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# A Daylighting Evaluation in Offices Under Clear Sunny Skies

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## ABSTRACT:

Various research works revealed that occupant's behaviour and preferences in terms of daylight are of a great importance to these purposes success. 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 two office buildings with less and over solar protection and aims to identify the impact of climate and culture on the occupant's reaction (behaviour and satisfaction) to daylighting design in non domestic buildings. This paper presents the results of this investigation.

Conference Topic: Testing and surveying methods

Keywords: Daylighting, offices, clear sunny sky, post occupancy evaluation, occupant.

## 1. INTRODUCTION

Daylighting is a thriving field of research. It is an issue of research embracing various disciplines that requires an involvement of specialists from areas as varied as economics, psychology, energy, health, environment, architecture etc... The main corpus of research on daylighting might be broadly divided into quantitative approaches (luminous efficacy, prediction of amount of light...) and qualitative ones (perceptual and visual comfort of occupants...).

Most of these researches have taken place within the temperate climate, while the clear sunny daylight conditions have at most been approached in quantitative terms [1]. Yet, a growing number of studies stress the importance of daylighting design to achieve primarily the occupants' comfort [2,3,4,5].

This paper presents a research that investigates 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 overhear and glare, ii) the cultural values of the local society which are known to affect window design [6] and most likely daylight preferences.

## 2. THE IMPACT OF CLIMATE AND CULTURE

It is well admitted now, that both climatic and cultural background strongly influence occupant's appreciation and behaviour [7,8,9,10,11,12,13]. While building's occupants under the cold climate have what

is called a *hunger of sun*, hot and arid climate people are always searching protection against the intense sunrays. In daylighting terms, what is appreciated as *gloomy luminous ambience* by the former group of people [14], is perceived as *clement* and much *desirable ambience* by the latter [15,16].

Culture also influences occupant's attitudes to daylight admission in relation to window design. Privacy, for instance, might be strongly affected by window design and this dimension has strong cultural connotations. Within the conservative Arab Muslims societies, a great deal of importance is attached to privacy particularly inside the home [17,18].

Previous researches confirm that people, from different climatic and cultural regions, vary in terms of preferences and react differently from one to another [19,20]. Under the building, the window open to the exterior is then, the most sensitive element to privacy intrusion. Hence, window design for daylight may often conflict with the desire for privacy and will in turn affect the occupant's attitudes towards it [21]. Parameters such as the position, size and type of window's shading are some of the means allowing to achieve privacy while influencing the quality and quantity of the daylight admitted.

Studies investigating the qualitative aspects of daylighting under clear sunny skies of the hot arid regions of the Arab Islamic world are in majority experimental [22,6] or limited to the case of the traditional dwellings [23,24]. Field studies considering the qualitative aspects of daylighting within contemporary buildings are few and investigated essentially individual dwellings and classrooms

[25,26]. This paper presents the preliminary results of a field study focusing on the workplace (offices).

### 3. THE RESEARCH METHOD

The diagnostic Post-Occupancy Evaluation (POE) method was used in this research [27]. This evaluation was initially based on the POE method for daylight [28] but was adapted to the climatic and cultural specificities of the case study's context [29]. 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 [30].

The diagnostic POE includes complementary techniques to the questionnaire (subjective responses) consisting on 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.

### 4. 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. The office building houses a major state insurance company (Caisse Nationale de l'Assurance Sociale).

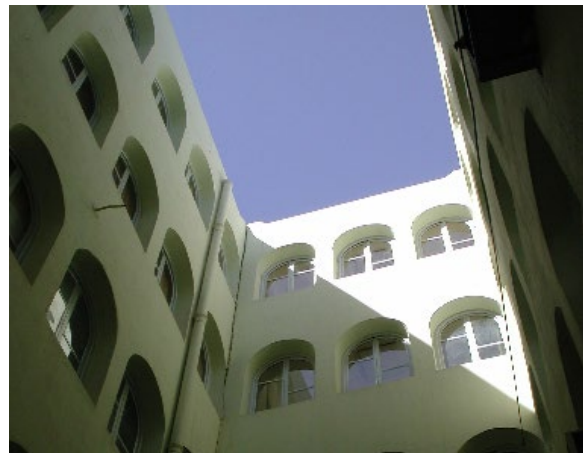
The building is five storeys high organised around an uncovered courtyard with four facades (Fig. 1, Fig. 2). The majority of offices are of a small size (Fig.3). Open plan offices are few but exist in every floor (Fig.4). The offices are limited to the upper floors. Windows vary in areas but could be classified as big and small size with few solar protection. 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:** A view of the investigated building: CNAS (Caisse Nationale des Assurances Sociales) showing its various openings.

