Considerations on glazed office buildings retrofit focusing luminic and visual comfort

Sigried Neutzling Buchweitz, Leopoldo Eurico Gonçalves Bastos, Teresa C. F. Queiroz and Eduardo Breviglieri Pereira de Castro

PROARQ/FAU/UFRJ: Programa de Pós-Graduação em Arquitetura da Faculdade de Arquitetura e Urbanismo da Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brasil. alice_in_mirrorland@yahoo.com

ABSTRACT: This paper is about retrofitting office buildings with glazed surfaces. Variables that interfere with the user’s comfort are analyzed, specially focusing the luminic and visual comfort. The aim is detecting what aspects can be improved in the occasion of a retrofit, such as the way tasks are executed in an office nowadays like the use of computers, the panoramic office concept, among others. For such, measurements are taken in a floor and also interviews with some of its users at PETROBRAS headquarters, situated in Rio de Janeiro’s downtown. This award-winning project has glazed façades entirely protected by brise-soleil. Despite the presence of those protection elements, it still has some typical glazed buildings issues as glare. About one third of the users interviewed considered the task vision just acceptable or slightly uncomfortable, and that this is related to the use of the protection equipments on the façade (43% of the users mentioned their manipulation as the reason for visual comfort decrease and 50% point the brises opening as an improvement factor).

Glazed office buildings retrofit is important because of their great energy consumption. When natural lighting is considered, it not only provides luminic and visual comfort but also can reduce the amount of energy spent. Improved comfort also increases users’ performances. To reduce glare, simple solutions can be used, as furniture that provides a more adequate positioning to the envelope, or the use of task lighting among others.

Keywords: retrofit, offices, glare, visual and luminic comfort

1. INTRODUCTION

The aim of this paper is detecting what aspects can be improved in the occasion of a retrofit, such as: the way tasks are being executed nowadays in an office like the use of computers, the panoramic office concept, among others.

The commercial buildings typology was chosen as a matter of study due to its great energy consumption. Office buildings located in hot and humid climate are subject to great amounts of incident solar radiation, requiring control of the incident natural lighting. The implantation of new constructive elements in existing constructions, as external protections, can have high initial cost. It is also considered that the older the building is, more difficult it becomes to insert new technologies.

When attending to the current demands of luminic comfort in office environments and considering the commercial need for maximum exploitation of the terrain where the construction is implanted, it becomes almost impossible not to use artificial lighting. However, external or internal protection devices can increase indoor natural lighting availability and an increase on light quality. As a consequence, the need of artificial lighting can be diminished. It happens not only because of its use as a primary or secondary source but also because natural light gives the best color rendering, and less of it is needed to perform a task than it would under artificial light. [4]

For such, variables that interfere with the user’s comfort are analyzed, specially focusing the luminic and visual comfort. The place chosen for those measurements is part of Petrobras headquarters (EDISE) floor, situated in Rio de Janeiro’s downtown. Indoor measurements were taken and some of the ambient users were interviewed.

This award-winning project has glazed façades entirely protected by brise-soleils. Despite the presence of those protection elements, there is glare, due to the characteristics of façades with great glass extensions. About one third of the users interviewed considered the task vision only acceptable or slightly uncomfortable, and this is related to the use of the protection equipments on the façade (43% of the users mentioned their manipulation as the reason for visual comfort decrease and 50% point that brises opening is an improvement factor).

The retrofitting of glazed offices is important to reduce the building’s energy consumption. It can include the promotion of better environment conditions, besides contributing with the constant evolution of the urban tissue.

When the activities and the workstations layouts adopted nowadays (open concept) are taken in consideration, it is possible to obtain good results with architectural interventions, as the implantation of
passive systems for solar control and a good use of natural lighting, protective glazing, changes in the layout, exploitation of the opening of the windows, among others. Vertical openings offer sight and pleasant contrasts, but the natural light penetration is small. This generates contrast in the vision field. To diminish it and to offer lighting that attends the users demands, attention must be given to the indoor interreflections and to use artificial lighting as a complement, if possible.

The use of more up-to-date equipments, as elevated floors for the implantation of Information Technology infrastructure and more modern lights and light bulbs, permits a reduction of the building’s energy consumption.

