6th International
Conference on
Sustainable
Energy
Technologies

SET07

6th INTERNATIONAL CONFERENCE ON SUSTAINABLE ENERGY TECHNOLOGIES

CAMPUS LO CONTADOR I SANTIAGO DE CHILE I 5-7 SEPTEMEBER I 2007 I

TOPICS

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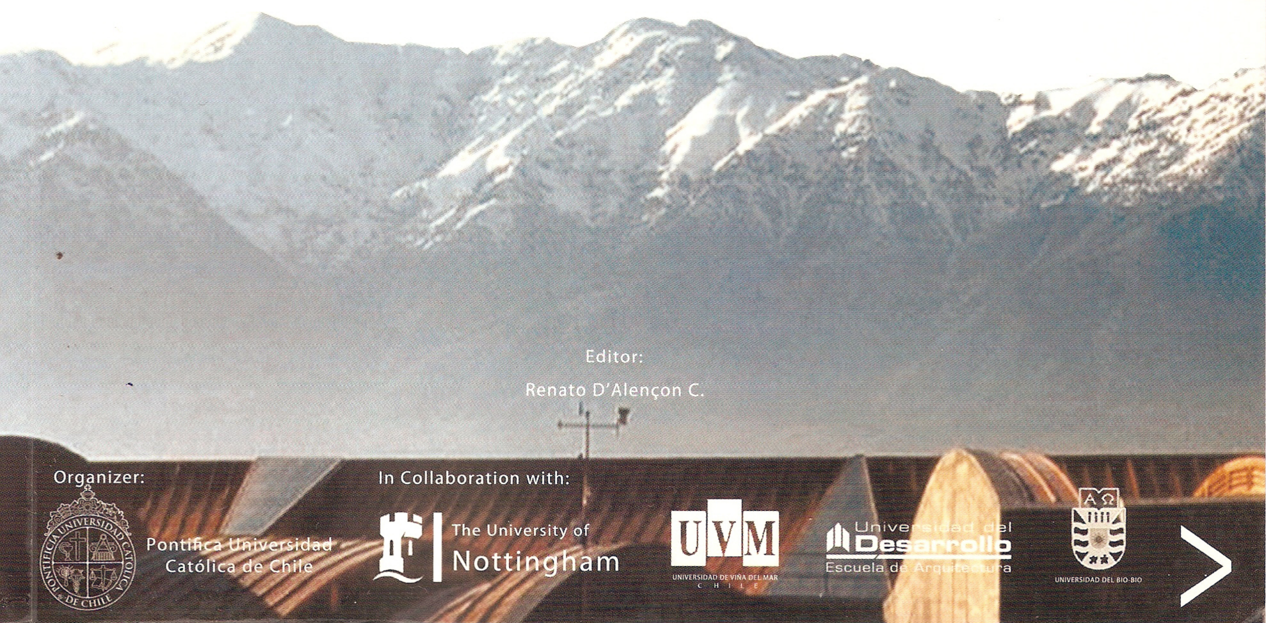

Editor:
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Design strategies for thermal improvements in social housing: Applications in the town of San Lorenzo de Tarapacá, Chile.

Bernardita Devilat and Felipe Lanuza

Master in Architecture Program, School of Architecture
Pontificia Universidad Católica de Chile, Santiago, Chile.

ABSTRACT: The approach to social housing solutions in Chile have been historically focused mainly as an economical issue, but not paying enough attention to quality design, neither environmental concern. This situation becomes critical when standard solutions are applied through different regions of the country, which have specific climate conditions. In the town of *San Lorenzo de Tarapacá*, these solutions do not match with the local aspects of built heritage, identity, and thermal comfort that exist in most of the traditional houses. This problem become evident with the Earthquake of 2005, when most of the village was destroyed and the new housing solutions were clearly out of context. Due to this, it is necessary to understand Architecture as an integrating discipline, which should include different approaches to build appropriate housing solutions. One of these approaches is the thermal comfort. Attempting to recreate traditional ways of building with contemporary new possibilities, there should be a direct correlation between the new models of housing and the cultural inheritance that determinates the lifestyle in San Lorenzo. This paper checks different constructive systems through the thermal behaviour of pre-existent solutions and the new building responses, in order to establish the most important aspects to recover and replicate. From this start point, the second part corresponds to an architectural exercise, which will be evaluated in terms of its thermal performance. Finally, it is presented a reflection of this design solution related to the other architectural approaches: built heritage, public space conformation and management.

