Traditional Architecture as a Typological Basis for Ecological and Sustainable Architectural Design from a Climatic Perspective. The Colonial Houses of the Central Valley; Santiago, Chile.

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Abstract. The present study aims to explore the Colonial House in the central valley of Chile, as a typological basis for an ecological and sustainable architectural design, mainly in relation to passive climate conditioning strategies, thinking about the minimization of external agents that take care of this. The city of Santiago is selected as a case study because it is a highly urbanized area, implying constant challenges about sustainable urban development. Regarding the object, these are traditional constructions with local materials and vernacular techniques, therefore they are related to the material heritage of the area and present proven climatic strategies that can be extrapolated to establish them within a contemporary context. The methodology is carried out through a constructive analysis of a typical house to understand the decisions taken and how they influence the habitability of the building. This will be complemented with the study of secondary sources and the comparison with contemporary examples to explore the application of the referenced strategies. It is concluded that traditional typologies allow the development of new proposals associated with sustainable logics due to the constructive and climatic understandings that vernacular notions imply.

1. Introduction

The central valley has been recognized as the foundational territory of Chile. This is the place where the original customs of the country's identity were born. This territory is composed of the Paine Narrows and the Bio-Bio River, in the north-south direction, and by the Andes Mountain Range and the Coastal Mountain Range, in the east-west direction [1].

In the central valley is the city of Santiago, the capital of Chile, which was founded by Spanish conquistadors. Over the years, cultural miscegenation gave rise to a typical architecture of the nineteenth century, which although of Hispanic origin, began to adapt to the local environment, generating the colonial architecture of the time. Three main types of buildings stand out for their purpose: agricultural, religious and housing [2].

Among the dwellings, the colonial houses stand out. In Santiago, they were of the courtyard type, that is, their floor plan was organized through the simple addition of successive rooms with galleries
around open spaces [3]. In social terms, the situation of war against the aboriginal people, added to the importance of protecting the family, structured the fortified quality of the Chilean patriarchal dwelling, where the interior patios took on a fundamental role both socially and in the practical functioning of the dwelling [4]. In addition, the patios that extended from the street to the interior of the block had different roles and privacy [5].

2. Theoretical framework

The theoretical framework of this study focuses on vernacular architecture, sustainability and colonial houses.

Vernacular architecture is understood as the architecture of a place, created by a specific community, based on their knowledge of the physical and cultural environment [6].

In its essence, vernacular architecture is sustainable because it is born as a manifestation of the relationship of the place with its micro-climatic environment, it develops appropriate responses with adapted construction techniques and materials that contribute cultural traits specific to each region. [7] In environmental terms, vernacular architecture is sustainable because it is a manifestation of the relationship of the place with its micro-climate environment.

In environmental terms, vernacular architecture is considered an example of sustainability [8], since through its location, orientation and architectural configuration, it takes advantage of lighting, sunlight and ventilation to carry out technological solutions that regulate temperature with minimum energy expenditure and cost.

Originally, the colonial houses come from the Aragonese house, which was a three-story house with a very small central courtyard in order to reduce the impact of the sun, however, since Chile is a telluric country, the Chilean adaptation is extended on a single floor with a larger central courtyard [9]. From this, it is possible to observe that the architectural expression of colonial dwellings was intimately related to the place, its climate and geography [10] where they were located. They reflected the way of life of the country people.

Therefore, colonial houses were the product of the ways of life, closely related to the customs, material and economic resources available, together with the constructive technical knowledge acquired up to that time [3].

The various manifestations of Chilean vernacular architecture coexisted until the advent of the industrialization process at the end of the 19th century, after which this heritage slowly began to disappear [6]. This was mainly due to the rapid urbanization of Santiago [11], in addition to the lack of urban planning that was linked to the buildings and the lack of visibility of their cultural significance.

3. Methodology

In order to propose the constructive strategies and sustainable logics of colonial houses as a typology applicable to contemporary designs, the study follows two lines of research. First, a study of secondary sources associated with the case was carried out, seeking to characterize it from historical, social and patrimonial perspectives, in order to establish its role as an object of study. This first step was also used as a link with the second line of research.

Secondly, a constructive analysis of this type of building was carried out, considering the main operations that configure colonial houses. This exercise allowed us to recognize the motivations behind the decisions taken, both structural and material, in order to propose them as climate control strategies with respect to the environmental conditions of the site. This will also be complemented with specific climatic studies through the use of computer software.

