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Environmental performance of atria in the humid subtropical climate

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Abstract

This work first studies the illumination characteristics of atrium spaces starting from a review of completed work. Afterwards it presents the problems and advantages of atria in a humid subtropical region. Natural ventilation and natural and artificial lighting are the environmental parameters used in this analysis. Light as an element of architectural composition and modeling of atrium space is the focus chosen to complete the theme. The designer needs to know the conditioners such as the psychological effects of colour and light, knowing what is the visual illusion that he wants to create or avoid. Because in almost all cases where ambiguity is possible in space perception (in this case the atrium space) the lighting can be used to define it. But this does not occur in the studied case.

INTRODUCTION

The atrium has proved to be one of the most popular buildings forms of the last 30 years. The modern atrium can be seen to fulfill many functions, including aesthetic, commercial and social roles. However, perhaps one of the most important features of it lies in its ability to modify the physical environment within the atrium wall and the spaces that adjoin it. Through this function the atrium has the potential to reduce energy loads associated with heating, cooling and artificial lighting. In the case of lighting the atrium form allows natural light to penetrate into areas of deep plan buildings where permanent artificial lighting would usually be required. The atrium can also improve the distribution of illuminance levels within a space, thereby reducing the problem of brightness imbalance that can occur in unilaterally glazed rooms. The importance of the atrium environmental performance has led to several investigations: Kim and Boyer [1], Tread and Gillette [2], Bender [3], Jones [4], Liu et al [5], Wilbold-Bohr et al [6], Sharples and Need [7], for example. But few of them related to typical situations in subtropical regions. All the authors recognised the need to use criteria and tools to enable designers to estimate environmental benefits from a proposed atrium design at an early stage. But the reality is that in the tropical regions there is neither a preoccupation nor a special care about these aspects. Maybe one of the first studies of building atriums in subtropical regions was conducted by Stahl [8].

We will analyse an open-sided atrium with glazed roof, located in a zone of the city of Porto Alegre without any special interesting aspect to illustrate the real situation of atrium space project here (See Figure 1).

Figure 1 – View of the open-side atrium building neighbourhood.

OPEN-SIDE ATRIUM CASE STUDY

Porto Alegre is a city located in the humid subtropical region, having a short cold winter and a long hot and humid period (30°C). The inclusion of atrium spaces in buildings has been increased in the city in recent years for several reasons. Building atria are dramatic architectural features, providing for a significant change of scale within the enclosing structure and allowing great flexibility in interior layout. Atria also can be efficiently incorporated in flow and smoke control strategies, especially in hot humid regions. Indeed, one of the most pleasant uses of atrium spaces involves the replication of an attractive park-line setting within controlled interior environment, complete with trees, plants and flowers. While the psychological benefits of environmental aspects in cold climates are well documented, potential benefits (and problems) of its use in hot regions are not explored.

Measurements were made in a twelve-storey building. It has an open-side atrium orientated to the north with vertical tinted glass walls (See Figure 2). This atrium has been used as a circulation between two wings of the building. The visible light transmission of the glass is 20% and the shading coefficient 0.40.

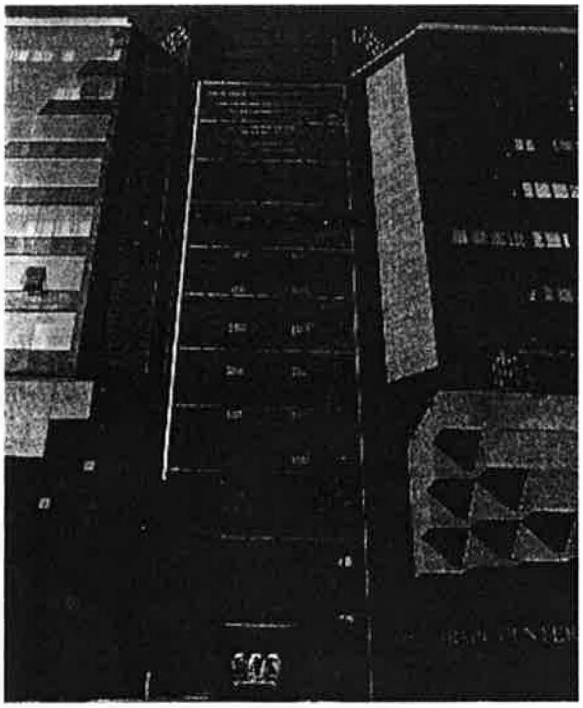

Figure 2 – External view of "foyer".

The perimeter rooms are offices and they have no windows in the atrium walls, but there are small ventilator aluminum wind screens (See Figure 3). The purpose of the measurements was to obtain information about daylighting performance, temperature conditions within the atrium and adjacent spaces and solar shading strategies.

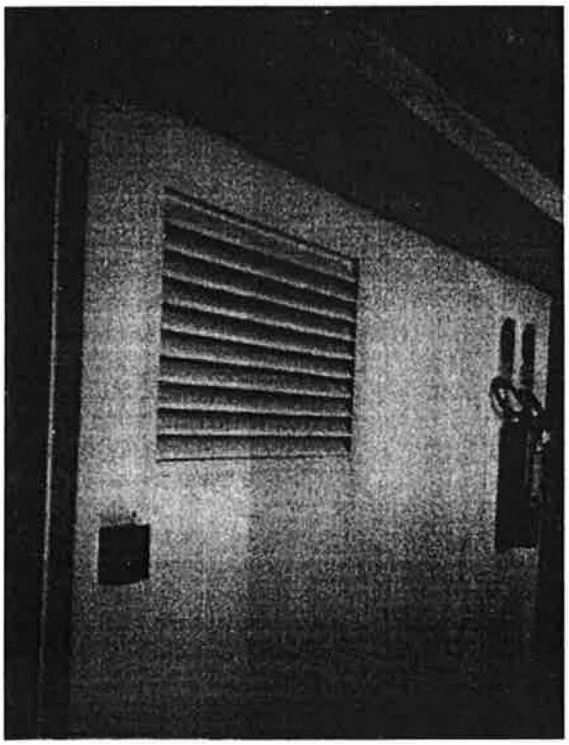

Figure 3 – Interior view of small aluminum windscreens.

