Residential Buildings with Large Glazing Areas: Experimental Analysis during Heating and Cooling Seasons

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SUMMARY
This study presents the results of a monitoring study carried out in residential buildings with considerable glazing areas (more than 70% of the façade) with different solar exposures in Lisbon The monitoring was performed during the summer and winter months in 2007-2008 (first phase) and 2008-2009 (second phase). Temperature and relative humidity sensors were installed in 23 units (45 compartments) with different solar dispositions and localizations in several buildings with specific relevant characteristics for study.

A large portion of the units showed uncomfortable temperatures most of the time during summer and winter monitoring (comfort temperatures 20ºC and 25ºC respectively for winter and summer). Some factors were of great influence on the results; these were in some way directly related to the daily habits of the residents. The professional needs to take care with the glazing areas and solar protection in these kinds of buildings, to make them more sustainable.

KEYWORDS
Glazing areas, thermal behaviour, heating, cooling, thermal comfort

INTRODUCTION

The increase in glazing areas of residential buildings over the years in Portugal is notorious. Large glazing areas in residential buildings are architectural solutions that allow a more homogeneous exterior aesthetic view, scenery contemplation, greater transparency and luminosity; while having a direct influence in the comfort of its occupants and in the thermal behaviour of the building. The main thermal exchanges in a building generally take place through the transparent elements, and these can be considered an element of great flexibility and adaptation to climatic variations.

Taking into account the important role of the transparent elements in the thermal behaviour of the buildings, this work has as main objective for verify by an experimental analysis, if it is possible to obtain comfort in residential units, during the summer and winter seasons, for large glazing areas with different solar expositions.

METHODS

The monitoring took place from 2007 through 2009, whenever possible the flats have the same typology and similar design. The 23 apartments were monitored, most of them presents: one exposed face, a form factor (for all monitored compartments) that varies between 0.1 and 0.85, transparent double glass, exterior walls and roof thickness insulation between 30mm and 40mm (U exterior walls 0,6 – 0,7 W/m² ºC). In relation to exterior shading systems the sample presents systems of the following types: horizontal shading (all buildings), window blinds, venetian blinds and vertical awnings.

Temperature and relative humidity sensors (Mini data logger Testostor-175) were installed in two places, in the living room and bedroom environments. The monitoring took place in periods of approximately 15 days (varying between 7 and 30 days). The occupation and utilization pattern of each residential unit was also recorded during the measurements; this information is important for the interpretation and analysis of the recorded data. The external climatic conditions were obtained from the Meteorological Station installed at Solar XXI Building at INETI.

RESULTS

Results during summer 2007 and 2008:

The mean indoor temperatures for all monitoring periods of the compartments was 27ºC, the mean of the maximums was 28,5ºC, in some cases reaches 31,5ºC. The relative humidity was normally between 35% and 65% in the monitored housing units.

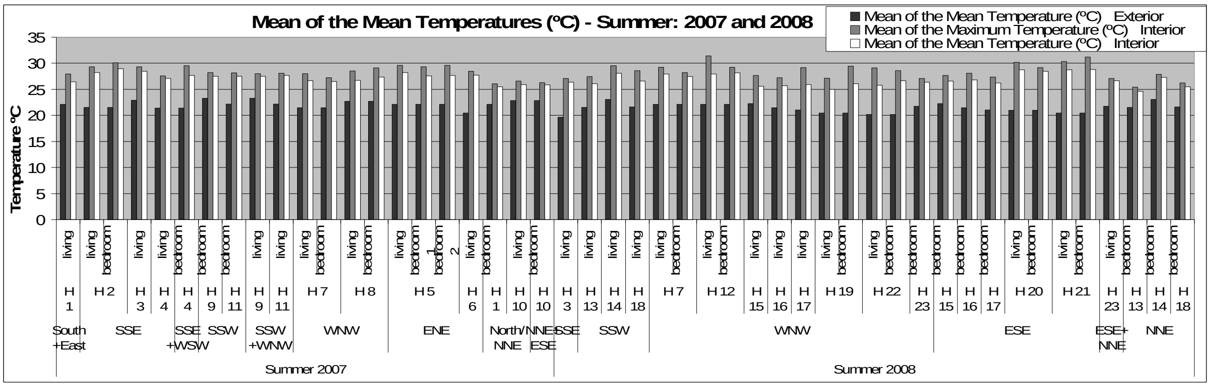

Fig. 1. Mean temperatures for the different compartments – summer 2007 - 2008.

