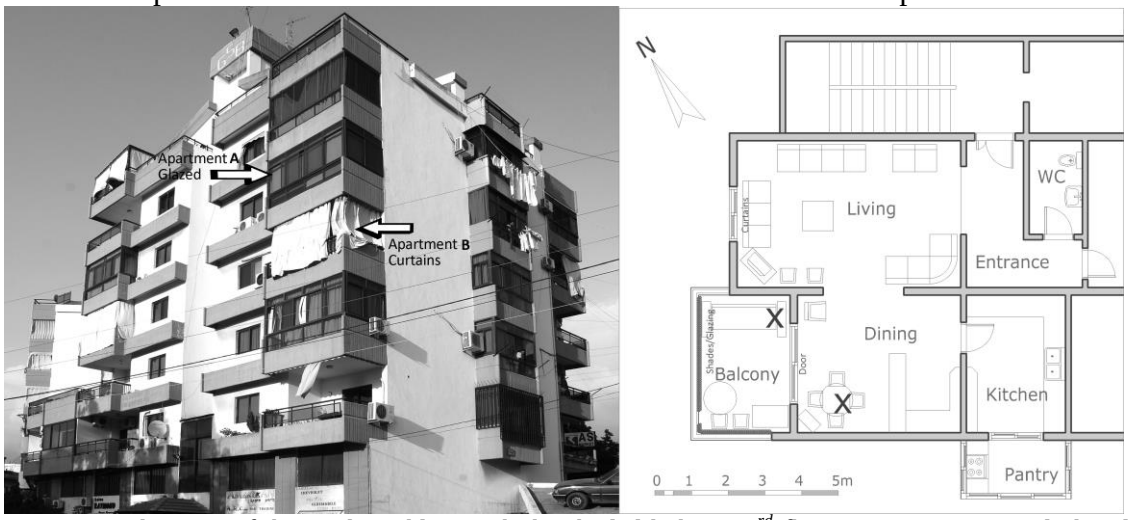

Figure 1a &b: View of the Zouk Building with the shaded balcony 3rd floor –apartment A- and glazed balcony 4th floor –apartment B-. Along with the typical floor plan showing data loggers locations.

2-FIELD WORK

Figure 1a shows the building with the 2 monitored apartments A with a curtained balcony and B with a glazed on. The data loggers were placed in the balcony, protected from direct sun rays and on the dining table inside (fig.1b) from June 26th, till July 1st. The graphs will show only the four full days of data recoding from June 27th till 30th.
Figure 2a shows both superimposed balconies' temperatures. The almost regular lines for apartment A show the limited activities within, in contrast with the bumpy line for apartment B showing different patterns of activities.
Both peak temperatures occur a couple of hour after the day's hottest peak. The temperature within the glazed balcony is constantly higher than the curtained balcony, by an average 3.1°K for the day's peak and 1.5°K for the night's lowest. For one hour only during the 4 days the curtained balcony had its temperature above the comfort band, when the glazed balcony had it for more than a few hours each day.

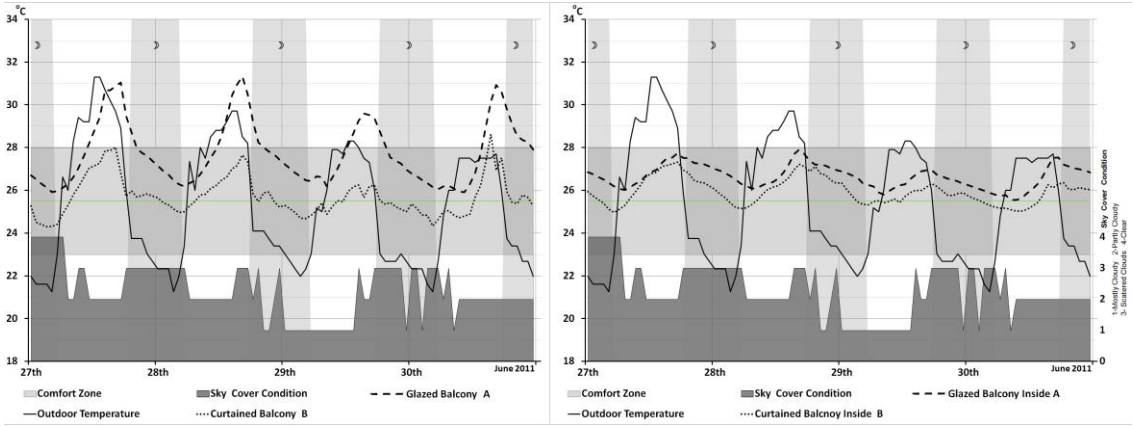

Figure 2a & b Temperature graph inside both glazed balconies as well as both interior living spaces.

