Learning from the past: Training for a sustainable future of the tourist sector in the Coastal Atacama Desert.

Abstract: *The Atacama Desert in Northern Chile is one of the driest places on Earth. Where this desert meets the ocean, the cold waters of the Humboldt Current and the Pacific Anticyclone produce a climate of consistently cloudy mornings and high humidity, yet with almost non-existent rainfall and clear afternoons with harsh solar radiation. Since pre-Columbian times mankind has inhabited this thin stretch of land between the ocean and the desert. Today the regions beaches, its flora and fauna, the phenomenon of the flowering desert, important paleontological remains and its more recent history, are beginning to generate an increase in tourism. At the same time the region is threatened by illegal occupation for holiday homes and the social and environmental impacts of the mining industry. This paper presents a study of the region's vernacular and indigenous architecture, local materials and existing infrastructure, looking at how the past can suggest a sustainable future.*

Key words, Vernacular Architecture, Tourism, Sustainable Architecture, training.

Introduction

Inhabited since pre-Columbian times the coast of Chile's Atacama Region, a thin shelf of land where one of the driest deserts on earth drops abruptly to meet the cold Pacific Ocean, offers opportunities for tourism that are only just beginning to be developed. With some of the most beautiful beaches in Chile, such as Playa La Virgen, important paleontological sites such as Cerro Ballena, the phenomenon of the flowering desert which occurs only in certain years following the scarce rainfall, national parks and the historic influences of the mining boom and European immigration of the late nineteenth century, the region has a broad appeal to both national and international tourists. Between 2006 and 2010 foreign tourism in the region increased by 61% whilst in the same period visits to the region's national parks increased by 53% (Sernatur 2011). With this increase in tourism is important that the tourist infrastructure is sustainable, both to preserve resources and the environment, and to compete in an ever more demanding international market. The region is already threatened by the environmental impacts of the mining industry and the illegal occupation of large stretches of coastline for the building of holiday homes for the inhabitants of the mining cities in the desert's interior. The former has contaminated water courses and in the worst example produced the build-up of over 320 million tons of toxic copper mining residue in the mouth of the river Salado in front of the town of Chañaral, an environmental disaster labelled as one of the most contaminated places on the planet (Cortés Alfaro 2010). The latter has led to the formation of illegal settlements without sanitary provision, basic services or considered planning. It is therefore imperative that the tourism does not further place a burden on the region but is instead a positive force.

In 2012 the Bioclimatic Laboratory of the Universidad Central de Chile was invited to participate in the Chilean government funded project "Hub for the dissemination of tools for the competitive sustainability of the tourist sector of the coast of the Atacama Region" directed by the Institute of Tourist Heritage of the same university. The assignment was to research sustainable construction for the region and to develop a series of workshops to share this knowledge with the local entrepreneurs involved in the tourist sector, with the aim of promoting best practice for a sustainable tourist infrastructure. There follows the results of the research which formed the basis for the three workshops that were undertaken in the region.

Climate and its impact on local construction

The climate of the region is produced by the meeting of the desert with the cold waters of the Humboldt Current and the Pacific Anticyclone. The climate is classified as BWn, "arid desert climate with abundant cloud cover" by the Köppen climate classification (Rioseco et al.). The characteristics of this climate are described by the Chilean standard NCh1079 of.2008 *Architecture and Construction- Climatic Dwellings for Chile and Recommendations for Architectural Design* (Russo et al. 2008) as "Desert zone with predominant maritime climate; little diurnal thermal oscillation; cloud cover and humidity which disperse at midday; strong solar radiation in the afternoons; zero precipitation in the north and scarce in the south; predominate winds from South and South West, with some interference from coastal breezes; atmosphere and ground saline; vegetation non-existent or scarce." The standard goes on to describe the winters as temperate in the north of the climatic zone and cold in the south, and summers as hot with an average daily summer temperature of 20,4°C. The standard recommends that residential constructions should have a maximum thermal conductivity of 2.0W/m^{2}K for walls, 0.8W/m^{2}K for roofs, 3.0W/m^{2}K for raised ventilated floors and 5.8W/m^{2}K for windows. Considering average daily winter temperatures of 13.6°C the authors believe that these values should be lower, at least for the walls, and recommend a maximum U value of 0.9 W/m^{2}K. Other recommendations of the standard are; a minimum roof pitch of 10% for rough surfaces and 5% for smooth surfaces; solar protection to west-facing fenestration; protection to construction materials from the high humidity and saline content of the air; and the use of controlled ventilation in order to avoid excessive heat loss in winter.

In addition to the recommendations of the standard, the authors identified the following requirements for sustainable architecture in the region; solar protection to windows and external spaces to avoid overheating and shade, however when thermal mass is present solar radiation should be allowed to enter during winter months; protection from the wind especially during the cool mornings; the avoidance of deep plan forms to maximise natural daylighting; the use of thermal solar collectors for hot water and photovoltaic panels for electricity; and a careful management of water use, one of the regions scarcest resources and where possible the recycling of grey-water should be implemented. These recommendations formed the basis of the three workshops organised in the region, together with the following study of local architecture and materials.

