VISUAL COMFORT ANALYSIS FOR AN OFFICE BUILDING THROUGH THE WINDOW LUMINANCE CONTROL

SANTOS[1], Cynthia M. L; BASTOS[1 2], Leopoldo E. G; BARROSO-KRAUSE[1],Cláudia M.L.

(1) Programa de Pós-Graduação em Arquitetura – PROARQ - UFRJ
Av. Brigadeiro Trompowski, s/n - Cidade Universitária, Ilha do Fundão
CEP 21941-590 - Rio de Janeiro, RJ – Brazil
(2) Escola de Engenharia da Universidade do Estado do Rio de Janeiro
c.marconsini@gmail.com, leopoldobastos@gmail.com, barroso.krause@gmail.com

ABSTRACT : Nowadays, daylighting use in office environments becomes a challenge for architects face the specific needs required by computers. Due to the vertical screen position is required a protection against glare from the window luminance and to reduce the contrast iluminance with the boundaries. The aim of this paper is to analyze the requirements to redesign a daylighting system to one office floor of a building in Rio de Janeiro, Brazil. From a post-occupancy study it was found that the users were dissatisfied with the existing lighting conditions (natural and artificial). The measured natural iluminance levels inside the office were low and the ambiance was dark. This was due to the interference of a thin film pasted on the indoor glass surfaces. Thus, a virtual model was considered for the office, and simulations were performed by the software "Desktop Radiance" to study a mean to use natural lighting without interference on the computers screens. Light designs that combine the use of natural and artificial means are according to the sustainable principles.

KEY-WORDS : Daylighting. Visual comfort. Sustainable Office Buildings

RESUME : L'utilisation de l'éclairage naturel dans les ambiences de travail administratif est devenue un grand défi pour les architectes dû aux besoins lumineux rigoreux causés par la présence des ordinateurs. La verticalité de l´ écran impose une protection contre l'éblouissement et l´excessive luminance de la fenêtre. Ce travail a pour but l`analyse d`un projet pour amelioré l´eclairage naturele pour un étage d`un bâtiment de bureaux à la ville de Rio de Janeiro, Brésil. En decourrence d´une étude de post-ocupation au bâtiment il a été constacté qui les usagers ne sont pas satisfaient avec les conditions lumineux aux bureaux (naturel et artificiel).Les niveaux des illuminances naturelles measureés sont très bassses, face le filtrage et distortion de la couleur visible provoqué par une pellicule adérente au vitrage pour réduir l´ensoillement. Ainsi, un modèle virtuel a été consideré pour le bâtiment et des simulations on été efectués avec le logiciel "Desktop Radiance" pour trouver une moyenne d´utiliser l`éclairage naturelle sans probléme de éblouissement sur les écrans des ordinateurs et proporcioner aux usagers le confort visuel et luminique. Les résultats obtenus montrent l'importance du contrôle de la luminance de la fenêtre, dès la conception du projet d'architecture, dont la position, l'orientation, les characteristiques des ouvertures et du vitrage, bien comme les éléments de protection solaire doivent être soigneusement analisés. Ces facteurs ont une forte influence sur les efficacités lumineuses naturel et artificiel, comme pour le confort visuel et la performance énergétique du bâtiment en accord avec le dévélopement durable.

MOTS-CLÉS: Confort Lumineux . Éclairement Naturel. Lumière Naturel aux Bureaux

1. INTRODUCTION

1.1. DAYLIGHT TO PROVIDE INDOOR COMFORT IN OFFICES

Daylighting combined with artificial means can contribute to reduce electric consumption and provide thermal and visual indoor comforts. Recent studies have shown that dynamic work ambiances can improve work productivity (BAKER et al, 1993). Thus, indoor daylight can valorize the building esthetics and stimulate people perception, due to the light variations in space and time and turns spaces more dynamics (BOYCE, 2003). Otherwise if glare is present, the daylight use can be managed. A solution for this problem is to control the luminance from the window, by means of adequate glasses and solar shade systems.