Figure 2a shows both inside temperatures. Both are within the comfort band. The glazed balcony's inside has slightly higher temperatures than the curtained balcony's inside averaging 0.7°K and 0.8°K for day and night respectively. Nevertheless the comparison is not very accurate when one apartment is quite crowded and the other has very limited occupancy.

3-SIMULATION RUNS

Using EDSL TAS [1] an accurate calibration is done and the simulation process strats with orientation and parametric runs.

3.1-TAS ORIENTATION RUNS

The orientation runs consist of simulating the building with its 10; 20; & 30% WFR, (Window to Floor area Ratio) same internal conditions for both open and glazed balcony. The cooling temperature set at 24°C for the 7 hours of living occupancy, from 3 to 10p.m. with an average of 6 persons in the living area and 4 in the balcony. For each simulation the orientation of the building and the balcony is rotated 30degrees. The orientation shown is the actual balcony orientation.
Figure 3 shows the combined patterns of cooling loads for a window to floor area ratio of 20% for both the open and glazed balconies un-shaded, as well as with and without the curtains on the adjacent living area window. The cooling loads vary for the open balcony with no internal curtains between 82 and 70kWh/m^2. The difference is 15%. As soon as the internal curtains are added those values drop to 76 and 69kWh/m^2 and the difference becomes 9%. Once the balcony is glazed the same scenarios will have their cooling load between 107 and 92kWh/m^2 with a difference of 14% and between 101 and 89kWh/m^2 with a difference of 12% respectively.

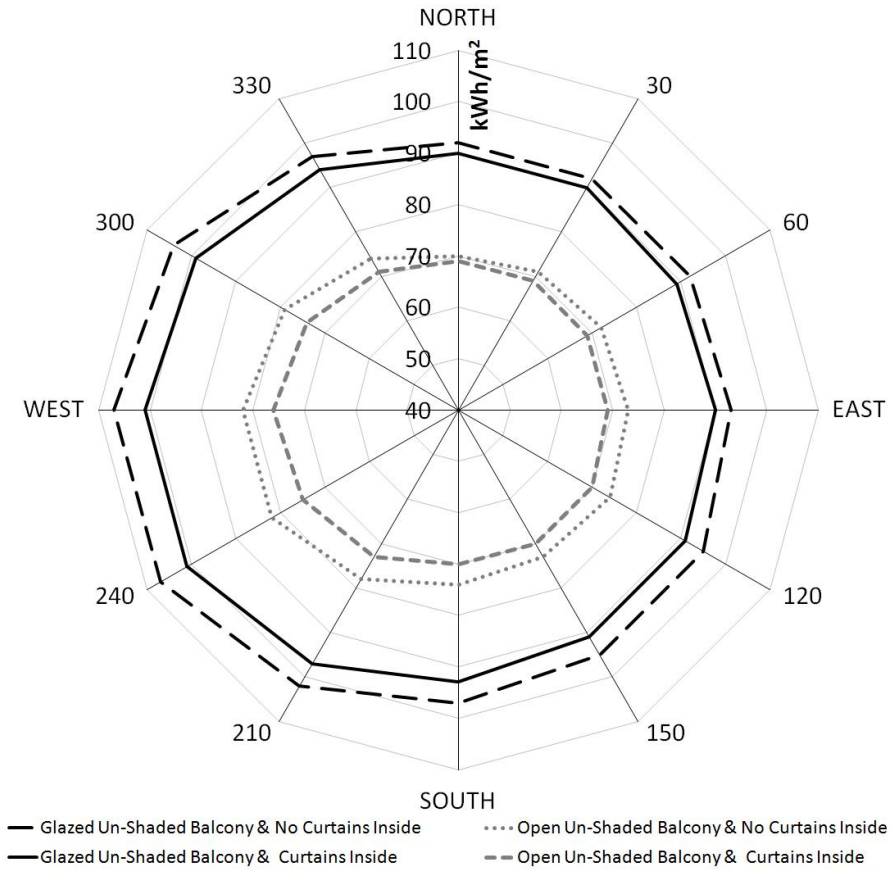

Figure 3: Cooling loads for 20% Window to Floor Area Ratio (WFR) with different orientations.

