The impact of tall buildings on the solar access of the immediate surroundings.

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Abstract. The text addresses the theme of verticalization in coastal cities, with a special focus on the city of Laguna, Santa Catarina, Brazil. Verticalization is a phenomenon where tall buildings are being constructed along the coastline, driven by population growth, tourism, and the demand for vacation residences. The text highlights the importance of considering solar access as a critical factor in the analysis of buildings and urban planning due to its impacts on quality of life, urban microclimate, and energy efficiency. It also mentions the need to revise the master plans of coastal cities to balance economic development with environmental preservation and community quality of life. The study concludes that uncontrolled verticalization affects building insolation and can cause urban problems, emphasizing the importance of regulatory measures for sustainable and high-quality urban development.

Keywords. Parametric analysis, solar access, verticalization of cities.

1. Introduction

Laguna is a coastal city located in the southern state of Santa Catarina, Brazil. Its territory consists of 20 beaches, with beautiful landscapes that attract tourists, especially during the months of December to March for vacationing. It is commonly estimated that the influx of vacationers doubles the city's population. The significant concentration of these tourists occurs in Mar Grosso, one of the city's neighborhoods, marking a migratory phenomenon in search of sun and sea.

Observing this change in morphology underscores the importance of the Neighborhood Impact Study (EIV), which emerges as an essential tool aimed at assessing the effects, both positive and negative, of urban developments on the quality of life of the resident population in the surrounding areas (REF). Within the wide range of factors addressed by legislation, lighting is a central aspect, with solar access gaining prominence as a right.

The debate about solar access becomes pressing as the continuous process of urbanization significantly transforms urban landscapes, giving rise to tall buildings. As our cities experience increasing population density and vertical growth, crucial questions emerge that directly impact the residents' quality of life

Within the scope of the Neighborhood Impact Study (EIV), solar access emerges as a critical factor. This concept refers to the ability of buildings and public spaces to receive direct sunlight throughout the day. It is an essential consideration for evaluating the environmental impacts and quality of life associated with urban developments or construction projects in an urban area. Solar access affects the urban microclimate, influencing temperature, ventilation, and thermal comfort in the neighborhood. Moreover, it plays a crucial role in quality of life by providing health benefits and reducing the need for artificial lighting during the day. It is also linked to energy efficiency, as well-lit buildings by sunlight can save energy. Furthermore, adequate solar access is essential for urban vegetation, impacting the growth of trees and plants. Therefore, responsible urban planning considers solar access when establishing regulations for building height and density, as well as when designing public spaces, aiming to create healthier and more sustainable urban environments.

Expanding the depth of the debate, the occupation of coastal cities has seen a growing trend of verticalization due to population growth, tourism, and the demand for vacation homes and apartments. This verticalization involves the construction of tall buildings to accommodate the continuously growing population and tourists seeking coastal attractions. However, this trend also presents environmental challenges, such as coastal erosion, in addition to impacting the local economy and urban infrastructure, emphasizing the importance of sustainable urban planning to balance economic development with environmental preservation and the quality of life of coastal communities.

Verticalization in cities like Balneário Camboriú, Rio de Janeiro, Recife, and Florianópolis is a notable phenomenon that stands out in the urban landscape of coastal cities. These cities are mostly known for their beaches and natural landscapes, making them popular tourist destinations and attracting real estate investors. The construction of buildings along the Brazilian coastline is understood as a strategy to enhance the real estate market, often driven by status and a symbol of modernity.

This verticalization phenomenon primarily manifests in the form of skyscrapers, luxury condominiums, and tall residential buildings along the coastline, as the demand for vacation homes and beachfront residences catalyzes this trend.

However, in the cases mentioned, verticalization is also a reflection of some flexibility in discussions regarding Master Plans, which, in an attempt to meet the demands of the local real estate and investment market, tend to overlook the construction of a landscape with parameters of comfort and urbanity.

Based on what has been presented, the objective of this study is to deepen the analysis of the interaction between climatic phenomena and a prominent newly constructed building in the urban landscape and its immediate surroundings. Our primary focus is on the impact on solar access. To achieve this goal, parametric tools were used for conducting bioclimatic analyses. The resulting analysis, stemming from the review of Master Plans, aims to provide a qualitative foundation for the sustainable development of the city, seeking to align development with the quality of life in coastal cities.

2. Research Methods

2.1 Case study

The city of Laguna, located on the coast of Santa Catarina and situated 110 km from the state capital, Florianópolis, stands out for its breathtaking landscapes that attract tourists. Like many other coastal cities, Laguna experiences significant population growth, which can double during the summer season. This sudden increase in visitors generates a high demand in the real estate market and strains the city's urban infrastructure. Mar Grosso neighborhood, characterized by the beach of the same name and hosting the city's main events, is the primary attraction for vacationers. Over the years, Mar Grosso has become the most verticalized neighborhood in the city and has gained the characteristic of being the second residence for people living in Laguna and nearby cities. This phenomenon has created a dynamic where the city requires significant infrastructure to accommodate these people during the summer and experiences a decline in population during the rest of the year.