1.2. LIGHTING REQUIREMENTS FOR OFFICE SPACES

The criteria related with visual comfort have been started more strict from the 1980 years, and themes as glare reduction from computer screens have been considered (FONTOYONONT, 2002). Several researches have been performed to establish the relationships between the user satisfaction and lighting conditions in work spaces (NEWSAHM, 1994); (NICOL et al, 2006); (SUTTER et al, 2006). The computer utilization creates a series of ergonomic problems and other human requirements: psychological and physiological. As the screen monitor has it own light, the ambiance lighting can be reduced up to available conditions to read a written paper sheet. But, due to its almost vertical position is possible to occur direct or indirect glares. Thus, lighting requirements are not the same for people to read at a screen monitor or a written paper. In the event these two functions are accomplished by people in the same space and almost at the same time. The challenge for architects is to conciliate these conflicting light requirements and permit to the worker a flexible utilization. Nowadays the light-designers need to develop projects for the office buildings related with luminance requirements and not only with iluminance as before, (STEFFY, 1995).

1.3. THE OFFICE BUILDINGS

Usually in these buildings day-light penetration and the sight to out-door are provided for lateral windows or curtain wall façades. These two opening requirements need to be considered by distinct procedures. Thus, in order to prevent glare at the work site from these apertures, opaque glasses are used up to the sight level and above this level are required high visible transmitance glasses. Despite importance of these opening characteristics, these two combined functions are not commonly found in Brazilian office buildings. Actually, are encountered several office buildings with façades without any kind of external solar-shades, following the International Style. This paper presents a case study of natural lighting performed for the Ford Foundation office by the GPAS - Grupo Projeto Arquitetura e Sustentabilidade- PROARQ – UFRJ. This group was invited by the Ford Foundation to evaluate a post-occupancy study for its work ambiances, face the user claims.

1.4. THE FORD FOUNDATION OFFICE

The Ford Foundation office is at the eight floor of an office building sited in Rio de Janeiro, Brazil. This building has curtain wall façades protected against solar gains and glare by a violet thin-film pasted on the internal glass walls, see figure 1. Daylight measurements at the façades, shown a transmitance value of 5%. This indoor low level of natural light is problematic when are required an efficient use of electricity and an environmental comfort. Additionally, ambiences large in depth, as this case, presents a day-light indoor reduction and a high electricity consumption by artificial lighting. Another negative point is the change to violet for the penetrated day-light, observed more careful if the electric light is off, see figure 2.

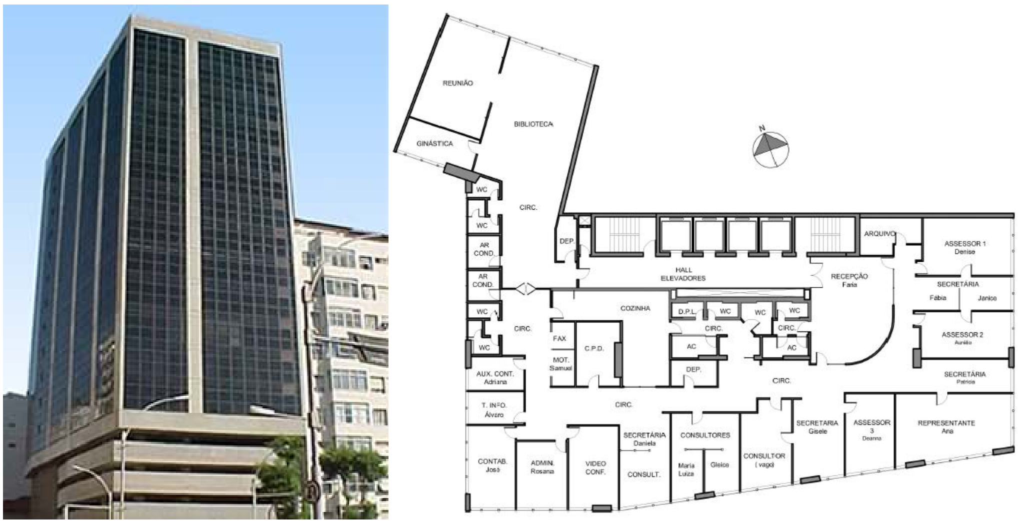


Figure 1 – The building view (left) and the floor plan (right)

Figure 2 – Picture of an office view to outdoor, under natural light only.