In some studied compartments with glazing areas practically to the south (South, SSE, SSW) the mean temperatures was close to 28º-29ºC (in dwelling H2 the compartments had the windows closed most of the time, without any solar protection devices activated and without any activated acclimatizing system). The studied compartments with glazing areas practically to the north showed the lowest values for the mean temperatures, around 25,5ºC. The majority of the units and compartments with East and West exposed faces presented mean temperatures close to 27ºC, while dwellings H7, H12, H20 and H21 (units with one face exposed – did not have compartments in opposite orientations with the possibility of promoting cross ventilation) showed values between 28ºC e 29ºC. In dwellings H20 and H21 when the windows were opened they were only during the day and never during the night.

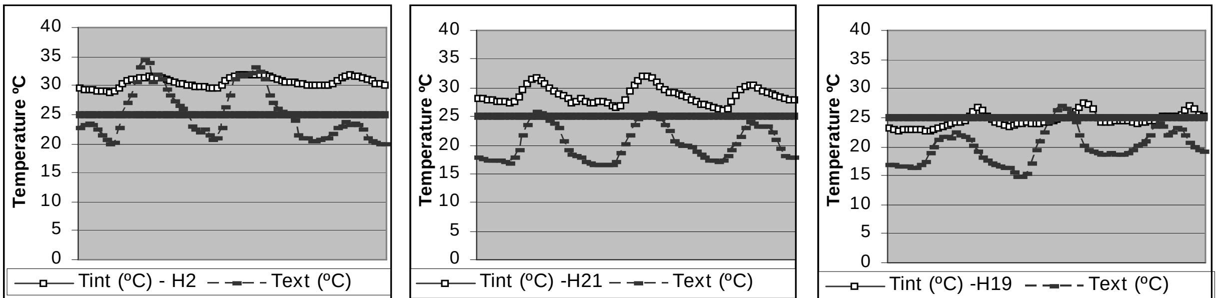

Fig. 2. Temperature distribution during three days (summer).

In dwellings H15, H16 and H17 the compartments with solar exposition practically to the East presented values for the mean of the mean temperatures slightly higher than those of the compartments of these same units with solar exposure to the West (26,5ºC for those to the East and 25,5ºC for those to the west). Dwellings H19 and H22, with large glazing areas practically to the West, showed values for the mean of the mean temperatures between 25ºC e 26,5ºC; in these units the windows were opened mainly during the night while in the bedrooms the interior shades were closed during the day.

Results during the winter 2007-2008 and 2008-2009:
The mean indoor temperatures for all monitoring period compartments was varied between 14ºC e 24ºC (in general the average was 19ºC). For the sample in general the mean of the minimum temperatures was 18ºC, in some cases it was close to 13, 5ºC. The relative humidity was normally between 35% and 65% in the monitored housing units.

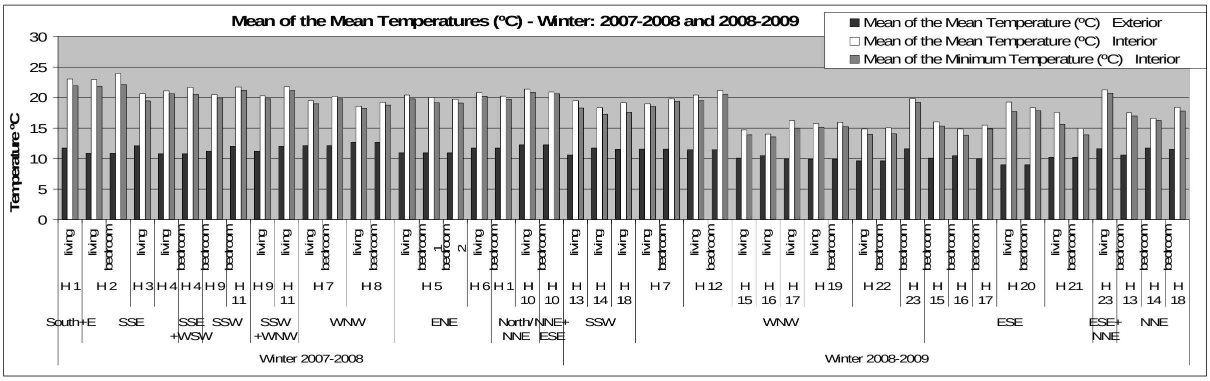

Fig. 3. Mean temperatures for the different compartments – winter 2007-2009.

