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Assessment of the Luminous Environment in a Modern Office Building in Algeria
Case Study: Public Treasury of Mostaganem

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Abstarct

Modern architecture remains an important part of Algeria's contemporary urban fabric. Many recent studies advocate for the preservation and revitalization of architectural heritage, particularly as it reflects the identity of each region, as well as the relationship between modern architecture and the climate dimension. However, with technological advancement and climate change, it is no longer enough to simply preserve the heritage; it is also necessary to assess and improve its physical environment. Good quality natural lighting is an important component in this type of building and has a direct impact on the quality of work and the productivity of employers. The goal of this article is to evaluate the luminous performance of a modern office building: the public treasury of MOSTAGANEM in Algeria, which was built in 1952. Based on a quantitative approach, we ran simulations with two versions of Software Radiance (2.0 BETA) and ECOTECT 5.5. To evaluate the luminous environment of a private south office, two parameters were chosen: I horizontal illuminance on work plane, and ii) luminance visual field. The results revealed a significant excess of the simulated indicator values for natural lighting (illuminance in workplan and luminiance in visual field) when compared to the recommended references during the winter period, which causes visual discomfort and glare problems. Because climate change and technological advancement have had an impact on the luminous performance of existing structures, new techniques for improving the interior luminous environment in office buildings should be adopted.

Key words: Modern architecture, Office building, Daylighting , Visual comfort, Radiance.

INTRODUCTION

Highlighting modern architecture in Algeria that emerged as a result of changes in the social, economic, cultural, and political structures (J.J.Deluz, 1988) . Colonializing nations introduced modern architecture to Africa in the 1930s only in Morocco, Algeria, and South Africa. These nations demanded their academic styles, and after 1950, the emergence of a new architecture of higher quality, architecture and urbanism designed for indigenous inhabitants, ensuring harmony between landscape, climate, and tradition (Michel Ragon, 1986). The architecture of these buildings has evolved in response to the evolution of design theories and methods (science and technology) (Fischer, 1983). In the absence of comprehensive and exhaustive studies dealing with Algerian colonial office buildings, despite the fact that these buildings still exist in the urban fabric and perform a function in the tertiary sector, many problems with discomfort in the indoor environment plague contemporary offices in Algeria. In recent years, there has been a greater emphasis on ensuring natural lighting in office buildings, including occupant comfort and energy savings (Martin R & al, 2003) .Office buildings are architectural spaces where lighting is a primary requirement for efficient activity performance (Aronoff & Kaplan, 1995; Mitchell McCoy, 2002). Lighting accounts for a significant portion of total energy consumption in office buildings. Improvements in energy efficiency are currently being made through artificial lighting reduction strategies and the intelligent use of daylight (Daniel Plörer&al, 2021). Galasiu and Veitch (2006) found that the preferred level of illuminance in the workplace varied from person to person. Based on the European Standard EN 12464-1, the main indicators determining the luminous environment are: 1) the absolute work plane illuminance, 2) the absolute luminance of surfaces in the room (Cantin &Dubois 2011), the evaluation of the luminous environnemet will be based on these two indicators in ordre to assess the performance of daylight strategies used by the architect in that period .

MATERIALS AND METHOD

The method used in this study is a quantitative approach based on numerical simulation using two software programs, Software Radiance (2.0 BETA) and ECOTECT 5.5. The “Radiance” digital light simulation software is among the most trusted in the lighting industry today (Dubois, 2006). He has proven his credibility in several research studies (Sharples. 2007). This assurance is the result of several studies concerning the validation of its validity for various sky conditions (Mardeljevic, 1995;Mezerdi et Belakehal, 2017), The Radiance software can be linked to other simulation software, such as Ecotect, to provide a more tailored simulation, including geometric data importation, material definition, and all parameters related to the position of the sun and the type of sky (Reiter,2004). Calculate the horizontal illumination in the work plane and the luminance in the visual field within a 120° cone of vision for a private south office on the third floor. The simulations are run every two hours on December 21, July 21, September 21, and March 21 under clear, sunny skies. Taking into account the outside environment, the results are interpreted using recommended reference values for lighting for the various simulated indicators.