2. METHODOLOGY

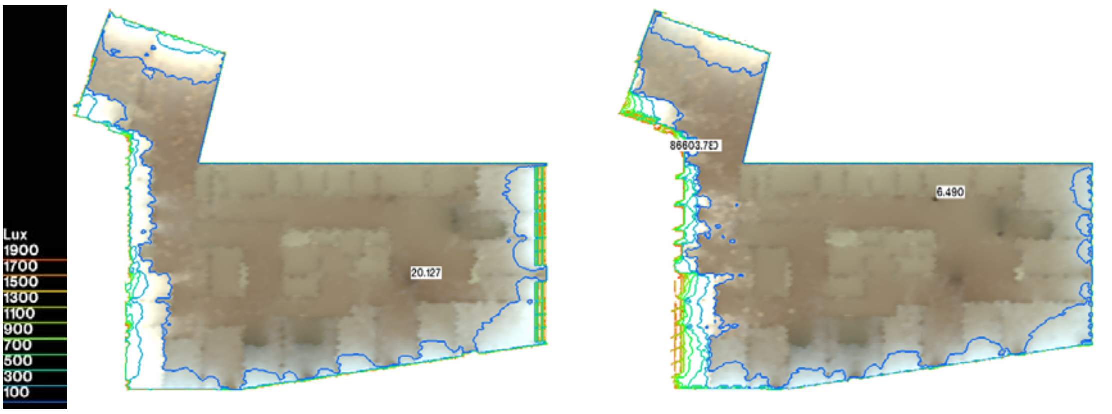
The indoor daylighting analysis for this office was developed according the following process : (a) an exploitation visit was carried out (enquires and photometric measurements); (b) modeling a virtual ambiance by AUTOCAD ; (c) performing simulations using the software "Desktop Radiance". The indoor iluminance levels on the work surfaces were obtained under a clear sky condition, for the summer solstice (22 December) ; winter solstice (22 June) ; and equinox (21 Mars), at 10h et 14h, see figures 3, 4 and 5. The colors band indicates the iluminance scale values on the work plane (75 cm), in lux.

Additionally, were obtained by simulations the luminance levels from the glass façades, in order to verify if is possible to improve the day-light transmission without loss of visual comfort for the users. The simulation studies have considered three work spaces, each one located at the building façades East, South and West. Figure 6 presents some obtained results for the window luminance, being the observer in front of the window, values in NITS (cd/m²). After this daylighting evaluation, others simulations were performed to study some means to improve indoor natural light without glare problems.

3. RESULT ANALYSIS

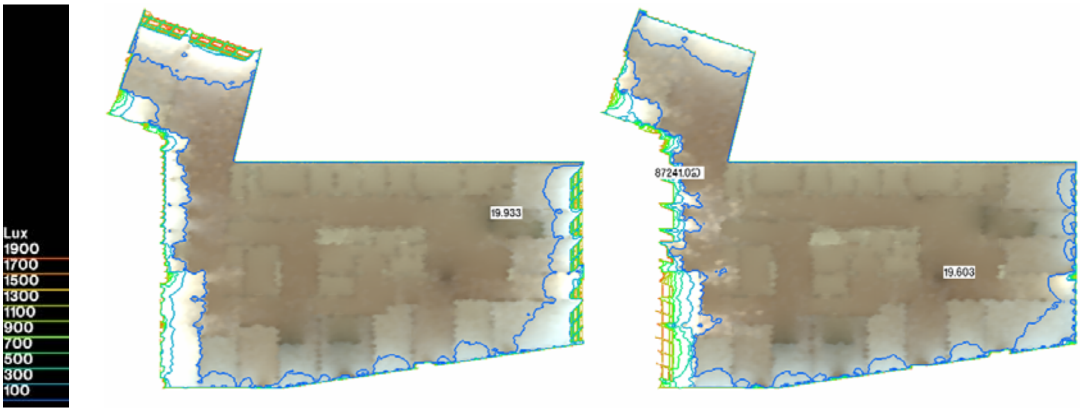
As cited above, figures 3, 4 and 5 show some simulation results for the indoor office day-light on the work-surface. These results indicate that the indoor natural light level is quite low, and is related with the low window transmittance in the visible range. The high value obtained was lower than 100 lux, minimum admitted value to an integration with artificial light.

