TÉCNICO LISBOA

Sustainable Architecture in Cape Verde

A New Village for Chã-das-Caldeiras

Extended Abstract

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INTRODUCTION

With the socio-economic, technological and cultural development, the demand for a sustainable arquitecture in Cape Verde is growing every day. Unsurprisingly factors such as lack of employment in the most vulnerable communities, causes a rural exodus in search of better conditions in the cities. These factors contributes, among other things, to the emergence of a network of illegal buildings that aim to accommodate the poor population. These buildings are models with a number of drawbacks as lack of planning, sanitation, illegal use of electricity, not to mention the very localization, form and structure of the house that does not meet the minimum requirements stipulated by the competent authorities.

In November 2014, the community of Chã-das-Caldeiras from Fogo Island has suffered a natural disaster - volcanic eruption - which destroyed a set of equipment's, including housing, leaving some 1,200 people homeless. It then becomes necessary to structure a project that makes possible the construction of new equipment in order to move the people who were displaced due to the disaster.

So this work is then primarily aim to analyze the construction environment in the Cape Verdean territory, and presenting a set of actions that guides the new constructors to a more sustainable construction and bioclimatic buildings. As a secondary goal we intend to propose a set of models for the construction of new houses that were lost in the volcanic eruption in Chã-das-Caldeiras, applying the rules set out in the main target, trying to get a set of constructions that obeys the lines that provide a bioclimatic building and minimizing the use of energetic resources.

This dissertation is divided into four chapters. The first chapter is an introduction to the archipelago of Cape Verde, analyzing the existing architectural typologies today, and the first settlements in the territory and how these have evolved over time. Following this analyses a presentation will be made, of some techniques that can be applied in order to take advantage of the energy available in the country. In the second chapter there are presented techniques or strategies that can influence and improve considerably in aspects such as ventilation, lighting, waterproofing and thermal comfort. The third chapter aims at analyzing the conditions of the island of Fogo, followed by constructive characteristics mainly in the area of Chã-das-Caldeiras. Then a brief description it's made of the damage caused by lava resulting from the eruption of 2014, followed up by the presentation and characterization of new models proposed as draft recommendations, describing the techniques and materials used in making the equipment in bioclimatic buildings and reduced costs.

Keyword: Sustainable Architecture, Chã-das-Caldeiras, Cabo Verde, Bioclimatic Architecture

ARQUIPELAGO´S ARCHITECTURE INTRODUCTION

Despite the possibility of the Cape Verde islands were discovered before the arrival of the Portuguese in the fifteenth century, there are no proof remains that testify to the permanence of people in this archipelago during this period. So part of it is assumed that the construction techniques and architecture have evolved from the colonization process, initiated at the time of European expansion.

The biggest architectural challenge in the early beginning for the population in the archipelago was to adapt the constructive doctrines, both European and African, to the natural environment of volcanic and Sahelian insularity and lack of natural resources that was unknown to both peoples.

We can then identify and characterize the main building typologies currently existing in the country, making the division into three main groups:

- Vernacular architecture - these are the traditional houses of volcanic stone, mainly seen in rural areas, with stone masonry walls and thatched roof;
- Colonial architecture - colonial buildings with roofs in ceramic tile, found in the main centers of cities;
- Contemporary architecture - consisting of villas and office buildings made of reinforced concrete in structural elements, walls of concrete blocks and roof slab of reinforced concrete.

The vernacular architecture is an architectural form very spontaneous and based on self-learning. These homes often have dimensions of 7x3m2 or 9x4m2 and are divided into two compartments. The walls have a thickness of approximately 40 cm and is constructed of basalt lute. Generally, the interior walls are plastered and whitewashed, and the facade is white fallen directly on the apparent stones. Coverage is usually skewed (gabled), covered with thatch. The doors and windows are both built with wooden lintels. The vast majority of domestic activity is developed abroad, with or without backyard.

In colonial architecture can identify two types of strokes, regular, imposed in the territory, following straight lines and practices in flatter areas, the second being the irregular layout, adapted to the terrain and practiced, especially in the rougher areas. In public buildings and in the possession of men of houses used up in prominent places, lime and sand mortar to bind stones and bricks imported. Coverage was generally composed of ceramic tile or wood, this also imported. The houses of possession of men were usually the houses or ground floor house with patio. We can also mentions the *sobrados*, which are a particular style, often cited in some cities and widespread in the villages in Fogo Island. They are very common, belonging to former landowners, traders and some notable farmers.

In contemporary model building, the walls are built with concrete blocks resting on a foundation wall and locked by means of pillars, lintels and slabs of reinforced concrete. The foundation is usually performed on a bedrock neat hand (riprap), on which is cast a concrete layer (rigging) to be armed with electro welded mesh in order to prevent cracking by shrinkage. The pillars are founded on direct shoes to the ground foundation. For this type of construction, sizing calculations focus primarily on slabs and stairs.