A questionnaire was administrated, face to face, to thirty nine occupants (20% of the total number of occupants) in twenty four offices (42% 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.



**Figure 2:** An open to sky courtyard is located at the centre of the building and on which are giving both offices and corridors.

### 5. 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 [31,32]. 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 three times while quietness was ranked first eighteen times. Quietness, a view out and ventilation precede lighting conditions. The latter took the same rank as a limited number of colleagues in an office and came before summer's freshness and privacy.

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). 97% of the occupants' agreed that good lighting conditions are necessary in the office, while 3% were indifferent.

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). Over half of the occupants (60%) work solely with daylight while 15% of them use sometimes artificial lighting and 19% work under additional artificial light all the time.



**Figure 3:** An office of little (standard) size.

## 6. THE ILLUMINANCE LEVELS

Cultural Variability of illuminance levels was previously confirmed [33,34,16]. 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.



**Figure 4:** An open office.

The preliminary interpretation of the 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

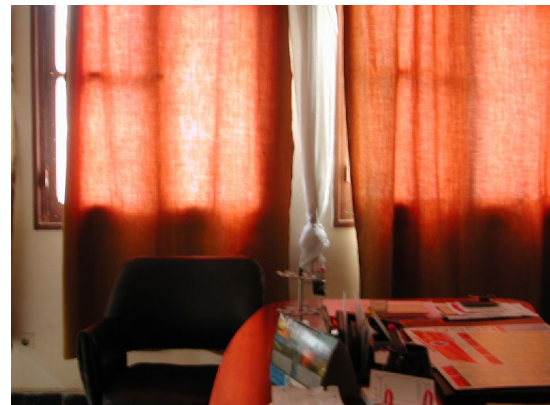
the discussion of the data is then needed in order to correlate subjective responses with objective measures. This could be done by means of indicators such as the daylight factor for clear sky [35].

## 7. 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 that could be caused by an uncontrolled admission of sunlight, this situation could create a stressful working condition [36].

The observation of the offices investigated shows that occupants control the admission of sunlight by supplementary devices to the existing ones. Whilst the curtains are the principal means used by occupants (Fig.5), the painting of the window's glass is another alternative to control the sunlight admission through the windows of large size (Fig.6). Also, occupants stuck thin or thick sheet of paper on the glass of small size windows. Thus, they used two kinds of devices (movable and fixed) to control the sunlight admission inside their offices according to the time of the day.

**Figure 5:** Internal curtains are the principal means



used by occupants to control sunlight admission.

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. 55% answers they often feel it warmer, 30% sometimes and 15% never feel it.

The importance of the possibility to control the admission of the heat caused by sunlight was also assessed. 77% believe that it is very important. About the means allowing the occupants to cut-off the heat associated to the sunlight admission, 51% placed air-conditioning as the first device.

## 8. 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 (Fig.7, Fig.8). The distance from the window indicates if the occupant is working within the bright, the dark or the intermediate areas of the office [37].



**Figure 6:** Painting the window's glass constitutes another mean to control daylight and sunlight admission.

The orientation of the desk was noted and its distance from the window was measured for each occupant. 36% of the occupants have the window behind them at a distance less than a meter to one and a half meter. 28% and 23% have the window respectively on the left and the right sides. The major number of the occupants is sitting in the bright area of the office (15% with the window on the left side and 7% on the right one) or the dark one (10% with the window on the left side and 7% on the right one) whilst the intermediate area includes only 5% of the occupants in this situation (window on a side). The occupants having the window in front of them represent 15% of the total number of occupants. None of them is sitting in the bright area of the office.