CONTEXT OF THE CASE STUDY

The studied building exemplifies modern architecture from the 1950s. These structures are distinguished by the geometric shape of their components, the simplicity and regularity of their facades, and their functional plans (Figure 01). The building chosen for our study is the treasury of Mostaganem.. It is situated in northeastern Algeria (latitude 35° 55’ 52 N and longitude 0° 5’ 21 E). This region has a local steppe climate with a clear and sunny sky, a hot and rainy summer with temperatures reaching 32.1° C in July, and a very cold winter with temperatures reaching 5.8° C in February. Rainfall totals 427.4 mm. The percentage of humidity does not fluctuate much between summer and winter; it might range from 68% to 81%. (O.N.M, 2009-2013).

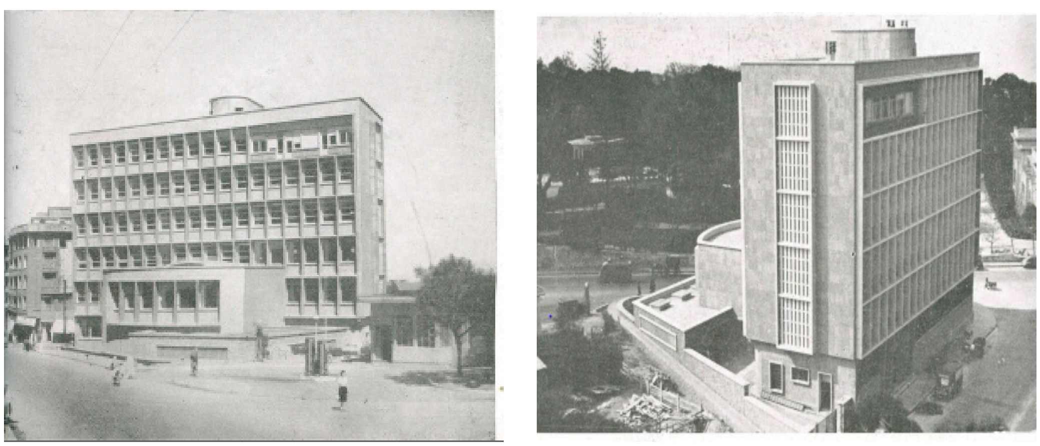


Figure 1. Public treasure building, exterior SOUTH face (left), exterior NORTH face, (Revue les chantiers Nord –africain N° 11; 1952, p 27)

The office building was designed by French architect Jean Baptiste Paravisini in 1952. His architecture is distinguished by the application of climate methods to adapt the project to its environment. The building has five storeys of offices (standard floor), with the bottom floor and an apartment on a section of the top floor dedicated for the Chief Receiver of Finance (figure02).

The architect’s description of the office building: the reinforced concrete frame, which is completely visible and rough, is supported by two rows of parallel pillars set back from the facades. The main facade NORTH and SOUTH span by beams-consoles are entirely composed of sash windows with three sliding panels, glazed glass thermo-lux separated by concrete mullions, prefabricated on site. They are protected from wind and rain in the winter and from the sun in the summer by a horizontal and vertical solar protection made of concrete sails with a 0.90 cm projection on the bays, while the east and west facades are completely closed. (Revue les chantiers Nord –africain N° 11; 1952, p 27).