Local, vernacular and indigenous architecture of the region

The indigenous people of the region now known as *Changos*, according to the local museum of Caldera, inhabited shelters composed of semi-conical structures of branches covered with grasses and seal skins, with a low base of dry stone walls. Similar structures can still be encountered today along the coast, used by the descendants of these people as either temporary or permanent shelters (figs 1 & 2). The low stone walls provide shelter from the coastal breezes and may offer some thermal inertia to provide comfort during the cooler nights and mornings.

Figure 1. Fishermen's shelter, Piedras Bayas.

Figure 2. Fishermen's shelter near Carrizal Bajo.

In the second half of the nineteenth century European immigrants arrived in the region drawn by the mining opportunities and the construction of Chile´s first railway linking the mining town of Copiapó to the port of Caldera. With them they brought an architecture of timber framed, timber clad houses, many prefabricated in North America. As a local adaption, the walls of these timber houses were infilled with a *quincha* (wattle and daub) a traditional local building technique consisting of a background of branches or split bamboos covered with an earthen render reinforced with straw. A notable example of this type of architecture is the *Casa Tornini* in Caldera (fig. 3). This house was built around 1860 for the North American William Wheelwright, the owner of the company that built the aforementioned railway, before passing first to the British consul of the time and then in 1907 to the Italian Tornini family who now run the house as a museum. The structure of Oregon pine was shipped in pieces from the United States and constructed with *quincha* infill, in this case using Guayaquil Cane bamboo (*Guadua angustifolia*) which arrived in Chile as shipping ballast. The bamboo is covered with a course earthen render of mud and straw, and finished with a finer render of mud and ashes (fig.4). The house has a covered veranda to the North, a feature common to many buildings dating from this period, and a glazed gallery to the East, a feature unique to this house.

Figure 3: Casa Tornini, built circa 1860, Caldera .

Figure 4:Detail of quincha wall build-up.

Local materials

The following local natural building materials were identified by the authors. They have a historical use in the region and are now being rediscovered and used in contemporary constructions. Practical, hands-on exercises of working with these materials were included in the workshops.

Totora (*Scirpus californicus ssp. Tatora*)

This sedge, *Totora,* is a subspecies of the Californian Bulrush or Giant Bulrush (*Scirpus californicus).* It grows in abundance in the few river estuaries that exist in the region, such as the estuary of the River Copiapó (fig.5). The stems of the plant can grow up to 4 metres in height and have a hollow cellular structure (fig.6).

Figure 5: Totora beds in the River Copiapó estuary.

Figure 6: Cut totora stem showing cellular structure.

This cellular structure gives the stems a good insulating quality with a coefficient of thermal conductivity λ calculated by the University of Minnesota as being 0,069W/mK (Niaquispe-Romero et al. 2011). The reed is traditionally used for roofing, wall coverings and windbreaks. For roofing the stems are doubled around horizontal timber roof poles and stitched together below the pole to secure. In modern application, a sheet of bituminous roofing felt is sometimes sandwiched between the doubled-over stems to provide greater water-tightness. For wall applications and windbreaks the stems were traditionally laid side by side and sandwiched between vertical branches or bamboo canes. A contemporary development of this technique uses lines of stitching running perpendicular to the stems to create mats that can then be applied to timber uprights. Given its coefficient of thermal conductivity the recommended U-value of 0.8W/m^{2}K for roofs (Russo et al. 2008) could be achieved with a thickness of 75mm and for walls 0.9W/m^{2}K with 65mm.

Brea (tessaria absinthioides)

This shrub known locally as *Brea,* grows in only a few specific locations within the region, these being principally around the village of Totoral (fig. 7) and in some parts of the upper Copiapo river valley. The shrub has straight stems with a diameter of approximately 5mm which grows to a height of 1.5m. The stems are harvested in bundles (fig. 8) and used both as the infill background for *quincha* (wattle and daub) and as freestanding windbreaks.

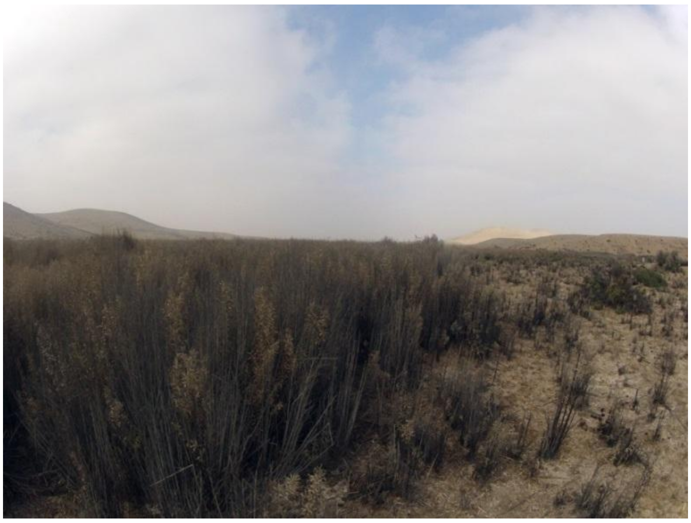

Figure 7: Brea growing near the village of Totoral.