For the studied compartments with glazing areas practically to the South the mean temperatures was 21ºC, in some cases reaches 24ºC without using the heating system (for example Dwelling H2). In H2 the mean of the maximum temperatures was 27ºC.

In a general the mean temperatures for the compartments with solar orientation to the East and West, was approximately 17, 5- 18ºC, being that in many of the monitored compartments with these solar exposures, these values were below 16ºC and in specific cases close to 14ºC. The lowest mean temperature obtained in the compartments with solar orientation to the North was 16,5ºC. The majority of the monitored compartments with solar orientations to the East, West and North are affected by the use of heating systems. Thus, some of the obtained results could be even less favourable if they had not used the heating systems.

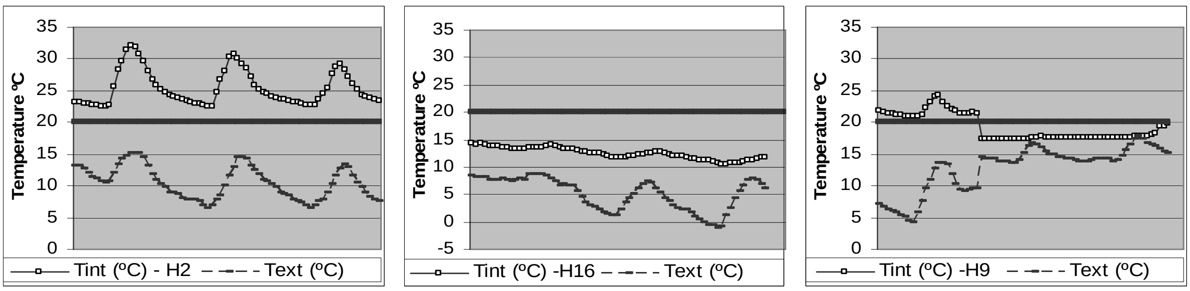

Fig. 4. Temperature distribution during three days (winter).

DISCUSSION
In the summer, taking into account that most of the dwellings did not have a cooling system (air conditioning) and that those that have it practically did not activate the system during the hot season, it’s clear that the natural ventilation conditions are intrinsically related with the obtained results in the various monitored units during the summer seasons of 2007 and 2008.

In those cases where there are no protection devices (blinds or other similar one), opening the windows to promote natural ventilation during the hours when it is more advantageous (use passive cooling normally occurring in the night), becomes fundamental to obtain better interior conditions in this station of the year. Meanwhile, the most of the monitored apartments without an exterior protection device (only horizontal shades were present) the users did not totally exploit this cooling possibility. This way, natural ventilation can, or not, contributes for more comfortable environments, depending on how it is promoted by the users. Another important question is the presence of solar devices, the compartments that have these devices achieve a better adaptation and control of the unit in relation to the external conditions. However, in the majority of the cases these possibilities weren't exploited to take advantage of more comfortable environments.

The way in which the users occupy and use their dwellings is fundamental to assure the desired comfort, for example, observing the results obtained for dwelling H2 (during the summer) and dwelling H9 (during the winter). Both dwellings had large glazing areas practically to the South and only one face in contact with the exterior. They were unoccupied during a good part of the monitoring, with closed windows, without any cooling and heating systems, in the case of dwelling H9, with the window blinds activated. As a result, both had situations of considerable discomfort.

In the winter, the indoor temperature of some monitored compartments was influenced by the use of heating systems, mainly on the minimum temperatures values as well as the intensity of the discomfort. The results obtained during the different monitoring periods are directly related to the exterior conditions and the corresponding monitoring duration. The accuracy of the mini data loggers used during the measurements is ± 0,5ºC for temperature and ± 3% for relative humidity.

CONCLUSIONS

The majority of the apartments had a degree of discomfort in the summer and winter seasons. During the summer monitoring 11 apartments presented temperatures above 27ºC most of the time (65% to 95% of the time), and during the winter 11 apartments presented temperatures below 18ºC most of the time (70% to 90% of the time). However, some factors can be crucial in obtaining better results depending on the correct use by the residents, which has the possibility to adapt all devices and the flexible elements of the environment to the external conditions; however in most of the cases these possibilities have not been fully explored. In conclusion, the professional needs to take care with the glazing areas and solar protection in these kinds of buildings, to make them healthier and more sustainable.

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