The negative aspects of glazed buildings can be diminished when passive solutions are implemented by occasion of a retrofit process, taken in account the ambiental comfort and energy savings. In Brazil, the commercial sector (category where office buildings are inserted) has an electric energy consumption constantly increasing. This is partially explained by the change of architectural typology in office buildings, following foreign concepts.

2. ORIGINS OF TALL AND GLAZED BUILDINGS IN RIO DE JANEIRO – A BRIEF EXPLANATION

The construction of the first tall buildings or skyscrapers initiated after the change in the structural system used at the end of XIX century. Instead of being supported mainly by structural walls with rock bases, they started being supported by a steel skeleton with the weight distributed by columns, permitting the creation of more floors. Those monumental buildings landmarked the skylines of big cities like Chicago and New York.

Later, with Modern Architecture the concept of free plant gave more flexibility to divide the building’s ambients. The free concept façade, also from Modern Architecture, in which the structure would not intervene with the façade, gave rise to the Curtain Wall, which is a façade made entirely of metal frames and glass. In Brazil, the tall buildings -- although not reaching the same heights -- also had the function of landmarking the skyline of big cities as São Paulo and Rio de Janeiro, as a symbol of economic development. The production of this kind of architecture is especially significant in the period from 1930 to 1980 decade. A big influence from architecture of developed countries, especially U.S.A., is noted since that time: the architecture follows international tendency, in spite of the climatic and social differences between countries.

One of the most expressive influences is perceived at the end of the 1950’s decade. The progress of the national Industry created a propitious field for the development of projects with a more elaborated technology. At the end of that decade the first building entirely made with metallic structure was planned and built in Rio de Janeiro, the Avenida Central building. Its volumetry marked by a tower and a wide basement, clearly evoking International Style, inspired in Mies Van Der Rohe projects.

3. THE MATTER OF STUDY

The Building headquarters of PETROBRAS (EDISE), projected at 1960’s decade, is considered a landmark in Rio de Janeiro. A competition carried through gave the authorship to the architects Robert Luis Gandolfo, Jose H. Sanchotene, Abraão Fortes Assad and Luiz Neto. When the project was conceived, Brazil was in a great cultural raving, with innovations in all areas, including architecture. "The Niemeyer Brasilia’s aesthetic was already consolidated and there were challenging national vanguards, represented in São Paulo mainly by Artigas and Joaquim Guedes and in Rio de Janeiro by Sergio Bernardes" [5]. Considering the history of the office buildings in Rio de Janeiro, it is observed that after the 1960’s decade a trend was initiated: to erect buildings with great unsheltered glass surfaces. EDISE constitutes an exception to this rule. The region where EDISE is inserted has constructions of great historical and architectural meaning. Opposing to the common practice in Rio de Janeiro’s downtown the boundary existing buildings are in center of terrain, generally with gardens around. As the building is implanted far from others, the ensemble of the region has low building density and the buildings receive solar radiation in all its façades.

Figure 1: EDISE building’s location.

The impacting volumetry of the building is divided in three parts: base, shaft and crowning. The building has elements of the Modern Architecture vocabulary, as stilts, free concept plant and free concept façade. Although not having terrace-gardens, the building presents green areas interpolating the floors sections, alternating full and empty spaces in its volumetry.

These full and empty spaces are formed in virtue of typical floors overlapping. Three main types are superposed by two, forming the façades openings. The typical plants are in the following formats: cross; letter H; and a lying letter H (called ",") , shown in figures 3 trough 5. The openings receive gardens projected by Burle Marx. These internal gardens provided by the interpolation of typical floors work as natural light capture zones, lighting parts of the floor that would normally be dark. The vertical circulation,
bathrooms and storage area are concentrated in the nucleus of the building.

The building is entirely regulated by a mesh of 1.25m modulation, from the plants to the façades. The façades are composed of aluminium and tempered gray glasses. The NW, NE and SW façades have protective brise-soleils, elements widely used in the Brazilian Modern Architecture period. It is important to notice that brises of the NE and Southwest façades are vertical and are horizontal on the NW façade. This was made due to façades orientation, which normal axis is only 19° shifted from the North. Faced to the Sun incidence on these façades, vertical brises are more efficient when façades are oriented between NE and SE or NW and SW; the horizontal brises are more efficient between NW and NE.