Keywords: built heritage - social housing - thermal behaviour - San Lorenzo de Tarapacá

1. INTRODUCTION

1.1 Built heritage

It means all representation of a moment in a community ´s life, that in an extensive perspective, it is not only determined by the antiquity of its representation, but by the social, cultural, and historic value that it can include. In Chile, *"The cultural patrimony is part of the collective wealth of the nation; it is integrated by cultural resources that precede so much of the past as of present, with value in themselves*

Figure 1: View of Vigueras street. San Lorenzo de Tarapacá, Chile. 2006.

whose appreciation and importance doesn't depend on derived limitations of its property, use, antiquity or economic value, but rather they have transformed in patrimony by the cultural-social action that they comply."[1]

1.2 San Lorenzo de Tarapacá (Fig. 1)

It is located on the edge of the Gulch of Tarapacá, approximately at 110 kilometers from the city of Iquique, in the north of Chile. It is conformed in their majority by houses from XVIII century, whose main material is the adobe and the quincha [2].

As other towns of similar characteristics, it is crossed by a channel of irrigable water and structured by a continuous façade housing, which configures the public space of the streets. Likewise, it is fundamental the church and its steeple, reference point in the whole town. San Lorenzo of Tarapacá is considered "Typical Zone" (category of the *Nacional Monuments Council of Chile*), as part of the built heritage of the country.

This town was affected by an earthquake in 2005, magnitude 7,9 in Richter scale. The existence of an event that modifies the urban and architectural structure of the place so radically makes explicit some problems: necessity of reconstruction, non existence of design strategies for patrimony and cultural housing, etc.

Relating this case with Aldo Rossi's vision, Tarapacá is conformed by monumental punctual elements of strong character, as San Lorenzo's church and its square, and an urban weaving, of smaller scale, constituted by the houses. [3] The large scale elements express the religious and symbolic bond with its inhabitants, and the houses configure the streets: the domestic public space, so they are the main builder of the formal identity of the town. Here, it is possible to understand the town in these terms: it is conformed by an agrarian economy that does not need large infrastructures of large cities, which distort this simple scheme.

So, beyond the monuments that are part of this built heritage, those that are already approached; the emphasis it is on the housing, as a heritage weaving. Thus, is impossible to understand Tarapacá, and perhaps other hereditary towns of the northern zone, if we don't pay enough attention on this point. The only intervention in certain punctual elements will not help to re-configure the whole town. [4]

Another aspect is the economical problem, because the people of Tarapacá have not enough resources to live, so the reconstruction processes have been slow and difficult. This is the reason for think in the improvements of social housing.

About the location conditions, the village of San Lorenzo de Tarapacá, has a dry climate, with high temperatures in the day and low temperatures at night, producing a thermal oscillation of 20 to 25 degrees per day. For this reason, it is important to save the day energy and use it in the night, when the ambient is coldest. In this case, some aspects like sun, wind and orientation configure special ambient conditions for the building. For example, the hills at the north and south of the village determine that the wind slows down. So, at night, the low temperatures are not so extreme; but instead, the sun energy stands direct for almost 14 hours per day, without ventilation, even when it is winter.

1.3 Objective

To generate design strategies for the improvement of thermal behaviour in new social housing for desert zones, responding at the same time to built inheritance.

1.4 Methodology

To check a comparative thermal and material analysis of eight houses in the town of *San Lorenzo de Tarapacá* and identify aspects to recreate or to recover; then, to identify sites with reconstruction possibilities and their solar orientations in the main façade. With this, it will be presented a proposal of social housing, considering the specific conditions of the particular sites which are necessary to reconstruct. Afterwards, the proposal will be tested with a thermal behaviour program: TAS.

Finally, for conclusions, to reflect about the results, mostly in the thermal issues and its correlation with built heritage, suggesting new possibilities of design.

1.5 Hypothesis

A lineal standard block, constituting the façade to the street, is able to perform a good thermal behaviour, through different variations, according to its orientation.

It should be a basic device, with thermal properties, of a progressive house that grows along the backyard. This device would be adaptable to the different façade lengths of the chosen sites.