The model of occupation of Fogo Island is characterized by spontaneity of settlements, resulting in a dispersed territorial occupation, which is provided by a relative internal mobility, and a great sense of "land ownership" bridging the urban space rural, thus shaping the process of social integration.

The streets are relatively narrow, the areas with the highest concentration of buildings pathways are cobbled with basalt stones, but in the other locations, the floor is in clay, sometimes, when it in fact exists, is made out of rough stone resulting in uncomfortable to traffic.

Sustainable Aspects

The use of imported materials is a major problem for sustainable construction in Cape Verde. Since the country's occupation of the early materials for the building were always imported, and today there is that fact with the bulk import of most materials, including Portland cement. This import is much given the insular condition of the country. The high cost of these imports and the existence of natural materials in the country must therefore be key factors for the formulation of a development and sustainable construction strategy.

Although the concept of sustainability has not yet existed at the time, it is clear the search for comfort, even if unintentionally, this has always been a universal concept. Equipment for ventilation or cooling systems such as air conditioning or fans had not yet been invented, and it required a better fit and better architectural provisions to create a comfortable, ventilated and with enough light for housing and development of enabling activities. It is also clear recognition of the influences that different colors in homes can cause regarding the absorption of sunlight, because the use of white lime or blue iron oxide in some homes.

The *sobrados* houses, characteristic of this island, are a good example with regard to sustainable practices by type of projection they show such as high ceilings, large windows thereby extending the liabilities spaces, and the sobrado houses that protect the spans the direct incidence of sunlight, moreover, these buildings have openings on both facades promote cross ventilation. Another factor that it is important to mention is the use of sand and slag locations from the volcano, which contributes to decreasing the import of excessive cement outside. These constitute an isolated example of sustainable practices in relation to most buildings built in the country, yet urgent measures are needed that contrast the contemporary architecture, especially in the interior locations of the island, besides not being ecologically sound, there have sometimes the minimum conditions which ensure the health and well-being of its inhabitants.

Figura 1.14 - Sobrado Djar Fogo, ilha do Fogo
[Fonte: Amélia Sacramento Monteiro (2011)]

Capabilities and Sustainable Practices

Compared with the rest of the African natural resources Creole islands are close to zero, but there are four main sources from which we can take advantage of: solar energy, wind energy, marine current energy, and geothermal energy, and the first two are the most potential present in addition to being easier to deploy, and being the country deployed in sub-Saharan Africa lacks drinking water, and buffeted by winds and droughts, the population must sensitize themselves to develop strategies beyond natural constraints caused by geographical location.

The solar panels take advantage of solar energy to heat water. We have to adapt the solar heating collectors on the roof of buildings, facing south and with 30 degree tilt, its slope is dependent on the location of the cold water tank. This process constitutes a self system for heating water tank and a solar collector.

Wind energy as an alternative to fossil fuels, is renewable, is permanently available, can be produced in any region, is clean and produces no greenhouse gases during production. In a country like Cape Verde in the wind is constant during the 365 days, the utilization of the domiciliary system can be a key element in electricity savings and the demand for sustainability of the country's homes. The obtained electricity can be stored in a distribution network and then used in the absence of wind. The wind use for pumping water from wells and electricity production is made in the traditional way in some Cape Verdean islands.

Photovoltaics is the conversion of solar radiation into electrical energy through solar cells so called capture, generally sunlight. Passive photovoltaic and solar technology is the form of an ideal system.

There is no shortage of sunlight in the creole island throughout the year, so a housing that fits this type of system is self-sufficient in the production of electricity.

The islands have a volcanic origin resulting in an accumulation of eruptive materials, there is the existence of natural mineral materials with enormous potential and across the archipelago. These are ornamental rocks and industrial non-ornamental of different natures. The deposit of these minerals - dimension stone - originating from limestone type rocks are mainly in the shallow islands, including São Vicente, Sal, Boavista and Maio. Non-ornamental rocks, basalt, limestone, sand, clay, gypsum and pozzolan, are undoubtedly the best potential. Basaltic rocks that predominate in all the islands have been explored either as ornamental or as building materials in the production of sand and gravel.

SUSTAINABLE ARCHITECTURE STRATEGIES

Bioclimatic architecture - consists in building design taking into consideration the climatic conditions to which it is subject in the place of deployment, using the resources available in nature - sun, vegetation, rain and wind - to minimize environmental impacts and reduce energy consumption. A bioclimatic house can achieve great energy savings and even be sustainable as a whole.

It is understood that in the city center deployment sites are pre-selected by municipal councils, but in the mountainous regions where it is free will, it is necessary to know that the rooms should be deployed in the lower areas of the mountain, above the bed the streams, where it circulates more air. The landscaping is extremely important to protect the interior from excessive solar gains of housing, so the facades facing the sea should be protected by porches of generous dimensions in order to reduce the impact of the sun's rays reflected on the sea to the interior of the housing.