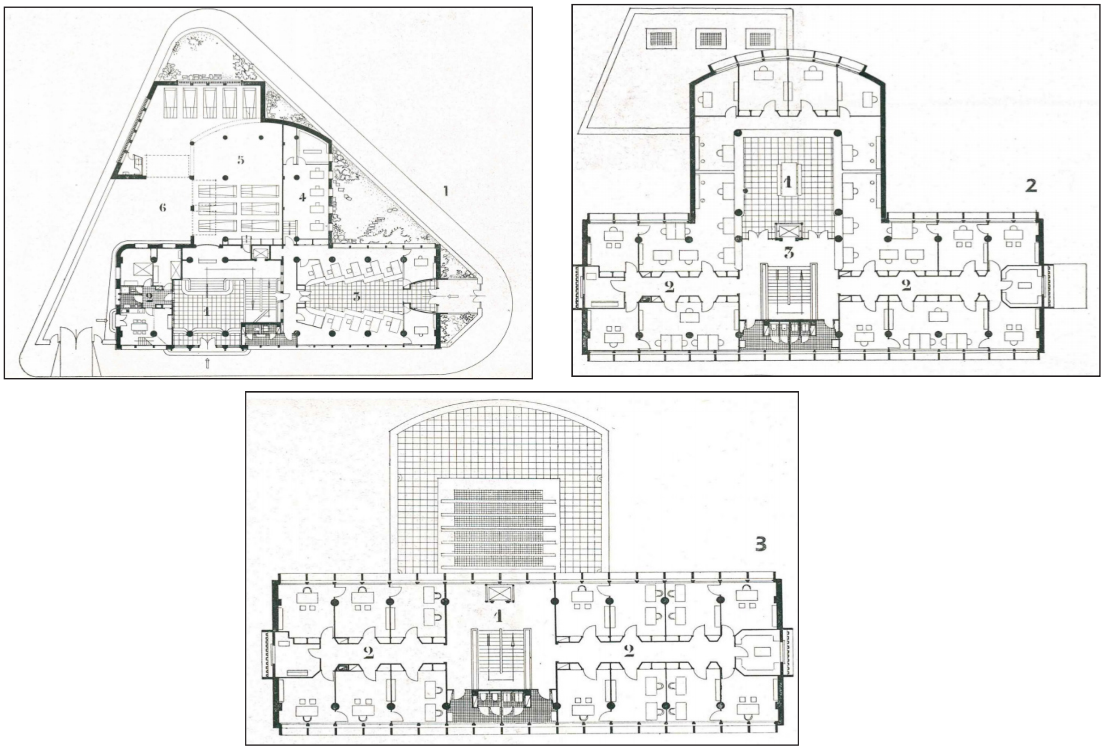


Figure 2. Different plans of public treasury building 1) Ground-floor, 2) Second floor, 3) current floor, (Revue les chantiers Nord –africain N° 11; 1952, p 27)

Thermo-lux window glass is a translucent glass made up of two layers of glass (glass, polished glass, or cast glass), with a fiberglass layer sandwiched between them and sealed on all sides by a flexible joint. (CSTB, Avis Technique 6/14-2175, 2012). The dimensions of the simulated office are 3.70 m at the width, 3.70 m at the depth and 3.3 m at the height (figure03).

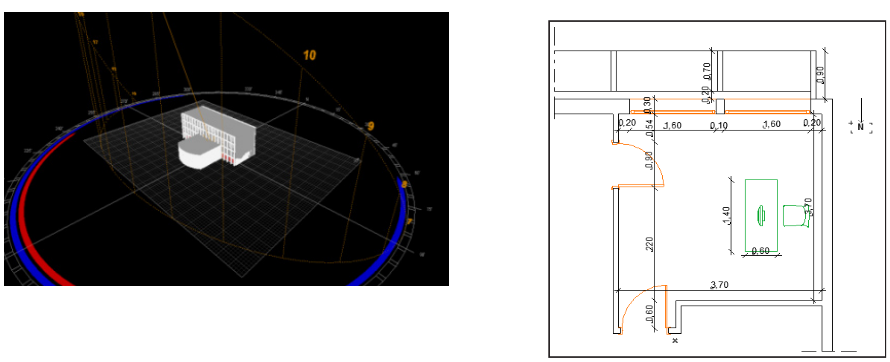


Figure 3. Ecotect office building Modeling (right) , typical office plan (left)

The reflectance of office's surfaces is 0.70% (floor), 0.80 % (walls), 0, 90% (ceiling) with 49% window to wall ratio. The window properties are summarized in table below (table 01).