2. DEVELOPMENT

2.1 Thermal Analysis of previous cases

The materials of the chosen cases are old adobe, new adobe [5], wood [6], wood panels (with isolation), concrete blocks, bricks and quincha. In all of these cases it was chosen a north wall, so they receive sun during all day. It was taken the contact temperature of this wall, from inside and outside, so it is possible to compare the behaviour of the wall material. Also, it was taken the inside ambient temperature and the exterior ambient temperature, to define the users inside thermal feeling. It was measured the lighting too, because it affects the inside temperature of the building. It is relevant to mention that it was impossible to measure the temperature during night, because the study would have bothered the families that live in the houses.

In general, all the chosen cases had an inside ambient temperature that was below or equal than the outside temperature. In the same way, all cases with materials related to clay element had an increase of their inside temperature when the day is over, except for the new adobe.

The graph (Fig. 2) shows that the best thermal behaviour is the quincha, because it has the best relation between it situation during day and night. While other materials show a good behaviour only in the day, in *Tarapacá,* quincha and also adobe have the capacity of absorb and release heat, which determines a good behaviour with high and low outside temperature. [7] In this way, the concept of charge and discharge, meaning the process of transferring solar energy when it is needed, appears as an important issue: in Tarapacá there is much sun energy during the day that could be used for heat the interior in the night, when the temperature decreases.

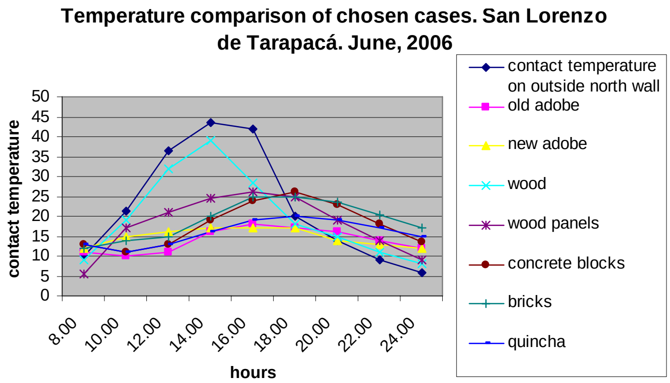

Figure 2: Contact temperature comparison of inside north wall in chosen houses. The outside temperature is an average of all cases.

However, there are some architectural and material conditions that determines the inside comfort in a house. In this sense, not only the wall material is important but also the components of the roof and the floor.

For example, in new adobe case, the inside temperature is higher than old adobe. This situation is produced by the metal roof that new adobe house have, mainly because it has no isolation. In day, this roof doesn't protect the interior from the heat of the sun. At night, the heat that adobe is trespassing to the interior goes up and dissolves into the exterior, because the roof doesn't work as a barrier. So, a house made with clay but with isolation problems in the roof or floor losses all its thermal properties.

2.2 Defining design conditions

From the study of the village after the earthquake of 2005, it was identified three types of buildings. (Fig. 3) In first place, the ones that are without damages. In second place, the buildings that have particular conditions so they have to be restored. In third place, the sites that it is necessary to re-built because of their damage level. The proposal is focussed in the last ones, because its reconstruction will allow to re-configure the continuous façade and to shape the public space of town.

Figure 3: Plan of San Lorenzo de Tarapacá zoning by earthquake damages. The dark red sites are the ones for been re-built and the gray ones are those for been restored.

The strategy is a flexible bar that takes all length of the main façade of these sites, been variable between 4 and 20. In most of the cases, the sites have a front of 10 meters, so this length will be the proposal extension, understanding its possible application on other cases with minor variations.

The objective is to save the solar energy from sun and to use it to warm inside during night. This determines the preoccupation on the building north position. According to the orientation of the access façade, most of the cases have south, north-west and south-east. In this study, it determines a different strategy for north and south façade houses.

2.3 Proposal

The bar is conformed by isolated walls, made with a wood structure and clay, and a special treatment in wall and roof according to the orientation of main facades.