Both operations gave way to the consolidation of the design of the colonial houses as a sustainable construction typology thinking about the passive climate control of the building.

4. Results

Given the Spanish influence resulting from the process of conquest and colony that characterized not only Chile, but also most part of South America from the 15th to the 17th century, it is possible to find clear links between the local architecture of the time with European examples [12]. In this sense, the
Chilean colonial house is presented as a clear example of this, showing clear similarities with the rural architecture of Andalusia, in Spain [13].

This type of construction spread throughout the central valley of the country [13], diversifying its construction itself into rural, urban [14], higher income or lower income versions, but always with a base volumetry associated with the courtyard house. In this sense, we are facing a heritage construction, which can be associated with the vernacular of the area. The latter, in relation to the adaptation of a European construction model to the environmental, social and local conditions [14].

The Chilean colonial house (figure 1) is characterized by being built mainly in adobe, wood and clay tiles [13], with occasional applications of stone and brick in some cases, generally associated with the importance of the building or the purchasing power of the builders [14]. Structurally, it was configured around a central courtyard rich in vegetation, surrounded by corridors that led to the interior enclosures built with thick adobe walls that were separated from the ground by stone foundations. The roof structure was built of wood, which supported the clay tiles that made up the exterior cladding. In case a second floor was built, the division with the first floor was also built in wood [13]. In more urban contexts, the patios could increase up to three, depending on the extension of the property, but the general configuration is maintained [14]. It should be noted that in addition to the material restrictions that adobe implies for building in height, colonial houses do not exceed two stories given the fear associated with recurrent seismic activity in Chile [14].

![Figure 1. Constructive-climate analysis colonial house of Santiago. Own Elaboration.](image)

While these decisions were largely subject to the availability of materials at the time and in the area, they also went hand in hand with the environmental understanding of Chile's central valley. Thus, the configuration around a courtyard allowed both the ventilation of the enclosures and evaporative cooling given the vegetation. In addition, the shaded corridors maintained low temperatures in the warmer months and allowed the sun to pass through in the winter months. While the stone foundations prevented the passage of moisture into the adobe walls, the adobe walls maintained thermal comfort due to the thermal inertia of the material, absorbing heat during the day and releasing it at night. Thus, the need for external agents was reduced at the time of air conditioning the house [13].

Starting with the second line of research, about the thermal and relative humidity analysis (figure 2), we can say that the Santiago region has temperatures ranging from -0.2°C in winter to 35°C in summer. Relative humidity rises to 100% in winter and drops to 10% in summer.
Figure 2. Thermal and humidity analysis in a year, city of Santiago. http://andrewmarsh.com/software/data-view2d-web/

For these values, the Givoni climate diagram is used, which introduces as a variable the effect of the building itself on the internal environment, proposing passive qualification actions to adapt the environment to a comfortable situation according to thermal and relative humidity values. According to this table (figure 3), in the case of the climate of Santiago, the passive techniques to be used in most of the year are those of internal gain, referring to those generated by the activity of the occupants as metabolic heat, by the use of electrical devices or by thermal emission of artificial lighting [15]. Between 13 and 8°C the passive heating as a passive qualification measure is functional, entering the scene the materiality and spatial arrangement of the house materials, such as adobe and wood. When temperatures drop below 8°C, in the winter, more aggressive qualification measures such as passive solar heating and active solar heating must be used. It may even be necessary to use artificial heating for a few days of the year.

Figure 3. Psychrometric Analysis of Santiago climate, Givoni Chart. http://andrewmarsh.com/software/psychro-chart-web/
5. Conclusion
From the constructive analysis together with the climatic analysis, it can be said that the materiality of the houses in Santiago contributes to the consolidation of a comfortable environment during most of the year, since it works as a passive qualification measure to temper the environment, meaning an energetic contribution by saving in active qualification measures. However, when temperatures drop below 8 degrees Celsius, mainly in the coldest winter months, it is necessary to apply more aggressive qualification measures such as active solar heating and artificial heating.

With this information we can say that the constructive, spatial and material logics of the colonial mansions of the central valley of Chile and in particular with the climate of Santiago, respond to its climate as measures of passive qualification, contributing in saving energy costs and functioning as a set of recoverable techniques for a sustainable development in construction.

6. References
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