The obtained luminance values through simulation in figure 6 show that glare is not present and is possible to increase the window transmitance without comfort problems. According IESNA (2000), the indoor office luminance inside the visual field can be up to 850 cd/m². Some new studies show that LCD screens luminance is about 200 cd/m², and the acceptable luminance from the window can reach 2000 cd/m² (LEE et al, 2007). The simulation results indicate that the luminance from the windows is about 450 cd/m² and then this value can be increased.



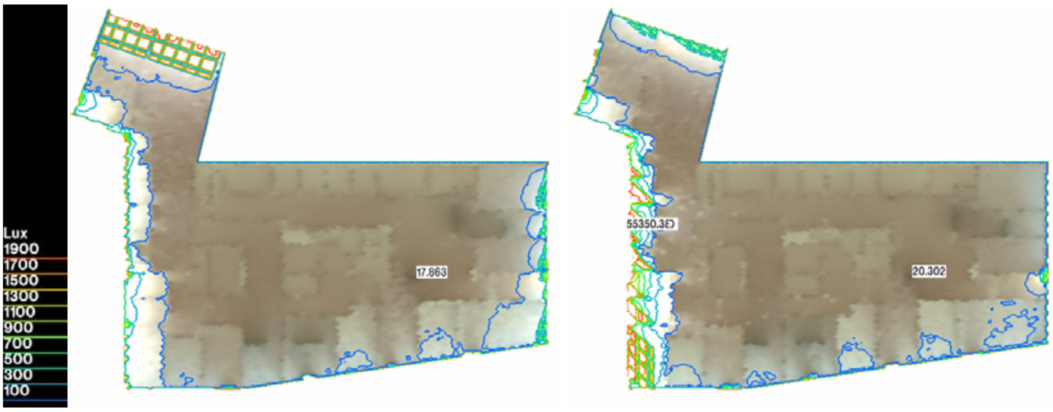
10h **14h**

Figure 3 – Iluminance simulation results, summer solstice (22 December) – clear sky



10h **14h**

Figure 4 – Iluminance simulation results, equinox (21 March) – clear sky



10h **14h**

Figure 5 –Iluminance simulation results, winter solstice (22 June) –clear sky

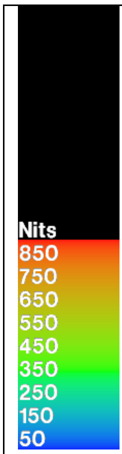
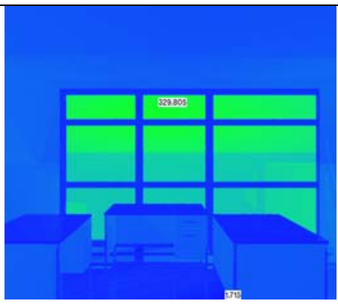
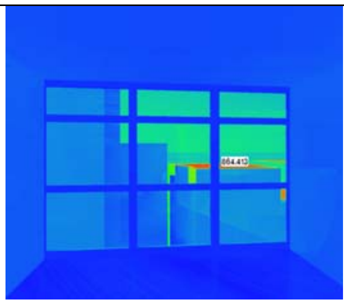
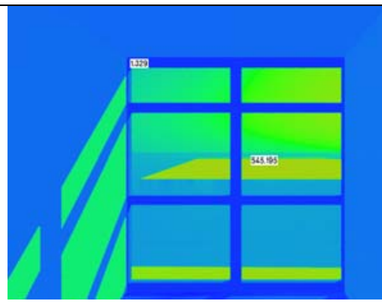
			
	Window luminance by simulation. Indoor to outdoor view, East façade, December 22, 10h.	Window luminance by simulation. Indoor to outdoor view, South façade, December 22, 10h.	Window luminance by simulation. Indoor to outdoor view, West façade 22 June 22, 14h.

Figure 6 – Picture of some window luminance simulations

4. PROPOSED SOLUTION

It is possible to realize from this performed study that the poor day-light performance in this office is due to the low transmittance from the glass with the pasted violet thin film. In order to define some strategies to increase indoor day-lighting performance without glare, several simulations were made. Considering the visual comfort it will be required to prevent glare at the work place; maintenance the landscape view; a daylight admittance to provide adequate luminic levels; and to avoid any color distortion for the penetrating daylight. In this way a solution can be the window partition in two and without the thin solar shade film by means a light-shelf (without external protrusion). The superior glaze, at the sigh work level will have a low light transmittance. At the bottom glaze a solar shade roller blind prevent glare problems, figure 7. Simulations performed for the window luminance show that the curtain can be able to have a visible transmitance according table 1.Where the luminance can not be higher than 2000 cd/m².

