

Lúcia Mascaró

**DENSIFICATION AND URBAN ENVIRONMENT
OF THE CITY OF PORTO ALEGRE**

**GĘSTOŚĆ ZABUDOWY I ŚRODOWISKO MIEJSKIE
W PORTO ALEGRE**

This paper studies the natural insolation, illumination and ventilation conditions of urban precincts in Porto Alegre.

Analysis of the insolation conditions of the urban precincts was done through computer simulations for different types of streets and conditions of winter and summer. The daylight illumination of the urban precincts was studied through the field research done throughout a year: dry and green squares, narrow and wide streets with the axis oriented N-S and E-W of homogeneous and heterogeneous profiles. Spaces between the buildings (nooks), crossings and open spaces were measured throughout the four seasons of the year. The natural ventilation was researched in the aerodynamic tunnel, simulating the action of the winds on the three morphologically different blocks.

Finally, the results obtained in each of the partial studies done were compared, and recommendations of normative character were drawn up.

THE CITY

Nowadays Porto Alegre is fundamentally a city built up in height, whose characteristics change depending on the criteria imposed by the Town Planning of each period, Figs. 1 and 2.

The space between the buildings most of the time is of exiguous proportions, consisting of a dry paved area; in some higher class neighborhoods it is planted, humid and cool, in which the façades of the buildings still receive the desirable sun in the winter and have good ventilation. But part of the urban area has the sun reflected on the roofs and top part of the north, east and west buildings façades as the only incident sun in the cold season and the wind blows above it.

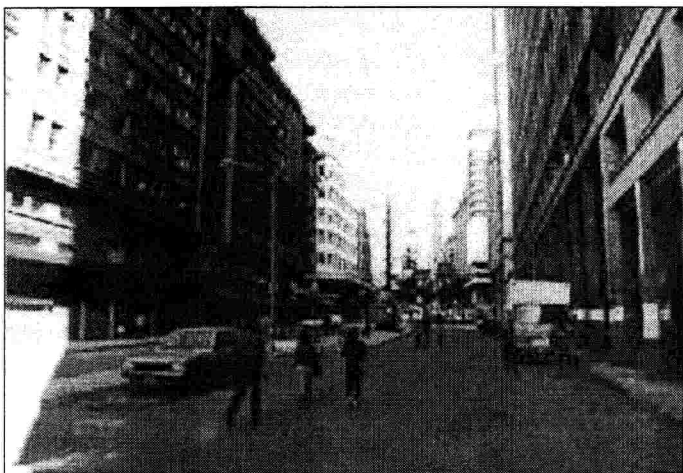


Fig. 1. Continuous façade (1959)

Rys. 1. Zabudowa ciągła (1959)



Fig. 2. Isolated buildings (1979)

Rys. 2. Budynki wolno stojące (1979)



Fig. 3. State Administrative Center, Porto Alegre

Rys. 3. Stanowe Centrum Administracji, Porto Alegre

Porto Alegre is actually a pathological growth in the height of the original city, with microclimatic areas from which have been practically excluded not only the wind, but also the winter solar radiation and thermal dispersion due to radiation and convection. The more recent part of the city answers to the modern principles proclaimed in the Athens Letter of 1933, but materialized on a land structure which makes its main characteristics unfeasible: "...elevate the constructions [...] implant them a great distance from each other...". In practice the modernistic city is a city exposed to the winds and the sun, facing all the existing climatic conditions only distorted (Fig. 3). Space which, from the ecothermal point of view, results in an inhospitable urban scenery!