Given this scenario of growth and verticalization in the Mar Grosso neighborhood, the importance of revising the city of Laguna's master plan is evident. This revision is necessary to ensure sustainable urban development that can meet both the seasonal demands generated by tourism and the needs of the resident population throughout the year. The analysis of buildings, as the highlighted object of study, becomes a crucial point in this process, as it helps understand how local climatic conditions should be considered in construction and urban planning.

The object of study represents the pinnacle of the neighborhood's recent verticalization and stands out for its location on the main avenue and as a focal point of the neighborhood. Its function is to be a high-standard residential building with apartments ranging from 153 m2 to 216 m2 of private area. It features a commercial ground floor elevated 1 meter above street level and three common area parking levels, followed by 13 floors of housing with eight apartments per floor, totaling 17 floors. This information was extracted from real estate websites and site visits, as technical drawings and documents were not accessible.

When initiating the analysis of the object of study, the first step was to examine information related to the macroclimate in which the construction is located. To achieve this, climate data for Laguna were collected. The city experiences dry bulb temperatures ranging from 14°C to 26°C throughout the year, with a notably high relative humidity, averaging above 80%. Additionally, there is a significant incidence of solar radiation, particularly during the summer. The presence of strong winds, mainly from the northeast and southwest, with average speeds of 20 km/h, is also recurrent. Given this climatic context, it becomes imperative to emphasize the vital importance of insolation as a fundamental factor in mitigating challenges associated with internal moisture in the constructed structures.

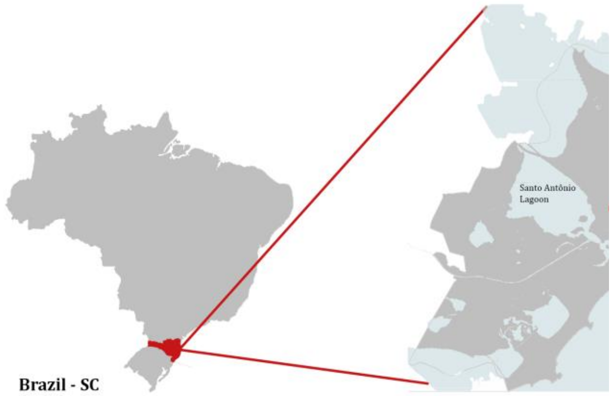

Fig. 1 – Location

2.2 Ferramentas de análise

Through the cadastral map of the city, an inventory of building heights was conducted. Using this data, a three-dimensional model was created in the Rhinoceros software, integrated with Grasshopper.

The integration of the Ladybug plugin, in conjunction with Grasshopper, has proven to be a valuable tool in revising master plans and improving urban management. This combination allows for a comprehensive analysis of urban conditions, encompassing environmental and climatic factors, making it more accessible to understand the built environment. Ongoing evaluation plays a critical role in ensuring that decisions yield the desired effects and can be adapted to changes in urban and demographic conditions. In summary, this tool demonstrates significant potential for enhancing urban management based on data-driven foundations.

This analysis was supported by simulations carried out through parametric tools, which allowed considering the influence of surrounding elements, such as topography and adjacent buildings, as well as geographical position. This enables the performance of climate simulations to calculate solar incidence on specific surfaces and at different times of the year. Moreover, it is feasible to conceive an analysis that illustrates the vectors of solar rays and their interactions with the model, providing an enhanced visual understanding of solar ray incidence.

The component uses a weather file obtained through a component called "import EPW," responsible for importing relevant data for each analysis. Santa Marta's files, the closest to the municipality in question, provided by the National Institute of Meteorology (INMET), were used for the graphical analyses. The "DirectSunHours" component was used for these analyses, which, based on each hour of sunlight throughout the year, projects, in the form of a color scale on selected surfaces, the amount of sunlight received during the specified period.

The accuracy of the generated graph is controlled by the "grid_size" parameter, which determines the subdivision of the analysis surfaces. Processing speed is proportional to the grid size, with larger sizes representing fewer surfaces, making the analysis faster. For these studies, a grid of 0.5m was used to obtain the results.

The careful selection of these metrics is due to their proven effectiveness in the analysis of simple geometries, streamlining data processing. This approach is particularly advantageous for preliminary studies, expediting the analysis and providing precise answers to essential questions related to the built environment.

However, it is important to note that more comprehensive and detailed analyses, taking into account a wide range of additional parameters, should also be conducted in subsequent project phases. These broader analyses may include elements such as reflection, absorption, color, and other factors that influence the interaction between the built environment and environmental conditions, ensuring a more holistic and refined understanding of the urban scenario in question.

3. Results and discussion

3.1 Modificações na paisagem

When observing the skyline of the surveyed region, three different periods of urbanization in the neighborhood can be distinguished. The first period featured low-rise structures, consisting of 4 or 5-story buildings and single-story houses, with a concentration of buildings and consequently higher density closer to the waterfront. Subsequently, buildings with up to 10 stories emerged, situated farther from the beach. Finally, the recent trend in the past few years has seen the development of buildings with up to 10 stories near the waterfront and buildings reaching up to 20 stories (Fig2).

