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Green corridors: Effect of tree shading on the surface temperature of pavements in Passo Fundo, RS

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ABSTRACT
This article presents a study on the performance of vegetation shading on the surface temperature of sidewalks in an area chosen to study the possibility of implementing a green corridor in the city of Passo Fundo, RS. The area is in the highly urbanized center of the city with the presence of medium-sized vegetation on the public promenade. Part of the pavements analyzed is exposed to direct solar radiation and part to the shade of trees, to be able to estimate the reduction of their surface temperature and, consequently, the thermal contribution to the ambience of the humid subtropical urban area. The method used was mathematical simulation accompanied by verification measurements. Through the visible sky factor of the urban area, the possibility of implementing a green corridor with trees is determined. The results indicate that only when the visible factor is equal to or greater than 45º does it offer adequate conditions to receive medium and large vegetation, as is the case of the streets of Passo Fundo. RS. They also report the problem of tree shading in the winter of the humid subtropical region.

Keywords: Green corridors, Urban enclosure, Surface temperature.

1 INTRODUCTION

According to Frischenbruder and Pellegrino (2006), green corridors are considered linear open spaces that perform several ecological functions, such as the connection between vegetation fragments, the protection of water bodies, the conservation of biodiversity, the possibility of managing rainwater, in addition to promoting multiple uses by the population, such as recreation, transportation and promoting social cohesion.

Green aisles can enable multiple simultaneous uses and functions in a small space. They can be planned, designed and managed in such a way as to take advantage of their biophysical conditions for human activities and generate economic benefits. They can also offer an opportunity to establish and maintain a daily relationship between man and nature, which makes it possible to educate a greater number of people on the environment. It is based on this criterion that research on possible green corridors in Passo Fundo, RS, is being carried out.

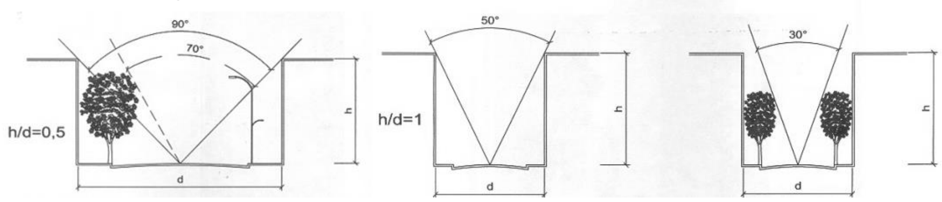
The projected shadow, always present, is a characteristic of urban enclosures. The simultaneous presence of sun and shade is one of the fundamental causes of the local breezes generated in them. An efficient resource against heat is the use of vegetation, which, in addition to providing shade, allows the passage of local breezes and effectively absorbs long-wave radiation through foliage refreshed by evapotranspiration. Along with transpiration cooling, tree shade can help cool the local environment by preventing solar heating of some artificial surfaces that are underneath the tree cover (e.g., pavements), and these effects can reduce air temperature by up to 5ºC (AKBARI et al., 1997).

2 THE GREEN CORRIDOR AND THE URBAN ENCLOSURE

An important aspect of the urban enclosure is its three-dimensional character, which not only includes the pavement and sidewalk as surfaces, but also the buildings that delimit them. The pavement is a more or less thin layer of durable material that covers the most powerful and natural element of every urban scene: the earth. In itself, it is austere, it has the quality of producing a sense of expansion and extension. The feeling of depth or grandeur is linked to the soil, to the terrain that is covered and on which the urban space is built.

The dissipation of long-wave radiation depends on the visible sky factor of the urban area (figure 1). The higher the h/d ratio of the enclosure (the lower the value of the sky viewing angle), the lower the value of the visible sky factor and the lower the dissipation of this radiation, reducing air cooling.