Table 1. Windows characteristics of simulated office

Characteristics	Quantity
Dimensions	(1,60x1,75) x2 m^2
Window type of glass	Thermoluxglass 02
	Double glazed
Visible transmittance	Thermolux (65%)
	Double glazed (70%)
Windowwall ratio	49%

RESULTS AND DISCUSSION

Work Plane Illuminance

We should compare our results to the standards of the 1950s, when the building was being constructed. An old study shows the evolution of recommended illuminance values from 1930 to 1990 in 19 nations in the Americas, Western and Eastern Europe, and Asia. Their findings show that in 1950 the average illuminance was varied from 100 lux as minimum average illuminance to 300 lux as maximum average illuminance (Piccoli B, Soci G, Zambelli PL, Pisaniello D, 2004). whoever the CNE (comité européen de normalisations) established 500 lux as the average recommended value , the simulations of average illuminance results reveal that values Eaveg were respected almost the whole year and the illuminance's distribution was uniform except on December 21st from 12:00 to 14:00, Eaveg exceeds the reference value. A second evaluation of the results should be performed using the revised reference values. The following ranges represent the recommended illuminance values: less than 100 lux is too dark for computer and paper tasks, between 100 and 500 lux is deemed suitable, between 500 and 2000 lux is deemed desired or less tolerable (Nabil &Mardaljevic, 2005 and Dubois 2003) . More over 2000 lux frequently causes visual discomfort . The study of the data reveals that the winter season's greatest illuminance level, Emax, was observed on December 21 and reached a value of 21020 lux. Due to the penetration of direct sunlight on the work plane, this value far surpasses the reference value of 2000 lux (Dubois, 2003), (graph 01). (Presence of a sunspot) (table 02) . South offices benefit from better lighting management and maximum sunlight in the winter, which is typically excellent [Givoni 1978]. The minimum illuminance value was always greater than the recommended value of 100 lux, indicating that no artificial light was required. The average illuminance levels on the work plane are usually always respected the value all year unless on December 21st, Users' use of paper on window glass to reduce daylight penetration in the office validates our findings (figure 04).

Table 2. False color rendering of illuminance values and the evolution of the direct sunlight (sunspot) and the light distribution in south offices