**Figure 7:** The position of the desk giving back to the window.

**Figure 8:** Various positions of the desks relating to the windows: on side, behind and face to the window.



## 9. CONCLUSION

While daylighting is increasingly considered as a main environmental strategy in building design, information on this field related to the case of the hot arid regions (with clear sunny sky) is still rare and more focused on the quantitative aspects. 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.

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 diversity of forms and sizes of the windows in their offices. Another study investigating a second building, considered as over protected against sunlight, will give more precision about this aspect of daylighting.

Illuminance levels did not reveal any quantitative constancy related to the subjective appreciation of comfort or satisfaction in this case study. Previous research confirms similar results [3]. 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.

Even the availability of the air-conditioning, the occupants use different means to occult or admit sunlight inside. This confirms their feeling of the warmth of sunlight despite the comfortable air-temperature. The use of internal protections and the recourse to artificial lighting, during the afternoon in particular, create a gloomy luminous ambience that seems to be well accepted.

The position almost chosen by the occupants is the one giving back to the window and within the bright area of the office. The window on side is more occupied than facing the window which is located far from the bright area. 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 the changes occurring in the Algerian society, the climatic adaptation of the occupants, and particularly in the case of sunlight and daylight, is still existing whenever the use of different new means and ways. The evaluation of the occupant's opinion, perception and behaviour showed that the user could adapt himself to the physical ambience conditions provided by the contemporary built environment. The task is then requested to architects, designers as well as planners to provide them the most appropriate environment.

## REFERENCES

- [1] A. Belakehal and K. Tabet Aoul. *L'éclairage naturel dans le bâtiment. Référence aux milieux arides à climat chaud et sec*. Courrier du Savoir Scientifique et Technique, N° 4 August, 2003, pp.3-13.
- [2] R. P. Leslie. *Capturing the daylight dividend in buildings: why and how?* Building and Environment, 38, 2003, pp.381-385.
- [3] K. Parpairi. *The luminance differences index: a new indicator of user preferences in daylight spaces*. Lighting Research and Technology, (34), 2002, pp.53-68.
- [4] K. Tabet Aoul. *Windows and Lighting: Design for visual comfort*. CIE International Conference, Bucharest, Romania, 28-30 November 2002, pp.122-131.
- [5] S. Coyne et al. *Daylighting for the human occupant*. Proceedings of the 1<sup>st</sup> CIE Symposium on Lighting Quality, Ottawa, 9-10 May 1998, pp. 197-205.
- [6] K. Tabet Aoul. *The Interaction of View, Window design and Shading Devices*. PhD thesis, The Building Science Unit, School of Architectural Studies, Sheffield University, September 1991.
- [7] A. Al-Mumin et al. *Occupant's behaviour and activity patterns influencing the energy consumption in the Kuwaiti residences*. Energy and Buildings, 35, 2003, pp.549-559.
- [8] G. Vinsonneau. *Culture et Comportement*. Armand Colin, Paris, 2000.
- [9] A. Bennadji. *Adaptation Climatique ou Culturelle en Zones Arides. Cas du Sud-Est Algérien*. PhD thesis, University of Aix-Marseille I, University of Provence, Press Universitaire de Septentrion, 2002.
- [10] K. Tabet Aoul and S. Sharples. *Climatic and cultural preferences in window design*. Proceedings of the 2<sup>nd</sup> European Conference on Architecture, Paris, 4-8/12/1989, C.E.E. (4 Pages).
- [11] M. Olivier. *Psychanalyse de la Maison*. Ed. du Seuil, Paris, 1972.
- [12] A. Rapoport. *Pour une Anthropologie de la Maison*. Ed. Bordas, Paris, 1972.
- [13] E. T. Hall. *La Dimension Cachée*. Ed. du Seuil, Paris, 1971.
- [14] A. J. Shepherd et al. *Measuring appearance: Parameters indicated from gloom studies*. Lighting Research and Technology, (24), 1992, pp.203-214.
- [15] A. Rapoport. *Culture, Architecture et Design*. Infolio éditions, Gollion, 2003.
- [16] A. Belakehal and K. Tabet Aoul. *L'ombre, esthétique et contrôle du rayonnement solaire dans les milieux arides. Cas des pays islamiques*. Journal de l'Environnement Africain, Vol. X1, N° 41-42, (1-2), 2000, pp.23-46.
- [17] M. Behloul. *Post-Occupancy Evaluation of Five Story Walk Up Dwellings: The Case of Four Mass Housing Estates in Algiers*. PhD Thesis, Department of Architectural Studies, University of Sheffield, October 1991.
- [18] K. Al-Kodmany. *Cultural change and residential privacy: The case of Women in Damascus*. Proceedings of 28<sup>th</sup> Annual Conference of the Environmental Design Research Association, Quebec, 1997, pp.58-70.
- [19] A. Rapoport and N. Watson. *Cultural variability in physical standards*. Transactions of the Barlett Society, The Barlett School of Architecture, London, 1968.
- [20] D. K. Tiller et al. *The effects of luminance distribution on perceived room brightness*. Proceedings of the CIE 119 Conference, 23<sup>rd</sup> session, New Delhi, 1995, pp.144-147.
- [21] K. Tabet Aoul. *Functions of window and fenestration design in a hot climate*. Proceedings of ISES Conference, Kobe, 1989, pp.1921-1924.
- [22] D. Rouag. *An investigation of Solar Shading Devices in Algeria*. MPhil thesis, School of Architecture and Building Engineering, University of Bath, 1987.
- [23] A. Belakehal et al. *Sunlight and dweller's emotions towards home. A phenomenological approach*. Proceedings of the Light and Lightning 2002 International Conference, 28-30/11/2002, Bucharest, Romania, pp.35-42.
- [24] A. Belakehal et al. *The impact of sunlight and daylight on the dwelling's occupancy. Case of the hot dry regions of Algeria*. Proceedings of EPUK 03, 23-25/06/2003, Aberdeen, pp.52-59.
- [25] D. Ouahrani. *TAGA. Daylighting of Houses in Desert Regions*. Thesis 1, School of Architecture, Lund University, 1993.
- [26] D. Rouag. *Sunlight Problems within New Primary Classrooms in Constantine (Algeria)*. PhD thesis, Department of Architecture, University of Constantine, 2001.
- [27] C. H. Zimring. *Post-occupancy evaluation: Issues and Implementation*. Handbook of Environmental Psychology, (Chap. 20). Ed. Bechtel R. B. and Churchman A., Wiley J. and Sons Inc., New York, 2002, pp.306-319.
- [28] S. Hygge et al. *A Manual for Post-Occupancy Evaluation (POE) and Test-Room Studies*. Guidelines for the Joule II Daylight Europe Project (unpublished), 1996.
- [29] A. Belakehal et al. *An evaluation method for daylighting quality in buildings under clear sunny*