SUN AND SHADE

In winter, in Porto Alegre, the shadows projected by the buildings over the other buildings and on the urban area predominate (Fig. 4), resulting from the little height of the sun during this season, making the free spaces, at ground level and in the shade of the higher buildings, colder and more humid than those outside of it. During the long hot (and always humid) period when the sun is high, the need for urban shade is felt. The proposal of densification made to revise the present Town Planning accentuates the unfavorable characteristics mentioned because the sun, in the subtropical winter, is low and high in summer. This behavior, so opportune in the

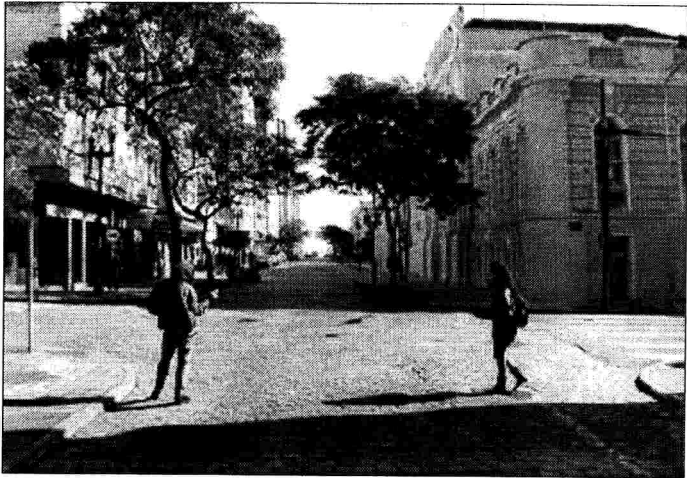


Fig. 4. Street in the downtown area of Porto Alegre

Rys. 4. Ulice w centrum Porto Alegre

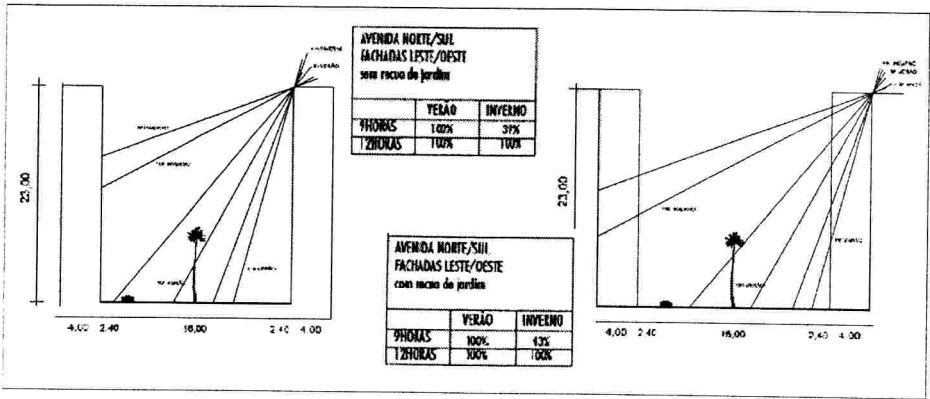


Fig. 5. Examples of insolation of the typical streets of Porto Alegre

Rys. 5. Przykłady insolacji na typowych ulicach Porto Alegre

relationship of the insolation of the façades, gives a totally inadequate result when dealing with an urban area: maximum in summer and minimum in winter, Fig. 5.

The insolation on the surfaces which make up a urban precinct in a subtropical region cannot be more unequal and variable. The shade, always present, is another of its principal characteristics. With the insolation simulated and the temperatures and relative humidity of the air measured

in the streets limited by high buildings, resulted from the combination of the past and present Town Planning, we can verify the following:

1st case: Narrow street with tall buildings, no vegetation (Fig. 6). Rua dos Andradas

– Building height: maximum above 90 m (Edifício Santa Cruz), average height is 30 m;

– Visible sky factor: 32% (Fig. 7);

– Obstruction angle: 93° maximum, 13 minimum;

– Shade: summer 0% (10 a.m. and 2 p.m.) and winter 95% (10 a.m. and 2 p.m.), with 45% of the façades with northern orientation in the shade at this time;

– Air temperature: summer: 3°C less than that of reference and in the winter: 5° less than that of reference;

– Relative air humidity: summer: +5% in the shade than the reference and in winter: +8% in the shade than the reference.

The small visible sky factor 32%, explains the 95% of shade in the horizontal surfaces and 45% in the vertical surfaces oriented to the north in winter, the lower temperature and higher humidity of the air and reduction in 95% of the natural illumination.



Fig. 6. View of da Praia St. (dos Andradas St.)

