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# Occupants and daylight in office buildings under sunny skies.

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# OCCUPANTS AND DAYLIGHT IN OFFICE BUILDINGS UNDER CLEAR SUNNY SKIES

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## ABSTRACT

It is expected that the climate of North Africa, one of the hottest regions of the world, will become still more extreme due to the effects of global warming. This would result in higher energy consumptions for cooling purposes in buildings. Daylight could be an efficient energy saving strategy as well as for enhancing productivity. This research aims to explore the relationships between occupants and climatic parameters, with a focus on sunlight and daylight. Previous research revealed the importance of daylighting design to office occupants.

The POE method was used to assess the daylighting quality in South Algerian contemporary buildings where the sky is sunny and clear almost year around. This assessment investigates an office building that is over-protected against sunlight and aims to identify the occupant's reaction (behaviour and satisfaction) to daylighting design. The results presented in this paper are the occupant's appreciation of : i) The importance of daylight, ii) The illuminance levels under which the occupants are working, iii) The sunlighting control means operated by occupants, and iv) The current sittings (desks position and distance) of occupants in relation to the window location.

Keywords: Daylighting, climate change, POE, clear sky, occupant, office.

## INTRODUCTION

Algeria is a predominately Arab developing country facing changes of various types. Endogenous changes deal with social, cultural and demographic mutations challenging a modernization with strong connections to traditional values. Exogenous changes are political and economic as well as climatic. All these changes produce a built environment where adaptation to actual current conditions and conservation of some older values

conflict. Indoor environment parameters in respect to climate change constitute an interesting issue to investigate within contemporary architectural local production. Indeed, it is expected that the hot regions of the world, such as North Africa where Algeria is located, will be hottest and driest. Hence, energy consumption for cooling in buildings would strongly increase and consequently air pollution too (Pearce et al, 1996).

This research aims to explore the relationships between occupants and climatic parameters, with a focus on sunlight and daylight. In non-domestic buildings, such as offices, daylight could be an efficient energy saving strategy as well as enhancing productivity stimuli among other benefits (Belakehal and Tabet Aoul, 2003). Previous research revealed that office's occupants are of great significance for the success of daylighting design and also stress the importance of daylighting design to achieve primarily the occupants' comfort (Leslie, 2003; Parpairi, 2002; Tabet Aoul, 2002; Coyne et al, 1998).

This investigation studies the appreciation of daylight by occupants from a hot and arid region: the south of Algeria. This region is characterized by two aspects which in turn may affect the occupants response to daylighting: i) the hot and arid climatic conditions generating overheat and glare, ii) the cultural values of the local society which are known to affect window design and most likely daylight preferences (Belakehal et al, 2003a; Tabet Aoul, 1991). Field studies considering the qualitative and/or quantitative aspects of daylighting within contemporary buildings are few and investigated essentially individual dwellings and classrooms (Rouag, 2001; Ouahrani, 1993). This paper presents the preliminary results of a field study focusing on the workplace (offices).

## **THE RESEARCH METHOD**

The diagnostic Post-Occupancy Evaluation (POE) method was used in this research (Zimring, 2002). This evaluation was initially based on the POE method for daylight (Hyyge et al, 1996) but was adapted to the climatic and cultural specificities of the case study's context (Belakehal et al, 2003a). 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 (Fischer and Vischer, 1997).

The diagnostic POE includes complementary techniques to the questionnaire (subjective responses) consisting of 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**

The present field investigation took place in a contemporary office building located in the urban setting of the city of Biskra. 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. Meteorological data analysis confirms a change of climate in the region of

Biskra. It reveals a significant increase of air temperature, sunshine duration and of annual thermal amplitude with a considerable decrease of the relative humidity (Van Thong, 1999). The office building houses a major state assurance company namely S.A.A. (Société Algérienne des Assurances).

The building is four storeys high (Fig. 1). Only the first three floors are occupied by workplaces whilst on the fourth are the workers' flats. Each storey possesses four facades and is organized around an internal covered hall. The majority of offices are of a small size (Fig.2).



**Figure 1: A view of the investigated building: SAA (Société Algérienne des Assurances).**



**Figure 2: Typical office.**

Open plan offices are few but exist in every floor (Fig.3). Windows have equal areas with an identical external solar protection (unopenable shutters but of variable inclination shutters)

(Fig. 4). The number of windows varies from an office to another due to the mere attention to the aesthetical appearance of the façade rather than the need of daylight indoors.



**Figure 3: An open office.**



**Figure 4: External and internal views on the closed and opened position of the external solar protections (shutters).**

A questionnaire was administrated, face to face, to thirty one occupants (67 % of the total number of occupants) in fifteen offices (83 % of the total number of offices). Further, the occupants' behaviour was observed, particularly their reaction to daylight and sunlight such as i) the location of the desk from the window (position and distance), ii) the kind shading devices and the time of their use to occult sunlight, and iii) the use of artificial lighting. Along, a set of physical measures was done for every occupant concerned by the investigation in terms of illuminance and luminance level measurements. The activities of the occupants include reading, writing, computing, supervising. VDU work is limited to a few numbers of occupants.

The results presented in this paper are the occupant's appreciation of : i) The importance of daylight, ii) The illuminance levels under which the occupants are working, iii) The sunlighting control means operated by occupants, and iv) The current sittings (desks position and distance) of occupants in relation to the window location.

## **THE IMPORTANCE OF DAYLIGHT**

The belief that access to daylight contribute to create a healthy environment has been assessed in various places in previous researches (Roche et al, 2000; Veitch and Gifford, 1996). In the present study set under a clear sunny sky, three questions were addressed to the occupants to explore the importance of daylight.