FAÇADE ORIENTATION	MAXIMUM VISIBLE TRANSMISSION BY THE SOLAR SHADE ROLLER BLIND
SOUTH	27%
NORTH, EAST, WEST	19%

Table 1 – Allowable light transmitance for the curtain.

The light-shelf can improve the indoor day-light distribution and can be made of aluminium eletrostatically painted of color white.

The figures 8, 9 et 10 present the indoor iluminance results from simulations performed considering this proposed solution. It can be seen there is an improvement for the indoor daylighting distribution

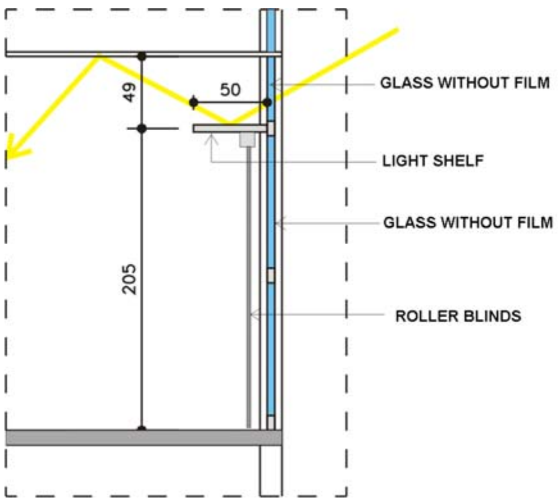
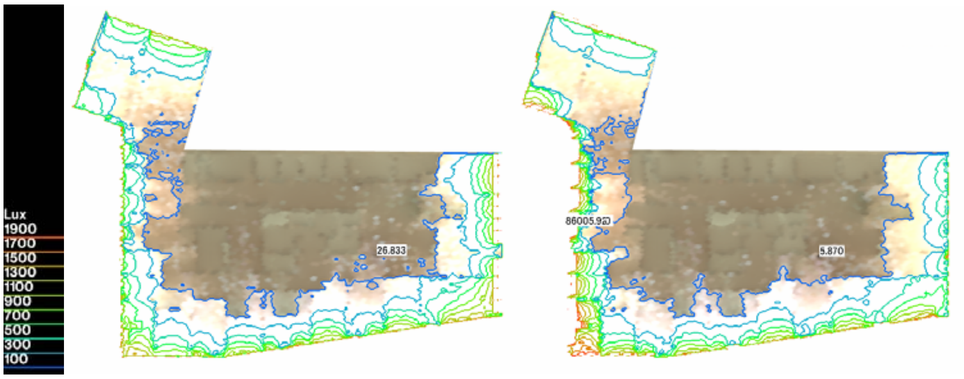
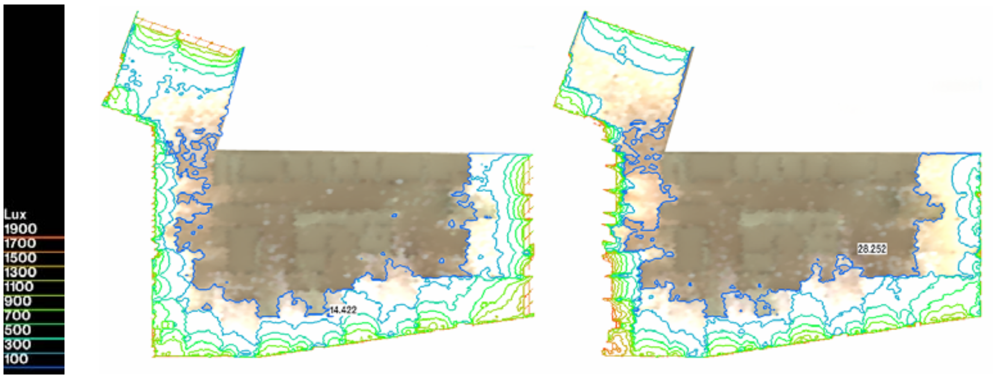


