Office occupants' appreciation of window size under a clear sunny sky: towards an efficient building regulation.

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OFFICE OCCUPANTS' APPRECIATION OF WINDOW SIZE UNDER A CLEAR SUNNY SKY.

TOWARDS AN EFFICIENT BUILDING REGULATION

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Abstract:
This paper' presents the results of a Post Occupancy Evaluation research undertaken in an office building in the city of Biskra situated in the northern region of the Algerian Sahara desert. The research investigates in-situ a common rule of thumb in architectural daylighting design that is the expression of openings in terms of window size to floor ratio. It explores through observation and questionnaires the behavioural adjustment strategies of the occupants to excessive light or heat that leads to the definition of a new window to floor ratio based on occupant's preference. Finally, a comparison with some previous recommended window to floor ratio under clear sunny sky is carried out.

Keywords: daylighting design, clear sunny sky, window size, occupant. POE.

INTRODUCTION

Hot and arid regions are characterized by year round clear sunny sky. Under such conditions, inadequate daylighting design usually results in overheating and glare. Also, the amount of daylight received inside buildings vary greatly according to solar position. Hence, quantity based recommendations are not almost relevant in this case. Daylighting phenomenon under clear sunny sky is becoming more complex than the overcast sky case [1].

When designing architectural daylighting, architects often rely on rules of thumb, expressing openings in terms of window size to 0oor ratio [2]. These spaces related rules are more suitable than any other recommended ones for the earlier stages of architectural daylighting design and are also more appropriate to easily be part of city planning and design regulations. However, most of the numerical values given for this ratio are based solely on quantitative research, resulting generally from modelling or computing simulation [3]. The occupant is neither taken into account nor directly associated to this experimental process. Yet, researches having taken into account the occupants' perception or preference revealed that office's occupants are of great significance for the success of daylighting design strategies [4].

The main aim of this study is to explore the behavioural adjustment strategies of the occupants to excessive light or heat that leads to the definition of a new window to floor ratio based on occupant's preference. Then, these results are compared with some previous recommended window to floor ratio under clear sunny sky.

THE RESEARCH METHOD

The Post-Occupancy Evaluation (POE) Method for daylight was reviewed and used in this research. It was adapted to the climatic and cultural specificities of the case study [5]. POE evaluates, systematically, a building upon a major criterion: the occupant's needs. The diagnostic POE is considered by some authors as the main post-occupancy evaluation (6].

The diagnostic POE consists on a set of complementary techniques to the questionnaire (subjective responses) including observations of the investigated place and physical measurements (objective observations). The diagnostic POE should be thus more appropriate for a daylighting evaluation because it considers the subjective and objective aspects of daylight together.

THE CASE STUDY

A contemporary office building located in the city of Biskra was taken as a setting for the present field investigation. The city is located in the northern part of the Algerian Sahara which is characterized by a semi arid hot climate and a clear sunny sky almost year around. The office building houses a major state insurance company: the CNAS (Caisse Nationale de l'Assurance Sociale).

The building's five storeys look on an uncovered courtyard and have four external facades (Figure 1). Offices are limited to the upper floors and those of small size are numerous (Figure 2). Open plan offices are few but exist in every floor (Fig.). The activities of the occupants include reading, writing, computing, supervising. VDU work is limited to a few numbers of occupants. Some areas present particularities that excluded them from this investigation such as the medical and the computing section. Activities undertaken in these sections, the kind of furniture and their arrangement are so different from the other parts of the building that they could not be compared with.

Figure 1 : An exterior view of the CNAS building showing its various openings.

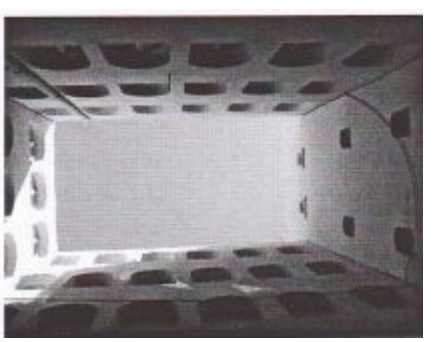

Figure 2 : An open to sky courtyard is located in the centre of the CNAS building

Thirty nine occupants (20% of the total number of occupants) in twenty four offices (42% of the total number of offices) were directly interviewed by questionnaire. Further, the means used by the occupants to control daylight and sunlight admission were recorded twice a time during the same day (the morning and the afternoon). Along, a set of physical measures was done for every occupant concerned by the investigation in terms of illuminance and luminance level measurements.