In this case, the analysis of daylighting had been organised around three considerations: daylight sources, light box and illumination. The atrium was designed with a glazed roof and a glazed side-wall; this last scheme is usually utilised to capture long-distances views, nonexistant in this case. The quality of side daylight is directional and harsh tinted glass is used to control glare, restricting availability of light. Exterior shading devices would be most efficient in controlling daylight under sunny conditions for Porto Alegre climate. A saw-toothed skylight with vertical glazing facing north is one of the most effective solutions under clear sky conditions. Although there is less daylight available from sky-dome, this skylight form can best be controlled from direct sunlight. A roof overhang or horizontal sunshades are necessary to keep the high northern summer sunlight from penetrating, allowing northern daylight in winter, very interesting for its intensity, golden colour and character (See Figure 4).

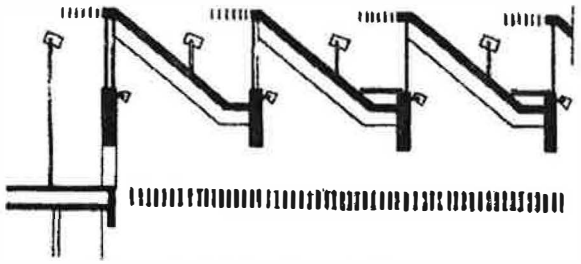

Figure 4 – Interior view of atrium space.

The next concern is the light box itself, designed as a device for light distribution. There are three factors: the section ratio, the sectional scheme and the atrium surfaces. The section aspect ratio (SAR) establishes the conditions for the amount of daylight that will reach the atrium floor and the spaces that surround it. In this case, it is not important for the glazed side wall. The sectional scheme can contribute greatly to daylight distribution; it had not been used in this project. The interior opaque surfaces are light-coloured, smooth and reflective but the use of tinted glass lost this advantage. The last and major daylighting design consideration concerns illumination of the zones around the atrium. The fenestration design of the atrium facades should acknowledge the differences in daylight levels between top and bottom of the space by means of different amounts of glass or different kinds of glazing. Likewise, treatment of the various sides of an atrium should acknowledge their respective solar orientations, as happens in good exterior facade designs. This does not occur in this project, which uses floor-to-ceiling tinted glass on the north facade on all levels. Galleries remove the occupant from direct contact with the atrium, losing the opportunity to use daylight in the occupied zones. Supplementary electric illumination is needed in the galleries to complement the low existing levels of natural illumination, representing an important share of total energy consumed in the building. Daylighting has compound energy benefits: it not only saves electricity for lighting but also reduces cooling loads resulting from heat generated by electric lights. Too many project mistakes made in this case.

NATURAL VENTILATION OF ATRIA

The atrium space has its own ventilation system. Two vent (See Figure 5) are used from floor-to-ceiling; the intak vents are arbitrarily located, the windward side does not face directly into the prevailing breeze.

Figure 5 – External view of two vents.

Each level has small air supply aluminum wind screen windows (See Figure 3). The air temperature and humidity are the same as in the outdoor atmosphere, as a design strategy was to avoid the greenhouse effect in the atrium space. This is a very bad solution for a climate which has both heating and cooling seasons. During summer, the atrium temperatures reach 35°C in a hot day, the same temperature of the exterior air. There is no cooling or heating strategy to render the local climate pleasant. Spaces surrounding the atrium on all levels are fully conditioned, consuming the largest parcel of electric energy of the building.

In the last analysis, it is possible to say the designers did not solve the energy equation for this building, by not utilising the potentials of the atrium concept. The factors in this equation are several [9]:

1. Local climatic conditions including heating degree days, but especially cooling degree days in the subtropical region, temperature extremes and diurnal swings;
2. Solar orientation, prevailing wind directions (both very important in our climate), existing trees, surrounding buildings;
3. Building use: heavy thermal versus light thermal, daily and seasonal use patters, user needs.

Taken together, an analysis of these factors can lead an effective energy strategy for the project in question. That is the essence of the design act, to weigh the factors and create a scheme leading to a balanced solution.

LIGHT AS ELEMENT OF ARCHITECTURAL COMPOSITION

Finally, light is an element of architectural composition and modeling of the space, particularly, the atrium space. Light is inseparable from the theme given in a programme. The choice of quality and quantity of light depends mainly on the theme. But, in this case, light is forgotten, losing a great opportunity of composition and modeling of the atrium space. As we approach the millennium, it is interesting to observe how architects explore light and shadow in the design of meaningful and substantial architecture. Furthermore, a greater awareness and understanding of the powerful history of light in architecture makes possible a reinvestigation of this element as an expressive and representational tool. It is a pity that the designers of this atrium space did not employ light as effectively, powerful and meaningfully as in past times. Or maybe, light and shadows used less mystically and metaphorically but exploiting the powerful qualities of light. Light filling up the atrium space, and reflected and refracted through the structure to create an experience of temporal spirituality. One great project opportunity was lost.

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