North access façade cases: To put the economic efforts in a thermal wall treatment in the north-west façade, because it receives the most part of the solar radiation. It is a structure of wood with adobe that gives the necessary thermal mass to equalize the temperature oscillation. For the direct solar gains by the roofing, it will be a ventilated roof with 2 layers: an interior one that gives the isolation during day and night and an exterior one that receives the solar radiation. (Fig. 4)

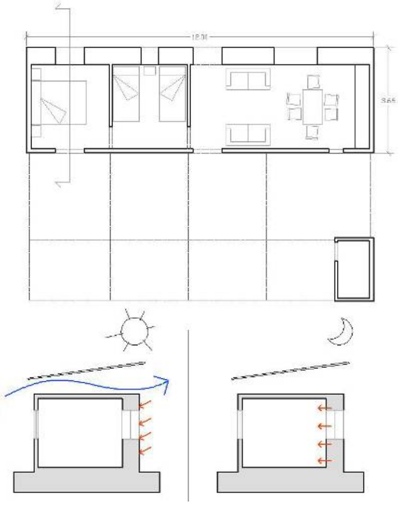

Figure 4: Proposal for north access façade

South access façade cases: Considering that the south façade doesn't receive solar radiation, so it doesn't allow the heat accumulation during day, like the previous proposal; the efforts will be in the roof treatment. So, it is proposed an air camera that elevates the air temperature inside it with the solar radiation, producing greenhouse effect in it. When the outside temperature is low, a ventilated façade and roof system allows the air movement from heat to coldest zone, so it warms the interior of the house. (Fig. 5)

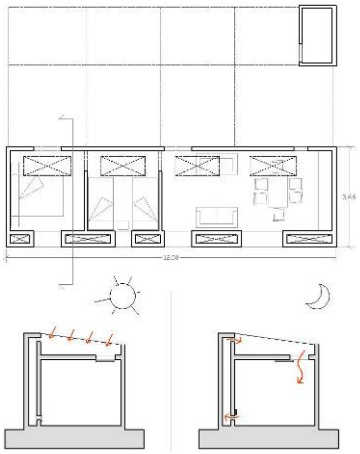

Figure 5: Proposal for south access façade

2.3 Proposal Thermal Analysis

For TAS analysis, it was taken a dry climate weather data from Camar, also in Chile, with a strong temperature oscillation during day. However, in order to be more specific, the weather data was modified for two days in the year: day 59 (February 28) and day 200 (July 22) because these days were measured by Tarapacá Group. So, the graphs shown are very close to the real conditions.