The face to face administration of the questionnaires to the occupants, the observation of their behaviour and the photometric measures were carried during the month of July and August. In this period, as in every hot arid land, the occupants are considered as feeling a major degree of discomfort due to excessive overheating and glare conditions.

The results presented in this paper concern: i) the occupant's appreciation of the window's size and its position, both horizontal and vertical, in the office wall, and ii) a window to floor ratio based on occupant's adjustments of sunlighting and daylighting control means.

THE WINDOW SIZE IN THE CNAS BUILDING

The CNAS building presents a variety of window size, position and form on the four external facades whilst the internal ones, looking on the courtyard, are uniform (fig). This variety grants a major external aesthetic character. Since the various windows are similarly displayed on the four facades of the building, it would be expected that windows are designed in accordance with the façade's orientation, the floor level and the office's floor area. For instance, each internal space (office) should have a window area in accordance with its floor area. That is to say, an office which is more spacious (and/or deeper) than another one, will have a bigger area of windows than the second.

For, bivariate correlations were computed between the window areas (designed not those adjusted by occupants), its orientation, the floor areas, the floor levels and the designed window to floor ratio. The results revealed: i) a positive moderately important correlation between the designed window areas and the floor areas ($r=0.493$, $p<0.05$) and between the window to floor ratio and the floor level ($r=0.055$, $p>0.05$). However, no significant relationship was found between the window to floor ratio and the orientation of the window ($r=0.269$, $p>0.05$).

THE OCCUPANTS' EVALUATION OF THE WINDOW SIZE AND POSITION:

The window position in the wall is not of less importance for architectural daylighting design [7]. Hence, a subjective evaluation of windows' areas and positions in the wall was carried out in the CNAS office building.

In a first step of this evaluation, the occupants of the CNAS building were asked to rank the importance of the window on a five ranging scale from not important to very important. Over half of the occupants (60%) believe that it is important and 20% important while 13% answers neither important nor important. A minor number of the occupants consider the window as less important (2%) or not important (5%).

Secondly, a question required the occupants to evaluate the windows' areas in their office. Most of the occupants answers the window are of adequate size (76%) while 24 % believe that they are too large. A third question was about the vertical and horizontal position of the window within the wall. Nearly all the occupants (92%) consider that the windows are too high in the wall and are located on the extreme right corner of the wall while a few number of them judge that they are located on the extreme right corner of the wall while a few number of them judge that they are well located (5% for height and 3% for width) or are too low (3%) and extremely left located (5%).

OCCUPANTS' MEANS TO CONTROL DAYLIGHTING AND SUNLIGHTING

The observation of the occupants' behaviour revealed that several means are used to control sunlight and daylight admission according to the time of the day. In supplement to the existing ones (external fixed solar devices and internal curtains), office workers paint sometimes the window's glass or stuck thin or thick sheet of paper on the glass of small size windows.

Offices' occupants were asked about the performance of the existing solar control devices. Most of the occupants (69 %) believe that they do it efficiently while 31% consider them as an excessive protection that leads to the use of artificial lighting. Surprisingly, no one from the CNAS office workers think that these devices do not protect him from sunrays.

The photometric measurements consisting on the vertical illuminance levels taken at the outside and inside faces of the window shows that the performance of such devices in controlling daylight admission varies from one mean to another. The glass used for the various windows of the CNAS office building has a transmittance coefficient of 84% and the dark painting of this glass could reduce this transmittance of about 50%. The thin and thick sheet of papers stucked on the small windows diminishes the daylight transmittance respectively by about 7 and 62%. The curtains used by the occupants are generally heavy and reduce the amount of the transmitted daylight by 60%.