Figure 8: Bunches of harvested brea

Stone

The stone used for construction in the region both historically and today is principally collected on the beaches as opposed to being quarried. Although traditionally used as dry stone walling, stone must now be used in conjunction with concrete and a rigid frame to provide resistance to seismic forces

Examples of local contemporary sustainable architecture

There follows a selection of pioneering projects that draw on the traditional architecture and construction techniques, whilst at the same time incorporating other active systems with the aim of providing a sustainable tourist infrastructure. These examples were included in the presentations made to local entrepreneurs to demonstrate what is possible in the local context.

Hostal Boutique Ckamur, Caldera

This hostel aims to revive the pre-Hispanic past of the port of Caldera and the surrounding region, building with traditional materials and incorporating designs found on archaeological remains. The building (fig. 9) has a timber frame infilled with *quincha* using *brea* and earthen render. The roof is thatched with *totora* and grey-water is recycled (fig.10) to irrigate the plants on the north facing terrace and surrounding garden. Measurements of dry-bulb temperature showed an average indoor air temperature of around 16°C in winter with no heating. Measurements of globe temperature showed this to be consistently lower than the dry-bulb temperature suggesting that the thermal mass of the *quincha* can have a negative impact if direct solar radiation is not allowed to enter during winter months. This also indicates that a higher thermal mass construction technique such as adobe would not be suitable in this climate.

Figure 9: Hostal Boutique Ckamur, Caldera .

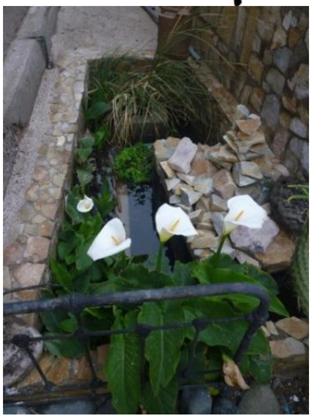

Figure 10: Grey-water recycling Ckamur, Caldera .

Base camp, Piedras Bayas

This project provides sleeping accommodation in 3 geodesic domes, however it is the communal kitchen/dining area and associated bathroom and offices (fig. 11) that are perhaps more interesting. These use a contemporary application of the local material *brea*. The *brea* is left exposed, confined in timber frames, with a layer of glazing or plywood on the inner face of the panel to improve air-tightness. Clear windows, free of *brea*, provide carefully selected views (fig. 12). The same system is used to provide external windbreaks but without the secondary layer of glazing or plywood. Electricity is provided by photovoltaic panels, however hot water is provided by gas boilers. The entrance to the site is delimited by low dry stone walls reminiscent of the bases of Chango dwellings.

Figure 11: Bathroom and offices, Base Camp, piedras Bayas. Figure 12: View out showing brea cladding

Lodge Pan de Azúcar, Pan de Azúcar National Park

This complex of cabins and camping is located within the National Park of Pan de Azúcar (Sugar loaf), so named because of the shape of the offshore island that dominates the park. The construction technique is the same as that used at Hostal Ckamur with walls of *quincha* earthen rendered *brea* and *totora* roofs. Hot water is provided by evacuated tube thermal solar collectors, the only example of thermal solar panels encountered by the authors in the region. Previously electricity was generated by a wind turbine and photovoltaic panels, however this installation was destroyed by storms and electricity is now provided by a diesel generator as the complex is not connected to the national grid. Bottled gas is used for cooking and for powering the refrigerators in the cabins.

Training Workshops

Using the results of this research a "caravan" of workshops was organised. These took place in three geographic locations, one in the north of the region, one in the middle and the other in the south. Those who took part were local entrepreneurs and those involved in the tourist industry. These workshops included interactive presentations and hands-on experience of using the natural building materials identified.

Conclusions

The researched showed that there exists low carbon, natural building materials in the region that have been historically used in the vernacular and indigenous architecture and which are now being rediscovered by local ecologically minded entrepreneurs. Whilst the availability of these materials is not equally spread across the region, thereby requiring some transportation, they are more local than other conventional building materials that must be transported from the south of Chile over 1000km away.

Although the climate is an arid desert climate the authors believe that thermal insulation is necessary to improve thermal comfort in the cool winter months and cloudy mornings. Other than the insulating properties of the roofing material *totora*, thermal insulation was not encountered in either the traditional or contemporary architecture. It would be interesting to think how insulation could be combined with the construction technique *quincha* in order to provide ecological walls with limited thermal mass and good insulating properties.

It is hoped that the workshops that resulted from this research have highlighted to the local tourist industry the potential of the local materials, seen in the vernacular and indigenous architecture, to provide a sustainable future for the regions tourism, learning from the past.

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