Figure 1 – Visible Sky Factor of Different Types of Streets



Source: MASCARO, MASCARO, 2009

When the street has large trees whose height equals that of the buildings, the shading of the vegetation is more significant, reducing the importance of the effects of the geometry and orientation of the urban enclosure for sky viewing angles of up to 45º, reducing the asymmetry of the shadows resulting from the orientation of the street axis. In this case, the thermal contribution of the pavements to the urban environment is small. When the visible sky factor is equal to or greater than 45º and the road has no vegetation, the paved surfaces heated by the intense solar radiation, typical of the hot season, contribute significantly to the unfavorable thermal performance of the humid subtropical urban area. The h/d ratio depends on the possibility of transforming an urban enclosure into an environmentally efficient green corridor, provided that only when the visible sky factor is equal to or greater than 45º does it offer conditions to implement medium and large vegetation, as in the case of the streets of Passo Fundo. RS

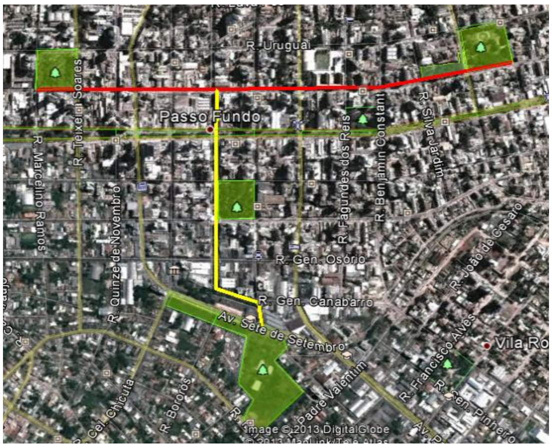
3 CASE STUDY

3.1 THE SITE

The case study was carried out in the city of Passo Fundo, RS, Brazil. The climate is humid (temperate) mesothermal, of the humid subtropical type, with cool winters and hot summers and a rainfall regime distributed throughout the year.

The delimited sections, in addition to having the role of green connectors, have historical importance for the city center. Delimiting, the research was carried out in section 1, which corresponds to the region of Paissandu Street (in red, in Figure 2). And section 2 corresponds to General Netto Street, with a perpendicular connection to Paissandu Street (in yellow, in Figure 2). Both stretches are structurally consolidated: they have built-up lots, high population density, presence in the majority of mixed occupational use (commercial and residential) and different situations of urban vegetation and vehicular traffic.

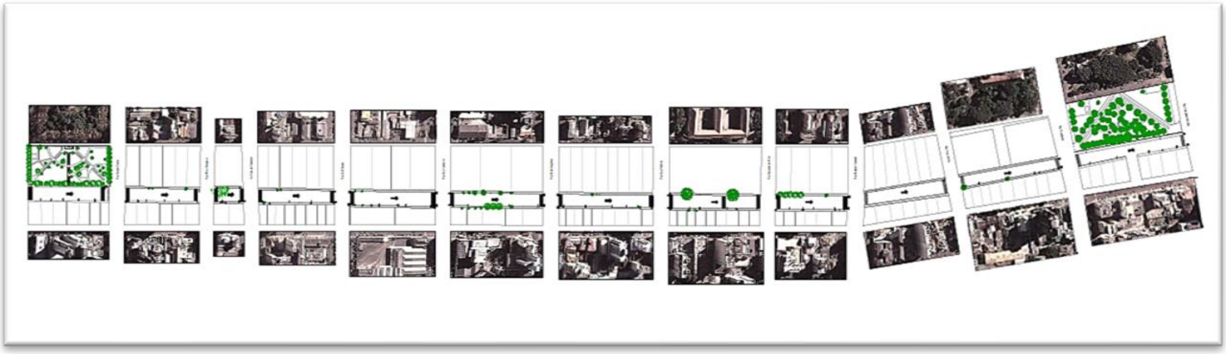
Figure 2 – Location of the squares and stretches surveyed, located in the Center. Legend: red: Section 1 (R. Paissandu); yellow: Excerpt 2 (R. Gal. Netto)



Source: Google Earth, 2013. Edited by the authors.

The urban area chosen to carry out the mathematical simulation of surface temperature was section 1 (Figure 3) corresponding to the Paissandu Street corridor, which has mostly buildings without garden setbacks, with buildings of size ranging from one to twenty floors. The trees found on the street are small, varying in species and size.

Figure 3 – Section 1 – Paissandu Street (East-West direction)



Source: Authors

In this enclosure, an area paved with asphalt shaded by vegetation was chosen (figure 4a), an area paved with concrete (figure 4b) and another grassy (figure 4c) were chosen, all with one part exposed to the sun and the other part exposed to shade.