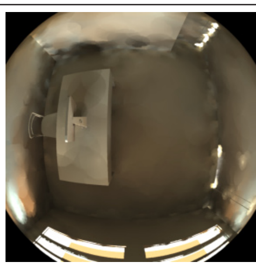
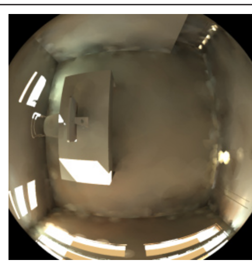
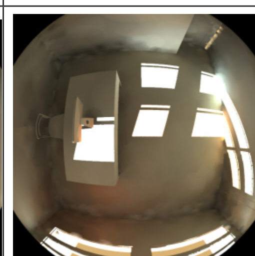
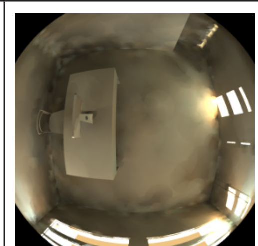
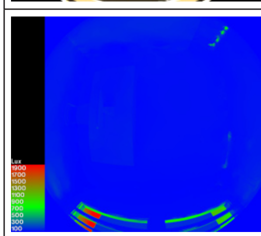
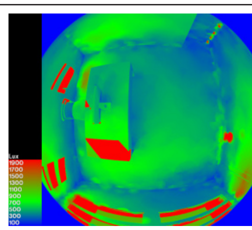
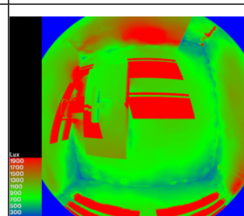
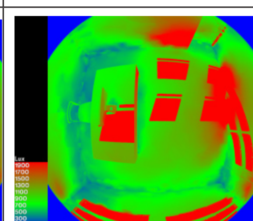
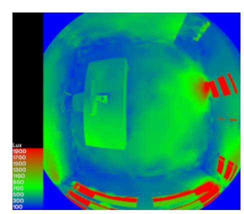
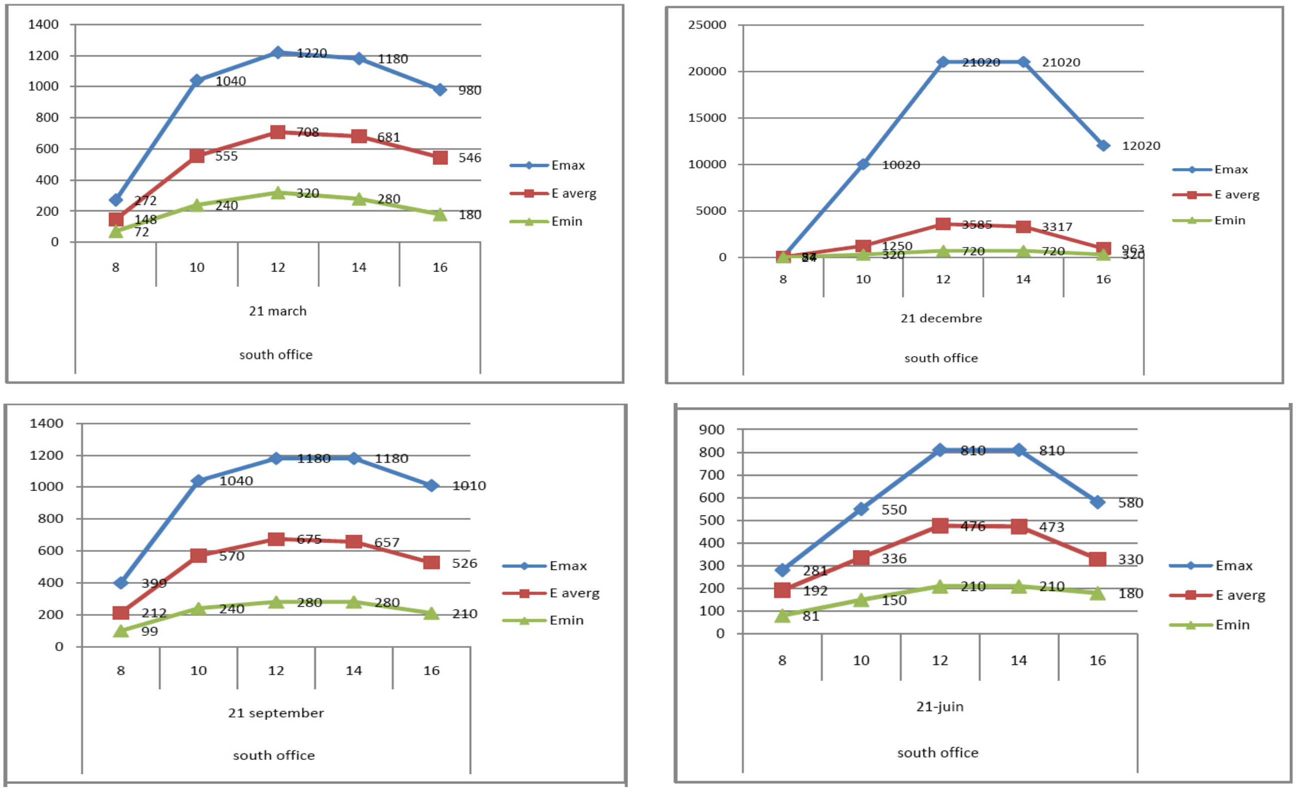
	South office				
	08:00	10:00	12:00	14:00	16:00
21 décembre					
					

Figure 4. Outside view of south face employees' behaviors for eliminate glare.
(Paper glued to the glass)