Figure 7 – Proposed scheme for the daylighting system



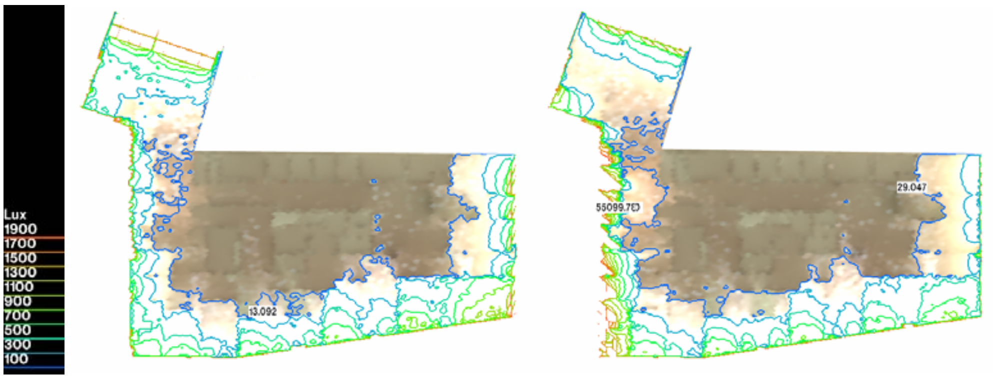
10h **14h**

Figure 8 – Iluminance simulation results, summer solstice (December) – clear sky



10h **14h**

Figure 9 – iluminance simulation results, equinox (March 21) – clear sky



10h **14h**

Figure 10 – Iluminance simulation results, winter solstice (June 22) – clear sky

5. CONCLUSIONS

The intent of this paper was to present a simulation study to compare the actual daylight indoor conditions for an office building floor in a tropical climate, with a retrofitting proposal. From the analysis performed for the existing building, it was seen the possibility to increase the iluminance levels along the room without glare problems. The proposed retrofit solution considers the use of a light-shelf, glazes without violet thin film, and a solar shade roller blinds at the bottom. The choose curtain can have a transmitance allowing a luminance comfortable limit (2000 cd/m²) and is an economic choice. The violet thin film extraction from the glazes will improve indoor day-light quality and will reduce the use of artificial lighting, contributing to the efficient energy use. The present retrofit proposal will be more interesting if applied to all building floors, and in this case will be dependent upon others users. This last point shows, how is important to consider in the architecture conception phase the luminance from the window and its relationship with the visual comfort. The choice of glaze materials and solar shade systems will more easily made during the project conception period. Also, the presented results show the importance of indoor daylight simulations tools to aid new or retrofitting projects.

6. REFERENCES

Baker, N. V; Fanchiotti, A.; Steemers K. A.; (Editors) *Daylighting in architecture – an european reference book*. Commission of the European Communities. James & James Ltd. London. 1993

Boyce, Peter R. *Human factors in lighting*. Taylor & Francis. London. 2003

Fontoynont, M. *Perceived performance of daylighting systems: Lighting efficacy and agreeableness.* Solar Energy, vol. 73, n°2, pp. 83-94, 2002. Elsevier Science Ltd. Great Britain. 2002

Iluminating Engineering Society of North America. *Lighting Design Handbook***.** 9ª edition. New York: IESNA. 2000.

Lee, E.S; Selkowitz, S.E. *The New York Times Headquarters daylighting mockup: Monitoring performance of the daylighting control system*. Energy and Buildings, 38 pp. 914-929, 2006. Elsevier B. V. 2006.

Newsham, G.R. *Manual control of window blinds and eletric lighting: implications for comfort and energy consumption*. Institute for Research in Contruction. National Research Council Canada. 1994. www.nrc.ca/irc/ircpubs.

Nicol, Fergun; Wilson, Mike; Chiancarella; Cecília. *Using field measurements of desktop illuminance in European offices to investigate its dependence on outdoor conditions and its effect on occupant satisfaction, and use of lights and blinds***.** Energy and Buildings n° 38. pp 802-813. 2006.

Sutter, Yannick Et Al. *The use of shading systems in VDU task offices: A pilot study*. Energy and Buildings 38 pp. 780-789, 2006. Elsevier Science Ltd. Great Britain. 2006.

Steffy, Gary R. *Lighting the eletronic office*. Van Nostrand Reinhold. New York. 1995.