Rys. 6. Widok z ul. da Praia (ul. dos Andradas)

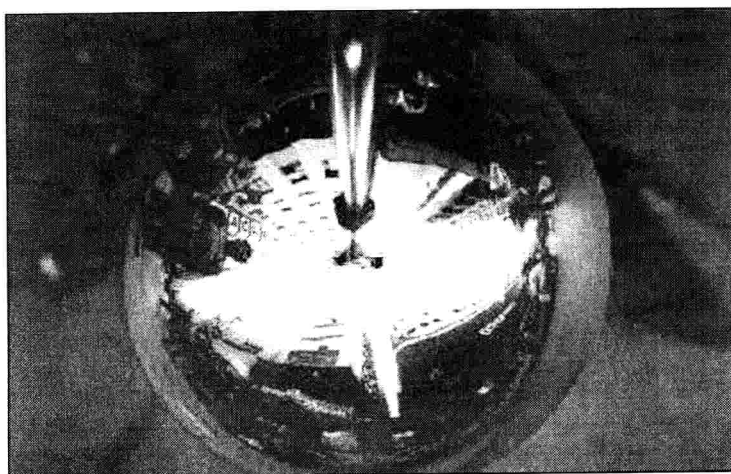


Fig. 7. Visible sky factor

Rys. 7. Współczynnik widzialności nieba

In the summer, the desirable shade does not exist on the northern façades from 10 a.m. when the height of the buildings is 8 stories, exposing the building to direct solar radiation, increasing the interior temperature of the building when the openings do not have shade factors and hold the heat in the opaque parts of the façades depending on the radiative properties and its color.

The shade of the northern façade increases with the height of the buildings in winter as is informed below:

- 8 stories 27% in the shade, 12 p.m. winter,
- 10 stories 43% in the shade, 12 p.m. winter,
- 12 stories 52% in the shade, 12 p.m. winter,
- 15 stories 65% in the shade, 12 p.m. winter.

The effect of the thermal island effect is accented, without obtaining a softening of the intense summer insolation. The Building Construction Code should legislate on the thermo-luminous characteristics of the insulated façades in summer conditions. There will be a larger energy consumption due to the artificial lighting necessary to do the visual jobs of each room in winter. The possibility of artificial heating, in areas with shade projected from the north façade as well as those with permanent shade of the southern façade should be taken into consideration in the estimate of energy consumption generated by the urban form, together with the energy consumption due to permanent artificial illumination of the southern façade. The urban densification proposal done to revise the actual Town Planning will accentuate the problems pointed out.

2nd case: Organized N-S Street (façades E-W – Fig. 8)

- Building height: maximum 23 m (8 stories), average 16 m (6 stories);
- Average size, discontinuous, irregular vegetation;
- Visible sky factor ψ : 87%;
- Obstruction angle: 45° maximum, 5° minimum.

SHADE

The shade of the façades in winter between 11 a.m. and 1 p.m. is the following:

- 8 stories: 40% in the shade, 80% of the street in the shade,
- 10 stories: 45% in the shade,
- 12 stories: 50% in the shade,
- 15 stories: 58% in the shade.



Fig. 8. Bento Martins St., Porto Alegre

Rys. 8. Ulica Bento Martins, Porto Alegre

In the summer the projected shade between the hours of 11 a.m. and 1 p.m. covers the sidewalk and 9% of the street as well as all of the Eastern façade during the morning and the Western façade in the afternoon with buildings 15 stories high (maximum height proposed for the new Town Planning). The continuous mass of high buildings from the beginning of the street projects long shade in the winter, only softened through the spaces between the buildings (empty lots and low buildings).

In winter, in the early afternoon, the temperature registered near the high buildings with a Western façade, in the sun, was 5°C higher than that informed by the 8th Meteorology District and 3°C higher than the average of the reference point. The minimum temperature was 4°C lower than that of the Meteorology Service. The relative humidity of the air was 67%, 9% greater than the 8th Meteorology District and 1% less than the reference. The increase of 5°C in the temperature in the sun showed the quick heating of the area due to the greater visible sky factor in the sunny areas. The accentuated difference of 10°C between the sunny and shady zones is also a consequence of the greater visible sky factor and shows the importance of the insolation on the temperature of the street and the thermal loss (the East façade, insulated in the morning had quickly cooled down).