- skies. Proceedings of EPUK 03, 23-25/06/2003, Aberdeen, pp.66-75.
- [30] G. N. Fischer and J. Vischer. *L'Evaluation des Environnements de Travail. La Méthode Diagnostic*. Presses de l'Université de Montréal, Montréal, 1997.
- [31] L. Roche et al. *Occupant reactions to daylight in offices*. Lighting Research and Technology, 32 (3), 2000, pp.119-126.
- [32] J. A. Veitch and R. Gifford. *Assessing beliefs about lighting effects on health, performance, mood, and social behaviour*. Environment and Behaviour, Vol. 28, N° 4, 1996, pp.446-470.
- [33] E. Mills and N.Borg. *Trends in recommended illuminance levels: An international comparison*. Journal of the Illuminating Engineering Society, Winter 1999, pp.155-163.
- [34] J. A. Veitch and G. R. Newsham. *Preferred luminous conditions in open-plan offices: research and practice recommendations*. Lighting Research and Technology, Vol. 32, N° 4, 2000, pp.199-212.
- [35] K. Al-Shaibani. *Average daylight factor for clear sky conditions*. Lighting Research and Technology, Vol. 29, N° 4, 1997, pp.192-196.
- [36] J. A. Veitch and G. R. Newsham. *Exercised control, lighting choices, and energy use: An office simulation experiment*. Journal of Environmental Psychology, (20), 2000, pp.219-237.
- [37] V. Berrutto. *Métrieologie de la Qualité Visuelle des Ambiances Lumineuses. Application à l'Eclairage des Bureaux*. PhD Thesis, Université de Savoie, December 1996.