Figure 4 (a,b,c) – Asphalt pavement (a); Concrete Pavement (b); Lawn (c)

Source: Authors

4 METHODS

The methods used were the mathematical simulation of the surface temperature of the three types of pavements chosen for the study and of the lawn for one week in February at 2 pm. The calculation method used was the one adopted by Rivero (1985). The measurement of the values obtained in the calculation was performed using a T-FA Thermohygrometer and a TD-750 ICEL Digital Surface Thermometer with Type K Thermocouple Sensor (NiCr-NiAl) on the same date and time of the simulation. Temperature and relative humidity were measured at 1 m on the analyzed surfaces; As calculation data and references for comparison with the measurements carried out in loco, the maximum air temperature and relative humidity reported by the Meteorological Service of EMBRAPA – National Wheat Center, Station 83914 Passo Fundo, RS, for the week of 02/14 to 02/22/17, especially the 17th, were used, as it was the hottest of the period.

5 RESULT AND DISCUSSION

Surface temperature of pavements.

Table 1 shows the results obtained for each situation studied.

Table 1 - Calculated surface temperature of paved and grassed surfaces

FLOORING TYPE	SURFACE TEMPERATURE (°C)		
	SUN	SHADOW	DIFFERENCE
Asphalt pavement	2	41	9
Concrete pavement	6	36	10
Lawn	4	20	14

Source: The Authors

It was possible to confirm the better behavior of the vegetal surface in relation to the inert surfaces, and the lawn in the sun presented a lower temperature than that of the concrete in the shade. The influence of vegetation shade on the surface temperature of pavements exposed to summer solar radiation and on the shade of dense canopy trees (sibipiruna, for example) was significant, between 9°C and 10ºC; when the canopy was less dense (rosewood, for example), this difference was of the order of 5ºC.

Table 2 contains results reported by other authors consulted.

Table 2 - Surface temperature of pavements and lawn informed by the bibliography consulted.

FLOORING TYPE	Dominguez		Laurie		Rivero	
	SUN	SHADOW	SUN	SHADOW	SUN	SHADOW
Asphalt	58	41	50	-	50	-
Concrete	55	37	47	37	-	38
Gramado	33	24	35	17	35	16

Source: The Authors
Note.:
Latitude: Dominguez - 40ºN
Laurie - 40ºN
Rivero - 40ºN

Both in the results obtained in the mathematical calculation and in the on-site measurement, it was possible to confirm the better thermal behavior of the plant surface in relation to the inert surfaces, and even the lawn in the sun presented a lower temperature than that of the concrete in the shade.

The shading of the building was only significant when the visible sky factor was small, in the order of 30º, (h/d=2), a situation not yet verified in the case of the city of Passo Fundo, RS. The combination of both types of shading was efficient for the h/d ratio equal to or greater than 45º, especially for sidewalks and parking areas next to the curb of residential streets, where the presence of heavy vehicles is occasional.

Taking into account that the local climate has a cool winter, it is necessary to take care of the insolation of the cold months in the green corridor to be proposed. The urban vegetation interferes with the thermoluminous performance of the urban enclosure and its buildings oriented to the north, east and west. Deciduous trees, in winter, present obstructions of sunlight and natural light that vary between 5% and 65% depending on the tree species, and those that block solar radiation up to 20% are considered suitable for latitude 28ºS; It is important to consider this effect when choosing vegetation for the green corridor. In summer, the light transmittance in most species varies between 5% and 10%, a reduction. Temperature and relative humidity: dense foliage causes differences of more than 5ºC between the temperature in the sun and the temperature under the tree, which is unfavorable in winter conditions.

6 CONCLUSION

It was possible to confirm the better behavior of the vegetal surface in relation to the inert surfaces, and the lawn in the sun presented a lower temperature than that of the concrete in the shade. The shading of the building was only significant when the visible sky factor was small, in the order of 30º, (h/d=2), a situation not yet verified in the case of the city of Passo Fundo.

The analyzed studies confirm the results obtained in this work, showing that a shaded green corridor can reconcile the user's comfort and the improvement of environmental conditions, especially with regard to the environmental and landscape quality of the humid subtropical urban area.

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