Then, we verified that the insolation has a decisive effect on the air temperature in the urban area and consequently on its relative humidity.

The degree of insolation on the surfaces of an urban precinct has a great variability and defines specific rules of thermo-accumulation.

The recommendations to be made become complicated because of the quantity of circumstances to be taken into account in each morphological situation of the urban area and in each moment, resulting in a very random theoretical proposal because of the unpredictable effect of the cloudy characteristics of humid climates.

Apparently we lose the possibility of guaranteeing sunny urban areas with correct sun, possibly due to the nature of the problem itself, which makes the ideal solution difficult for the local climate. We show the difficulties of the theme and accept the relative significance of urban insolation in subtropical regions in the set of problems to be solved.

The "opaque" shade produced by the projection of shadows of the buildings is the main factor of the decrease in illuminance in the urban areas. The vegetation presents variable values of shade as a consequence of the modification of the form of the crown of the tree and the density of leaves during the year. While the decrease in natural illuminance is 90% because of the "opaque" shade projected by the buildings, what results from the vegetation varies from 96% in summer to 60% in winter, according to the species and grouping of the trees. We verify then, that the vegetation, so adequate from the thermal point of view for the subtropical urban areas, significantly reduces the natural illuminance. This reduction also influences the artificial public illumination of the city, reducing its efficiency; on the other hand, the public electric system creates problems to the vegetation, deteriorating it. This theme deserves to be studied in order to organize not only the constructed area but also the turbulent urban underground area.

Concluding, the increase of the density reduces the illuminance of the urban area, principally in the equinoxes and in winter. The greatest reduction is of 89% in winter, while in summer it is 60%. The more open urban fabrics obviously allow for a better illumination in exterior spaces and internal areas. But, the density has different formats and this cannot be ignored when one considers its evolution. High densities in open spaces, considered modernistic (where the fabric is much more open) reduce the daylighting in an insignificant way, creating problems (excessive exposition to sun radiation) for the openings of the buildings, reducing (in another way) the illumination of its rooms. In the traditional city, the closed fabrics created problems difficult to be solved, because the environmental question is not considered in the standards and technical regulations that control the growth particularly in height.

DAYLIGHTING

The exterior space is defined with only two planes: ground and wall (important daylighting). It is roofless architecture; different from the totally closed space. This is the main difference from the point of view of daylighting. It uses natural and artificial materials that are adequate to (or should be adequated to) the local climate. Its design should also occur at the same time as that of the interior space, so that they can be compatible and complementary, reversible and not just subproducts.

URBAN PROFILES

One of the criteria proposed in the revision of the present is that of adopting a continuous and uniform profile for the organizing streets of the city. However, we verified in the "in situ" conditions that the homogeneous profiles are not favorable for taking the best advantage of the available daylight, especially when the distance between the façades of the buildings that limit the street is less than the height, presenting values approximately 50% smaller than those obtained in sequences of heterogeneous profiles favored by the greater number of situations of unobstruction of the sky, resulting from the difference of height or lateral distance between the buildings. The spaces between the buildings have better use in winter because of the angle of incidence of the sun, which allows it to reach the façades for a longer period and take better advantage of its reflectance. The intersections of the streets work in the reverse manner, without the advantage of the insolation of the façades. It is important.

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STRESZCZENIE

W pracy zbadano warunki naturalnego nasłonecznienia, oświetlenia i przewietrzania w Porto Alegre.

Analizy warunków nasłonecznienia dokonano za pomocą symulacji komputerowej dla różnych typów ulic w warunkach zimowych i letnich. Oświetlenie światłem dziennym analizowano na podstawie badań prowadzonych w ciągu całego roku: suchych i zazielenionych placów, wąskich i szerokich ulic o orientacji N-S i E-W, jednorodnego i różnorodnego profilu. Naturalne przewietrzanie badano w tunelu aerodynamicznym, symulując działanie wiatru na trzy morfologicznie odmienne bloki urbanistyczne.

Wyniki uzyskane w każdym z częściowych badań porównano i sformułowano zalecenia o charakterze normatywnym.