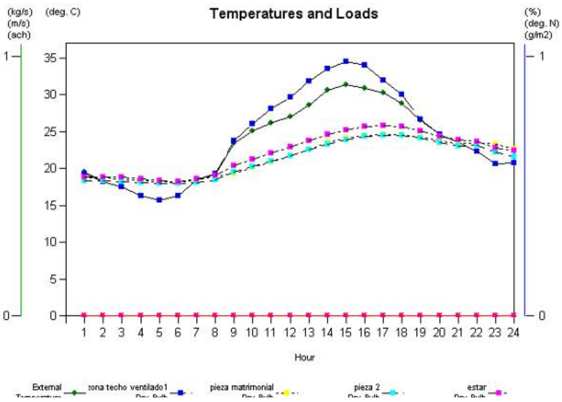

Figure 6: North façade proposal on day 59

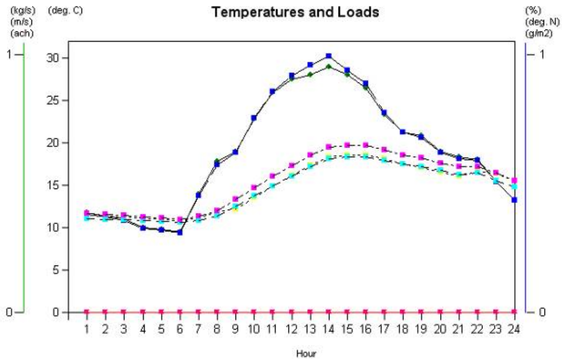

Figure 7: North façade proposal on day 200

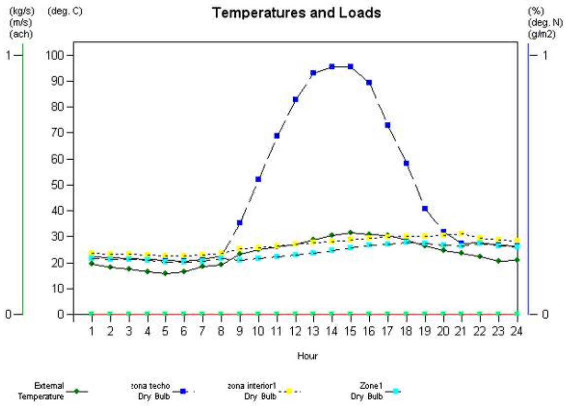

Figure 8: South façade proposal on day 59

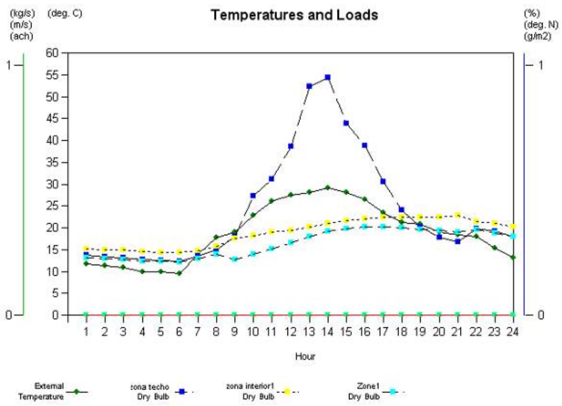

Figure 9: South façade proposal on day 200

3. RESULTS AND PROJECTIONS

Both models works properly, because their building elements equilibrate the inside temperature using the heat of the day. (Fig. 6, 7, 8, 9) However, the north model has low inside temperatures than south one, even when it has more direct sunlight radiation.

The graphs shows that the first model works better isolating from the heat, produced by direct solar radiation, rather than warming at night with the stored heat. The larger room has the better thermal performance, maybe because it has the larger area of the north adobe wall that receives direct sunlight. However, it was tested the same model with all adobe walls, and the behaviour was practically the same. This indicates that there is no necessity to build all walls with 60 cm of thermal mass (adobe) thickness, but only those that are receiving solar radiation.

The second model shows an air camera that storage heat in day and liberates in night in a most efficient way than the other model. This element could storage a great volume of heated air, at least enough for all night. Even when this proposal seems to be better for the temperature oscillation problem, during day it presents a small overheating situation. However, this problem can be solved by using more isolation in the elements that are in contact with the air heated camera.

Related to patrimonial problem, this adaptable scheme allows a reconstruction of the continuous façade of the town. Maybe through a more specific design, or adding other elements in the façades, it is possible to enrich the public space.

The proposal is very simple, according to get a social housing solution, but it is necessary to advance with economical evaluations, to verify that the proposal could be concreted in real conditions.

So, the two exercises presented here, could be a first step of a larger investigation. The primarily conclusions shows some ways to develop it, in order to improve the thermal behaviour and other aspects of these basic models.

4. REFERENCES

[1]VIÑUALES, 1990, mentioned in MARTÍNEZ, P; TORREJÓN, F.; MUÑOZ, D., “Conceptualización y aspectos legales en la clasificación del patrimonio cultural e histórico en Chile”, en *Revista de Geografía Norte Grande.* Nº 26. Chile, 1999. Page 135.

[2]Quincha is a vernacular building technique made from a wood panel structure, which are filled with clay and have 10 cm. of thickness.

[3]ROSSI, ALDO. *La arquitectura de la ciudad.* Editorial Gustavo Gili. Barcelona, Spain. 1982.

[4]TARAPACÁ GROUP. *Inform about student work in the north of Chile earthquake zone.* [on line] Pontificia Universidad Católica de Chile. Santiago, Chile. 14 of September, 2005. [query date: March 22, 2007] Available in: http://www.proyectotarapaca.org

[5]Old adobe is used traditionally and it is related with materials like wood, bamboo and straw. New adobe is a self-create denomination for the use of this material in the reconstruction process actually and it is related to metal roofs, wood and concrete. In both cases the thickness of the wall could be from 60 until 100cm.

[6]It refers to a prefabricated typology, made of wood but without isolation, with 3 or 4 cm. of thickness, used mostly for emergency housing.

[7]D´ALENÇON, R.; BOOTH, R.; KRAMM F. “*Reconstruction in Tarapacá: Earthquakes, Emergency and Built Heritage*” in *Revista de la Construcción*, Vol. 5, nº 1. Santiago, Chile. 2006. [on line] query date: March 22, 2007] Available in: http://www.proyectotarapaca.org

[8]All images by Bernardita Devilat. Graphics by the authors based on data from Tarapacá Project.