The South-eastern façade and part of the envelope toward the internal gardens constitute exceptions, in which the glasses are composed by tempered glass plates “sandwiches”, with internal black metallic micro blinds. The office’s areas directed toward the internal garden had not received internal protection elements; gardens are covered by the superior floors flagstones, which protect them from extreme lighting. In some points a glazing that is not from the original project was applied on the interior glass face.

This glazing diminishes the incidence of the natural light in its spectre, acting with bigger intensity in specific bands according to its properties. Brises are in aluminium with metallic gray painting, having rotation axis and distant half meter from the façades. The natural light is intense and passes through the brises openings, even when they are closed. This is particularly due to its rounded form. In the EDISE, the
superior part of the window frames are mobile, allowing its opening. The presence of brises in the NW NE and SW façades is a differential that can reduce the thermal load in the interior of the construction. By means of a Post Occupancy Evaluation, the ambient condition of natural lighting (glare and illuminances) inside a typical room was examined and from this, problems were detected that should be considered in the occasion of a retrofit.

4. METHODOLOGY AND RESULTS

The analysis performed considered the building’s overall characteristics; microclimate data; implanting site; accessibility; construction characteristics; room occupancy and utility systems.

The quantity and quality of light inside the building was evaluated following these proceedings: an analysis of the entourage, walktroughs documented by photographs inside and outside the building, interviews with some of the users, illumination measurements and a computer simulation.

A room in one of the typical floors was picked, and 15 points were chosen for measurements and interviews (see figure 6).

The users were asked about their perception of the indoor ambient comfort conditions. Measurements of illumination had been carried out in an “H” type floor, located on the 4th storey, with the largest façade oriented to 19º W counter-clockwise. A measurement point mesh was created, and in the interception points were measured with a Piwe ® luximeter. The day chosen was March 21, autumn equinox, and three measurements were taken along the day: 11 h; 15 h and 17 h.

During the measurements, the sky was partially covered, with great variability. A number of 15 measurement points were chosen, being 8 next to the windows and the remainders in the middle axis of the room. All blinds were opened, and the brises were positioned in their maximum opening, which is 45º, in order to verify the available potential of natural lighting.

The illumination was measured to compare the values given by the software and the ones obtained with the measurements inside the room. The results are generally proportional, and the variations can be attributed to the difficulty in simulating the use of brises and the corners of the façade.

The points where the users pointed some problem related to glare were near to the corners of the façade, as shown in figure 6.

It is important to notice that the point 3, located in the center of the façade, has a bigger illuminance, followed by those located on the vertices. This probably happened because of a reflective surface near the measurement point (a light shaded wall). The results are displayed in the figures 7 to 9.

Figure 6: measurement points

Figure 7: measurements results from points 1, 2, 3, 4 and 5, near to the façade turned to SW.

Figure 8: measurement results from points 6, 15, 14, 13 and 12, in the middle of the room.

Figure 9: measurement results from points 7, 8, 9, 10 and 11, next to the gardens.
Since the building has protections on all façades, it can be considered that sunlighting control was an important issue during its project. The building’s gardens reflect a concern about the view; it increases the window area, which are protected by the upper floors flagstones.

In fact, the photographs showed that the workstations located near the gardens are the ones who suffer less from contrast, in opposition to those near to the portions of the façade facing to the exterior, as it can be seen in figures 10 and 11.

The interviews were conducted in order to obtain an approach about the environmental quality of the occupied space. The users were asked about specific issues concerning their workstations and general aspects of the building. The questions were related to the observer’s task view and followed the model employed by Kaufman e Haynes [4] to detect glare, based on the difficulty of seeing the task. 31% from the interviewed people commented that the task view was acceptable or slightly uncomfortable. As the reasons: reflection, glare or light insufficiency (in this last case, the user was under a situation of great contrast, because one of the available near lights was not on), which are problems normally caused by a poor natural light distribution. Half of the discomfort sensations were extreme cases. Although more than 2/3 of the inquired considered the task view as good, more than a half notices better or worse sensation when brises are manipulated. From those who feel a change to worse, 43% mention it as problematic. 50% point out the role of brises manipulation into visual comfort improvement.