Considering the environmental perception of pedestrians and city users, it is important to take into account the issue of building height being linked to the proportions and scales of the urban environment, especially concerning the field of vision, the amount of sky visibility, among other factors. Since the walkway that allows for this visual connection often generates feelings of security, tranquility, and clarity. On the other hand, a walkway that compromises the visual axis of the sky, obstructing it in some way, tends to convey a sense of insecurity and apathy.

Fig. 2 - Skyline.

4. Análise solar

The influence of the building on its surroundings (Figure 3) is evidenced by the projection of shadows that even affect the beach area. The large number of affected buildings is directly related to the height and robustness of the building in question. Within the 250-meter analysis area, various regions experience shading impacts to varying degrees, including the beach sandstrip.

The need for sunlight exposure becomes even more crucial due to comfort conditions throughout the year. About 51% of the year is characterized by discomfort caused by cold in the winter, while 29% is marked by discomfort due to heat in the summer(5). This highlights the importance of access to sunlight, particularly during the winter months, to improve comfort conditions.

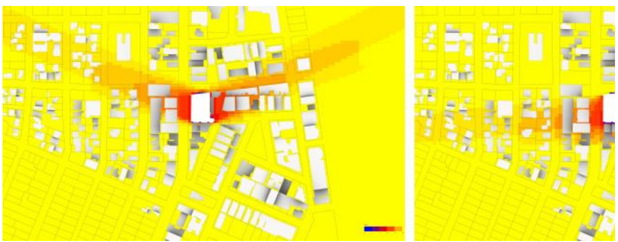

Fig. 3 - Analysis of the building's shadow caused during the solstices and equinoxes.

There is a significant decrease in the number of hours of sunlight on the facades of the buildings that make up the immediate surroundings (FIG 4). Some buildings experienced a reduction of more than 50% in the hours of sunlight they receive throughout the year.

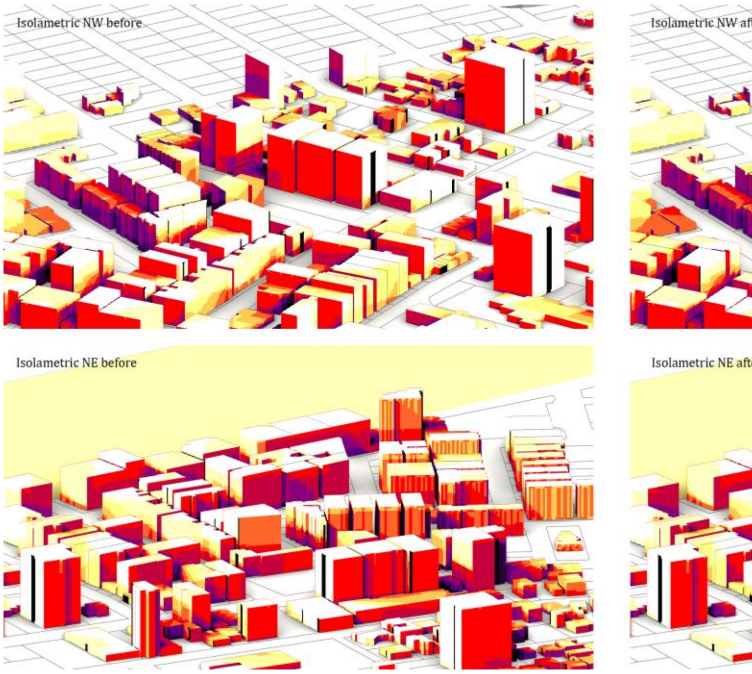

Fig.4 - Analysis with and without the study object of shading on surrounding buildings.

In addition to the impact on insolation analyzed in this study, it is important to highlight that uncontrolled verticalization can lead to other impacts such as strain on infrastructure services, traffic congestion, and loss of urban identity. Therefore, the regulation of vertical growth in Laguna should be carefully considered in the process of revising the master plan.

Since it is not possible to effectively measure the hours of sunlight penetrating the environment, it remains important for buildings to receive direct sunlight, even on blind facades.

5. Concluison

This study has demonstrated that the sudden and uncontrolled increase in building height in Laguna has a significant impact on insolation, potentially affecting the thermal comfort and lighting of the surrounding areas. Furthermore, we emphasize that verticalization without regulatory parameters can trigger a series of other urban problems. Therefore, it is crucial for the city to consider regulatory measures in the process of revising the master plan to ensure sustainable and high-quality urban development.

Our results have revealed that verticalization without prior studies in Laguna has significant impacts on building insolation within a radius of 250 meters and, by extension, on the thermal comfort and lighting of the surrounding areas. This can have direct consequences on the microclimate of the region and the quality of life of the city's inhabitants.

6. References

1. Rhino - Rhinoceros 3D [Internet]. [cited 2023 Sep 26]. Available from: https://www.rhino3d.com/
2. Ladybug Tools | Home Page [Internet]. [cited 2023 Sep 26]. Available from: https://www.ladybug.tools/
3. EPW Map [Internet]. [cited 2023 Sep 26]. Available from: https://www.ladybug.tools/epwmap/