Figure 3: The changing effect due to the curtain's use is largely attested by the appearance of the luminous ambience

From a qualitative point of view, the observation of daylight and sunlight patterns inside the studied office revealed that only heavy curtains and thick sheet of papers could efficiently cut the sunrays and change the appearance of the luminous ambience (Figure

3). The painting of glass and the thin sheet of papers reduce the amount of daylight but still diffuse sunrays since one can easily obse rve a sun path inside.

THE OCCUPANT'S BASED WINDOW TO FLOOR RATIO

The occupants' use of means to control sunlight and daylight admission results primarily in a reduction of the window size which could lead to the definition of a new window to floor ratio based on occupant's preference.

Statistical descriptive analysis of the designed window to floor ration (WFRDes) revealed that 30% is the mean value of this ratio found in the studied offices of the CNAS building. However, the most current value of this ratio (35% of the offices) is between 20 to 30% while I9, 23 and 12 % represent respectively the WFRDes' values of 10 to 20%, 30 to 40% and 50 to 60%. Only 4% and 7% of the studied offices have a window to floor ratio respectively under 1 0 % and 40 to 50 %.

The window to floor ratio based on occupants' adjustments (WFROcc) has a mean value of 19% in the same offices of the CNAS building. An important number of the offices (32 %) have a WFROcc value situated under 10% while 28% of them are with about 20 to 30%. The values of 10 to 20% and 30 to 40 are respectively restricted to 16 and 12% of offices. Only two groups each representing 4% of these offices have values varying from 40 to 50, 50 to 60. Also, 4% of the offices did not know any adjustment to change the window size and thus have an equivalent value between the WFRDes and the WFROcc. The computed correlation shows a strong positive relationship between the WFRDes and the WFROcc ($r = 0.780$, $p<0.001$).

COMPARISON WITH PREVIOUS WINDOW TO FLOOR RATIOS:

Specialists in building design for hot and arid regions often recommend small window as guidelines for the openings sizing [8]. More precisely, Evans [1] notes a window to floor ratio of 8% (which must be reduced to 6% in hot dry desert lands) whereas Saini [9] suggested a minimum value 6% and Etzion [9] a maximum one varying between 10 and 12.5%. Certain of these values are usually used for the case of housing design, but in this investigation, they will be compared with the resulted WFRDes and WFROcc.

The results of this study reveal firstly that the WFRDes value equal to 20-30% (representing 35% of the studied offices) is largely above the recommended values. Secondly, it shows that one third (32%) of the offices has a WFROcc value inferior to 10% which is under the maximum recommended value while 28% of these offices have a WFROcc values fixed between 20 and 30%. Whereas, it can be noticed that the mean value of the WFROcc that is equivalent to 19% is still above the recommended one.

CONCLUSION

This research aims to explore the relationships between office building's occupants and daylighting. It is more concerned with their appreciation of a daylighting architectural design feature: the window. In addition, the POE method is used in the context of hot and arid regions where the research field is s till more focused on quantitative aspects.

Window size and position in the wall were studied not only as designed but also as adjusted by occupants. The analysis was based on the window to floor ratio which was compared with previous recommended values for this ratio.

The results of this study reveal that in the design of the CNAS building the aesthetical concerns were more determinant than the respect of climatic specificities and the internal requirements (i.e.: daylighting). Face to this situation, the occupants reacts by readjusting the window size. Their behaviour attest the perpetual existence of a climatic adaptation related to sunlight and daylight. This also confirms the importance of windows for the occupants as they expressed it.

The comparison with previous values of window to floor ratio shows that the rules of thumb values carried out through quantitative research seems to be somewhere exaggerated. It is then more appropriate to recommend not only larger window size than those found in the literature but also an adaptable mean to adjust the window area.

Finally, this research demonstrates that to recommend such values it would be necessary to take into account occupants' needs, appreciation and behaviour. In addition to a comfortable healthy environment, a city planning and architectural design regulations based on these human considerations will lead to an architectural space shielded from any occupants' profound acts of building alterations.

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