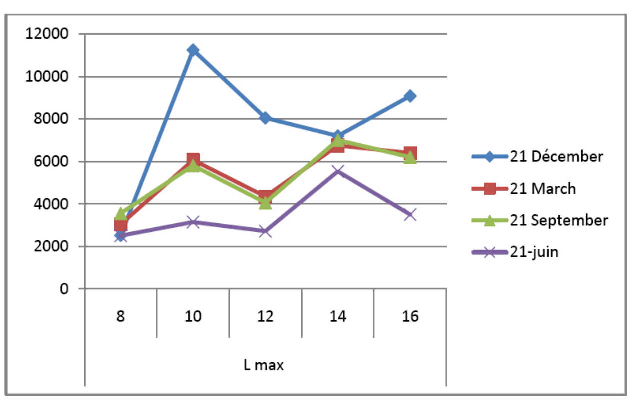


Graph 1. Diagram showing the maximal, minimal and average illuminance

2/ Luminance

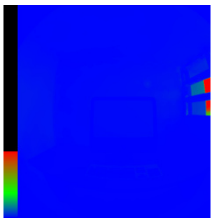
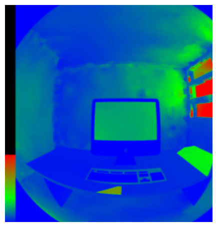
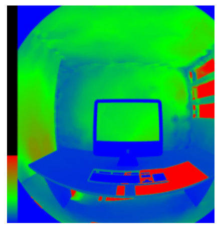
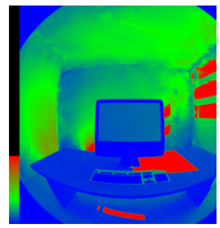
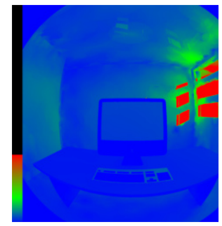
The recommended luminance value varied as following: Less than 100 cd/m2 is considered unacceptably dark; less than 500 cd/m2 is preferable; more than 1000 cd/m2 is considered too bright in the visual field; and more than 2000 cd/m2 is considered too bright anywhere in the visual field (Nabil & Mardaljevic, 2005; and Dubois 2003).Visual discomfort and glare are related (De Herde, A., &Liébard, A. 2005), and have effects on the mood, motivation, and productivity of workers (Menzies and Wherrett, 2005) which reduces the quality of indoor workplace lighting effects.

The findings demonstrate that Luminance's propagation is constant in the office throughout the year. that Luminance's propagation is uniform in the office throughout the year, according to the type of translucent glazing used «thermolux», except for the month of December from 12:00 to 16:00 or when the maximum luminance level reaches a value of 11245 cd/m2 (graph 02) . This value exceeds in excess the reference standards (Nabil &Mardaljevic, 2005 and Dubois 2003), and is considered too bright in the visual field , Because of the penetration of the sunspot inside the office, this direct light is projected on the desktop and the wall in front of the desktop and creates a glare light source for the employees (table 03). This is what explains their behaviors by glutting paper in window glazing to minimize glare and visual discomfort.



Graph 2. Diagram showing of Maximal luminances results in visuel field for south office

Table 3. False color rendering of luminance values in employees visual field in their workstations for the southern Office

	South office				
	08:00	10:00	12:00	14:00	16:00
21 December					
					

CONCLUSION

The integration of a range of modern climate strategies in the office building demonstrates the intentions of the architect Jean Baptiste Paravisini regarding the climatic conditions of the city of Mostaganem, while the simulation results have shown that the physical environment of the southern offices is characterized by a visual discomfort and glare aspect only in the winter period. This qualification is confirmed by the simulation of the quantities of natural light. In the summer period, the values of the quantity of light were in accordance with the reference values and satisfied with the course of human activity for the accomplishment of the tasks. The amount of minimum light is almost all year below the recommended values, so artificial lighting will not be necessary and energy consumption for lighting is reduced. For the performance of the tasks, the amount of the minimum light is almost all year in accordance with the recommended values, so artificial lighting will not be necessary and the energy consumption for lighting is reduced.The historic dimensions of the building and its geographical location in the full city center of Mostaganem give them a symbolic value. The office building's strategies could ensure a comfortable luminous environment all year round, except in winter. As a result, it is necessary to integrate other technical solutions to solve problems of visual discomfort and glare, such as mobile solar protection, our future focus will be the evaluation of this proposal in order to improve the luminous environment of this modern office building

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