Computer simulations had been performed with the Natlite software, developed by Castro [3], in order to determine the natural illuminance and glare indexes of the building’s interior. The software is based on Dogniaux (1992) models and Chauvel et al. (1982) formulas in order to calculate glare indexes.

The Dogniaux model was developed to CIE in 1967 (Castro [3]). It permits the calculation of direct, diffuse and reflected external radiation (W/m²) components and solar illumination (lux), on any surface with any inclination or orientation. This software is also able to determine the total solar and luminic incidence on the exterior façade surface. In this model, the definition for clear sky is the one that presents less than 30% covered by clouds; the covered sky is the one that presents more than 30% of clouds; medium sky is variable.

Each chosen point inside the room had the available natural light and glare level calculated. The results are presented in the numerical or graphical forms, at each hour and by day to any month, lightened by a vertical window towards the exterior with any orientation. The simulations were carried out for the same measurement points. The software was configured to get the most similar possible to the conditions encountered. The software presents some limitations as the maximum size of 10m for the longitudinal axis along the room, and only one lateral opening for the room can be considered. Despite of these limitations the calculations performed shown a reasonable agreement with the measured illuminance levels and obtained people glare sensations.

The software only accused glare in a few of the 15 points measured. These results are possibly because of the software limitations. Those points were generally next to the window, which was according to the interview’s results. Although the software did not find all glare points pointed by people, its images gave a good visualization of natural light behaviour.
Figure 13: glare in point 12, SE façade, furnished by Radlite

5. PROBLEMS IDENTIFIED

Some of the problems identified had been: thermal discomfort; luminic and visual discomfort, notably glare in certain points inside the room. It looks like the problem that allows a passive solution. It was also the factor that bothered the biggest number of users, although its consequences do not affect them as negatively as an awkward thermal sensation would. For glare reduction, the workstations layout can be changed to give the users a more adequate position in relation to the envelope. In addition, passive means can be used to redirect and/or "filter" daylighting, or a combination of both. A way to reduce energy consumption would be to retrofit artificial lighting, taking the use of a complement natural lighting controlled by the user in consideration. The use of specific task artificial lighting can also help. Another solution would be to change the traditional monitors for LCD ones, which do not reflect the artificial light with much intensity. The specific task lighting can still help in the reduction of energy consumption: instead of illuminating the entire environment with the same level, the task can be more illuminated than the surroundings. The reflectance from the room surfaces also must be considered in the studied ambient.

The presence of light shaded surfaces perpendicular to the main façade can also collaborate for the daylight distribution, as it was observed from the point 3 measurements. The division of the room in smaller ambients, besides diminishing the noise, can improve the ambient luminic conditions. The solutions to improve natural lighting must be fitted to the space volumetry: the floors of the EDISE, are 2,5 m high, hindering the use of light-shelves.

About the thermal comfort, although out of scope of this study, there was not any discomfort pointed by the people. Only it was observed some problems due to the air distribution inside the room. Another important problem found is the number of users inside the room, much bigger than planned in the original project. This is a problem that affects the building as a whole. The excess of people increases the amount of latent heat must if removed from the room, and decreases air quality. It may be also one of the causes of the unbalanced distribution of air conditioning. Since the number of people will not be dramatically reduced in the following years, an update of the system, searching to insert more modern technologies and a revision of the amount and location of the air conditioning outlets can reduce the probability of discomfort. Some of the exposed problems, mainly related with lighting, object of this study, result from the building architecture and the ancient programme established. New uses and users requirements increase can lead to a building retrofit.

6. CONCLUSIONS

Nowadays, the compromise between energy efficiency, ambient comfort and quality for the building, must be taken in consideration. Frequently, artificial lighting and air conditioning are necessary to promote indoor comfort and a quality level. This fact becomes inevitable in many cases, especially in buildings with very deep rooms, great concentration of users and requirements of thermal sensation adjusted for people using clothes that are not suitable to the climate.

Thus, in order to be adapted to the climatic changes and new uses, the old buildings can be rehabilitated, by means of careful study of its real conditions and specific questions concerning the activity they shelter, besides improving luminic and visual comfort and obtaining energy savings.

REFERENCES