The first question required the occupant to rank the lighting conditions among other parameters that could make the office pleasant. Lighting conditions were ranked first only one time while quietness was ranked first seventeen times. Quietness, a view out and ventilation were ranked higher than lighting conditions.

The second question explored the conviction that office's occupants must work in a good lighting conditions with three possible answers (agree, indifferent or disagree). All the occupants (100 %) agreed that good lighting conditions are necessary in the office.

The third question was more focused on the relationship between daylight and the use of artificial lighting. Occupants were asked if they have worked solely under daylight conditions (with no additional artificial light). A small fraction of the occupants (16 %) work solely with daylight, roughly half (51 %) sometimes use artificial lighting and 33 % work under permanent supplementary artificial light.

## **THE ILLUMINANCE LEVELS**

Cultural Variability of illuminance levels was previously confirmed (Veitch and Newsham, 2000a; Mills and Borg, 1999; Rapoport, 1968). Illuminance levels were usually studied through experimental research investigating lighting preferences in particular. In this field study, the preferred illuminance levels correspond to the luminous conditions under which office workers are performing their principal tasks on their desks. Thus, horizontal and vertical illuminances (on the four sides of the occupant's head) were measured twice (during the morning and the afternoon). In addition, the occupant is asked if, in respect to the tasks done on his desk, the lighting conditions are eye straining.

The preliminary interpretation of the quantitative data reveals first that the illuminance levels vary greatly between the two monitored times for the same spot. Secondly, no correlation is found between the illuminance levels and the answer of occupants. A further development of the discussion of the data is then needed in order to correlate subjective responses with objective measures. This could be done by means of indicators such as the daylight factor for clear sky (Al-Shaibani, 1997).

The reading of the subjective data indicates that 48 % of the occupants found the lighting

conditions not eye straining, 16 % feel it more or less and 36 % feel it. The importance of the possibility to control sunlight admission was also assessed. 83% believe that it is important.

## **SUNLIGHTING CONTROL**

Under a clear sunny sky, daylight is commonly strongly associated with overheating and glare problems. Thus sunlight is carefully admitted inside buildings. Despite the physiological discomfort likely caused by an uncontrolled admission of sunlight, it can also create a psychological stressful working condition (Veitch and Newsham, 2000b). The observation of the offices investigated shows that occupants control the admission of sunlight by the existing shutters. Only a small proportion of windows have curtains. The practices of painting or covering windows with paper, which were observed in a previously studied office building, have not been observed in this case (Belakehal et al, 2003b). Thus, they used one kind of devices (movable shutters) to control the sunlight admission inside their offices according to the time of the day.

In addition, some questions were addressed to the occupants about sunlight admission and its control. The occupants were asked if they feel their offices to be warmer when there is sunlight inside in spite of the air-conditioning use. 61 % answers they sometimes feel it warmer, 25 % often and 14 % never feel it. 85 % of the occupants experience this warmth during the summer season. About the means allowing the occupants to cut-off the heat associated to the sunlight admission, 90% placed air-conditioning as the first device.

## **CURRENT POSITIONS OF OCCUPANTS**

The position of the occupant and his desk in relation to the window could be an interesting indicator in daylighting design particularly for architects. The position may reveal how the occupant is reacting to daylight being in front, back and /or by the sides. The distance from the window indicates if the occupant is working within the bright, the dark or the intermediate areas of the office (Berrutto, 1996).

The orientation of the desk was noted and its distance from the window was measured for each occupant. A large number of the occupants (38%) have the window behind them at a distance less than one meter. The occupants having the window in front of them represent 12% of the total number of occupants (Fig. 5). Only one of them is sitting in the bright area of the office (near the window).

## **CONCLUSION**

Given the actual and the expected climate change, daylighting is increasingly considered as a main environmental strategy in building design. This research is an attempt carried out in order to explore the qualitative aspects of daylighting from the point of view of the occupant. Thus, in respect of this objective, a post-occupancy evaluation of an office building was undertaken and this paper presents its preliminary results.



**Figure 5: The current desks positions in an office of the SAA building.**

The importance of daylight for the occupants was more revealed by their behaviour than the value they attribute to lighting conditions. The rank given to the latter seems to be due to the great availability of daylight and the important number of the windows in their offices. Indeed, each office of little size has, at least, two windows.

Illuminance levels did not reveal any quantitative constancy related to the subjective appreciation of comfort or satisfaction in this case study. Previous research, carried out within a real sitting (libraries) and not in an experimental one, confirms similar results (Parpairi, 2002). Hence, more appropriate methods are needed to associate subjective responses to objective measures. Several ratios related to quantitative data could be used to achieve this requirement. In addition, more than half the occupants confirmed some problems of eye-strain and the importance of control of sunlight.

Even with air conditioning, the occupants make use of shutters to control the admission of sunlight into the office environment.. This confirms their feeling of the warmth of sunlight despite the comfortable air-temperature. The use of these external protections and the recourse to artificial lighting, during the afternoon in particular, create a gloomy luminous environment that nevertheless seems to be well accepted.

The preferred desk position by almost all occupants is the one giving back to the window and within the bright area of the office. Next, the desk position on the side of the window occurred more frequently than the one located in front of the window. The latter occurred within the darkest area of the office.



These kinds of settings show that the occupants possess an adapted behaviour related to the luminous conditions. Also, according to the time of the day, the occupants adjust the movable devices to control sunlight and daylight admission, in addition to the eventual use of artificial lighting, and thus create their own appropriate luminous ambience. This study confirms that, despite several climate related changes currently occurring in Algeria, the human adaptive response to climate continues to be important, particularly in the case of sunlight and daylight. The evaluation of occupant's opinion, perception and behaviour in the building studied, establish that users have a capacity to adapt to the physical conditions in the contemporary built environment. The challenge is now for architects, designers and planners to provide them with environments that promote and take advantage of this adaptive potential.

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