3.2-ORIENTATION RUNS RECOMMANDATIONS

The higher the window to floor area ratio, the higher the cooling load is, but also the larger the difference between the highest load and the lowest load. The use of internal curtains will affect positively the cooling load by reducing it as well as reducing the difference between the low and high loads. Hence the bigger the floor to window ratio and the less shades and curtains are used the more vulnerable the internal space becomes to both the orientation and the outdoor environment.

4-PARAMETRIC RUNS

The parametric runs take the North and West orientation for lowest and highest values respectively, in addition to the 10%, 20% and 30% WFR and alter the following: closing and opening the window door; adding or removing the internal curtains; and integrating the glazed balcony into the cooling area or not.

Figure 4 gives a summary of all the different runs in this set with the following conclusions that can be drawn and simplified into 4 main points, two of which are positive in the sense of improving the overall thermal performance of the balcony by reducing the cooling loads and two of which are negative in the sense of making the cooling load higher.

1- The positive impact of the shades on both the balcony as well as in the interiors.
2- The positive impact of placing the shades on the outer edge of the glazed balcony.
3- The negative impact of keeping the door open between the inside and the glazed balcony.
4- The negative impact of integrating the glazed balcony within the mechanically cooled areas.

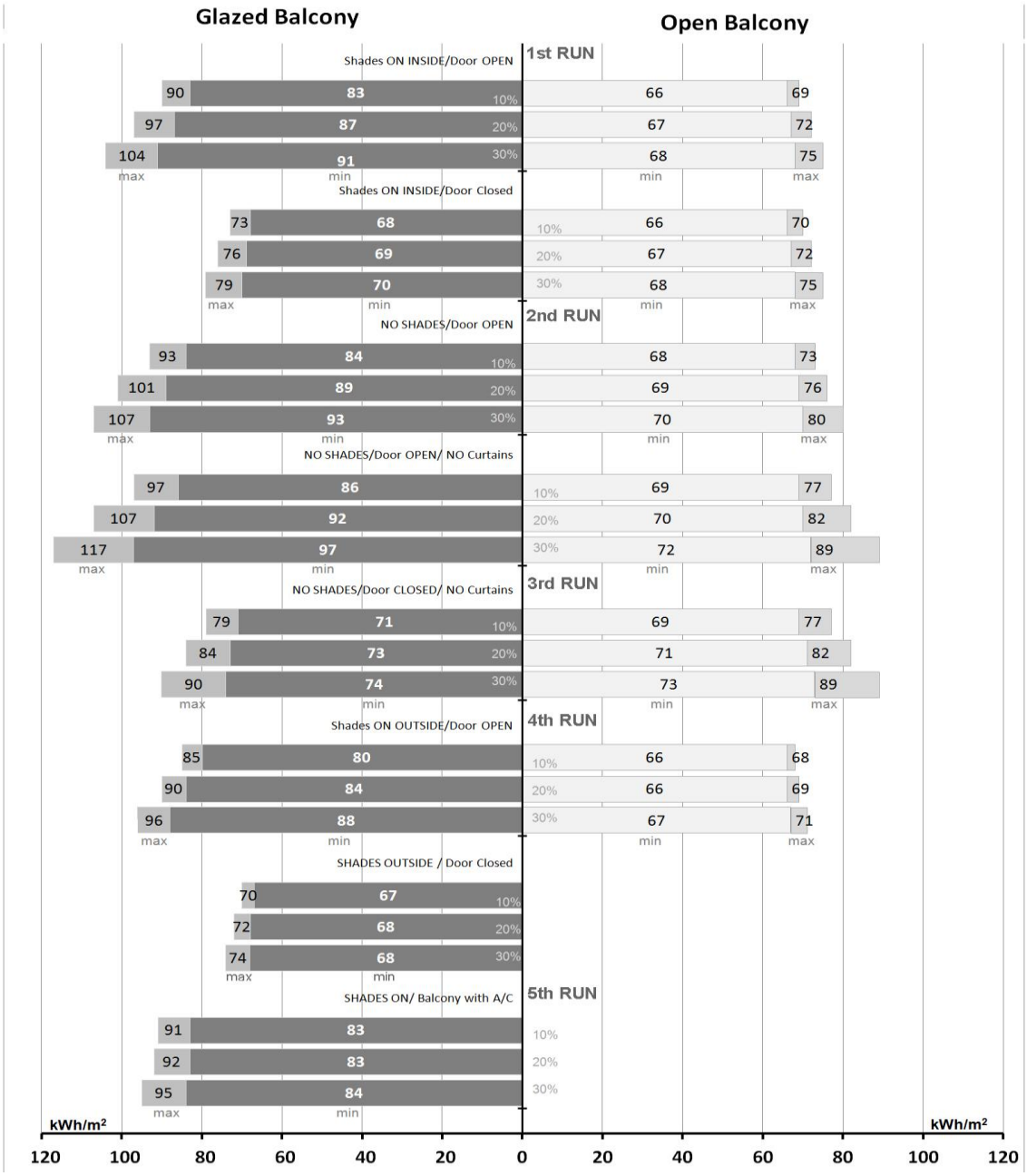

Figure 4: Runs for 10; 20 & 30% WFR for North and West orientation

5-Construction Runs

In this new set of runs, the construction is altered to different types of used or recommended construction methods, by the Lebanon building code or the Lebanon thermal standard [2]. In addition to these alterations, other runs modify the outer edge of the balcony using techniques from the existing vernacular as well as the recent past. Furthermore the effects of setting the cooling temperature higher than 24^{o}C as well as setting an aperture program or window openings on TAS to regulate the internal temperatures are also simulated.

All the runs in this set are for a 10% window to floor area ratio west oriented only. The base case is for both balconies shaded from the inside, the door is closed and the inside curtains are available. Those settings remain unchanged in all the runs.

Figure 5 gives a summary of all the different runs in this set, and the following conclusions that can be simplified into 4 main points:

1 The highest positive impact is achieved by setting the cooling temperature higher than 24°C, hence requiring user intervention, as well as redefining comfort.
2 The next positive impact is achieved by alternative construction method.
3 Followed by external walls shading.
4 The less positive impact is for the edge of the balcony alteration, as well as the window openings.

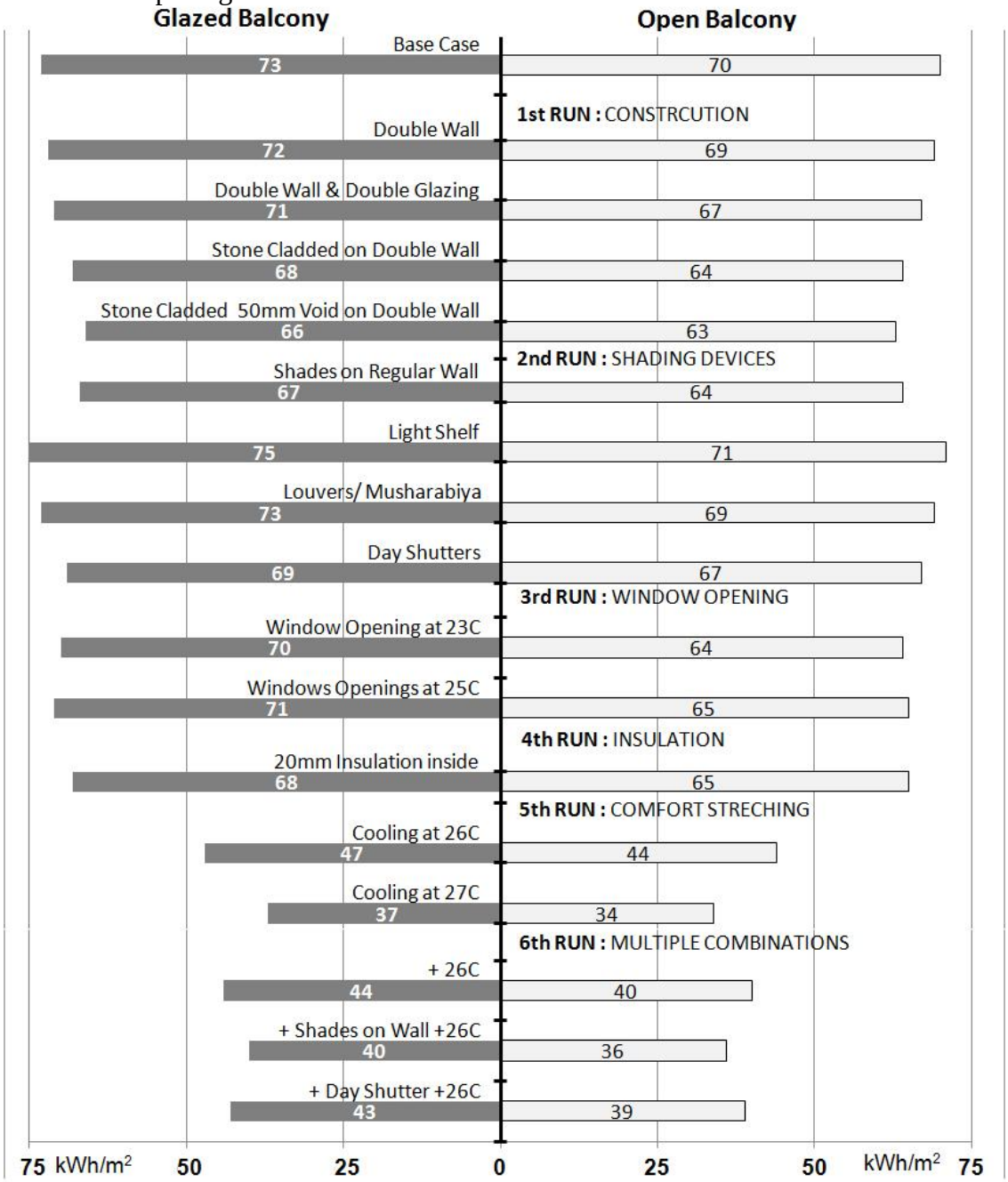

Figure 4: Runs for 10; 20 & 30% WFR for North and West orientation

In the 6th run, the results of combining different scenarios are shown. The external walls are now double cavity made out of 200mm and 100mm masonry blocks with a 50mm air gap in between. The external finishing is 30mm dry mounted natural stones with a 30mm air gap in between. When the thermostat level is set at 26°C the cooling load is reduced from 70 to 40kWh/m^2 and 73 to 44kWh/m^2 with a difference of 43% and 40% for the shaded and glazed balcony respectively. When the external shades are

added to the external walls this gives even better result and the loads are now 36 and 40kWh/m^2 with a difference of 48% and 45% for the shaded and glazed balcony respectively.
The impact of using the shutters during the day is not as important as using the external shades. Day shutters are reducing 1kWh/m^2 only when the shades are reducing 4kWh/m^2.
It is interesting to note here that for a west oriented glazed balcony the combined cooling and heating is 44kWh/m^2 and this is already 45% reduction from the benchmark set by the Lebanon Thermal Standard [2] at 80kWh/m^2.

6-CONCLUSION

Although glazing the balconies offers some practical appeal and, is becoming an extremely common practice that can be implemented to the entire building even before it is commissioned or at a later stage by individuals. Nevertheless from an energy concern it has significant drawbacks and inefficiencies and should not be a recommended practice.
If practical considerations outweigh energy concerns and the balcony is glazed, several best practices have been identified in the previous analytical section and will mitigate its drawbacks:
The first factor to deal with is orientation, and although in most cases the prevailing view is westerly, nevertheless, whenever possible full westerly orientation as well as $\pm 30^o$ West should be avoided as much as possible. The second factor to incorporate into the design are the shading devices to protect, at least, west and south oriented windows, balconies, as well as external walls. Those shadings are much more effective when they are placed externally, and they may be only temporary for the hot season, also they should be loose enough not to trap heat between them and the surface they are protecting [3].
After the technical part, there is the usage part as well as the definition of the comfort zone that still need to be tackled. Starting with the internal space adjacent to the balcony, it should always be separated from the balcony proper. Cooling and heating the glazed balcony is a practice that should be completely banned. Also all internal windows should have some type of shading.
Last but not least owners should be involved in determining their own comfort zone, and clearly understand the tremendous impact of the high energy consumption on the environment caused by apparently banal decisions such as setting the mechanically cooled room air temperature at 21^oC.

7-REFERENCES

1-EDSL TAS version 9.1.4
2-Lebanon Thermal Standard for Buildings, (2010) ADEME & Order of Engineers and Architect, Beirut.
3-Littlefield D. (2007) Metric Handbook, Planning and Design Data, 3rd Edition, Elsevier; Architectural Press, (p35-17).
4-Smith P. (2005) Architecture in a Climate of Change; a Guide to Sustainable Design, Elsevier; Architectural Press (p39-6)
5-Szokolay S.V. (2004) Introduction to Architectural Science: The Basic of Sustainable Design, 2nd edition Elsevier; Architectural Press (p47-51).