The areas where the building are naturally ventilated and lighted up are denominate passive areas, and can be considered as having a depth twice the height of the upright. This depth can be reduced when there are obstacles to natural light and ventilation, due to some appropriate interior partitioning or neighboring buildings. The aim is then always maximize possible passive areas. If no areas subject should endeavor to ensure that those areas are not occupied, for example, storage. And when the deployment area is too large, it becomes almost impossible for these spaces not to exist, so it is advisable to incorporate lobbies and atriums.

Choosing the best orientation is the best way to consider the passive areas since the beginning of the project, in order to reduce solar gain heat, help prevent overheating situations. The best guidance is parallel to the East-West axis, since it restricts the area of solar exposure of the façades that receive sun low angle (East and West), allowing shading the facade that gets the most sun high angle (South), also enabling natural lighting.

Although it seems something irrelevant to some, the coatings are an important element with regard to unwanted solar gains, especially when it comes to a group of houses clustered sometimes disorderly fashion, as is the case in some areas of the country where it turns out several examples where the walls are not plastered, painted a lot less, thus leaving the building at the mercy of the incident solar rays, causing the building to overheating.

Coatings of light colors such as light color paint is a method that does not require large expenditures in addition to being effective, therefore, contribute to reducing the temperature of the building envelope and reduce the heat input in the building, reflecting much of the sun's rays. The painting inside buildings also brings its advantages, because combined with proper openings in buildings, improvement in the internal levels of natural lighting, reducing the use of artificial light.

The isolations play a major role in the thermal comfort of buildings. It is true that this type of techniques is almost unknown or forgotten by the builders, perhaps by the fact that Cape Verde is a warm country, but it is a misnomer because the correct insulation location, protects the building against the heat gains during the warmer periods, and improves thermal comfort throughout the year. Furthermore, this can prevent hot air leakage into walls, reducing condensation problems on surfaces where areas have more humid climates, which is a problem found in most homes, particularly in the rainy season.

The dimensioning of the openings is critical to the proper performance of the building, since, as we known, much of the heat is transferred through the glazed areas on the facades as these offer little resistance to radiant heat transfer feature. The orientation and sizing of glass areas are fundamental in defining passive spaces and the glass type choices limits the amount of penetration of solar radiation into the building.

To a warm climate, with high incidence of solar radiation, such as Cape Verde, it is important to avoid large gaps in the glazed facades, leading to overheating and the use of air conditioners. Generally, the glazing area should not exceed 30% of the area of the facades on the north and the south, considering since the spans have adequate shade. The springs and sunsets facades, this value should be reduced to a maximum of 20%.

One can understand the phenomenon of natural ventilation in buildings as a set of procedures that promote, the control manner, the flow of air between the inside and the outside. It is essential to know how to use and control this phenomenon, as the wind can significantly influence the energy performance of buildings, through good conduct in the planning of natural ventilation.

The openings must be widely distributed in different facades, according to the wind's behavior and ensure that they have different pressures, improving the distribution of airflow in the building, however it is apparent that the distribution of lots in the city condemned the homes become glued to each other, both laterally and at the rear, which makes the provision of openings in the various walls, or at least the rear. Thereby it called attention to the need to think of new ways to arrange the deployment of lots in order to facilitate this action.

Thermal inertia is a certain capacity building to reduce heat transferred into your higher temperatures an outdoor environment and releases it to the indoor environment. This ability is all the greater for its thermal mass. This capability is key property to control temperature variations in a particular environment, and the optimization of this technique ensures the thermal comfort inside the building, as well as slow down maximum peak external temperature, provides a delay in the peak in the internal temperature.

Materials such as concrete, stone and bricks have high thermal inertia, these are the most used in Cape Verde, and allow for heat storage, regulating and softening temperature fluctuations. After a certain point, the heat starts to accumulate in the building's mass and thermal mass decreases its efficiency, so its use should be combined with ventilation strategies to remove the accumulated heat, and here comes the use of night ventilation, because the night ventilation strategies combined with a good thermal mass can reduce internal average temperatures during the day below the daytime outdoor temperatures.

In order to get an indoor environment of buildings thermally comfortable for its inhabitants, the standards of thermal comfort are essential, without taking into account the artificial energy consumption for such comfort temperature. To do this you can use the psychometric chart - the psychometrics is the branch of science devoted to the analysis of the physical and thermodynamic properties of mixtures of gases and steam and its practical applications. Through this you can see what would be a comfort inside a building in Cape Verde.

CASE STUDY

In late 2014 the Fogo Volcano erupted starting on November 23, 2014 extending until February 8, 2015, causing immense damage in the communities that are part of Chã-das-Caldeiras. According to some volcanologists the volcano was already showing signs of a possible eruption for some time, so the eruption of Fuego volcano was predictable, but no one was prepared for the amount of damage that this would cause.

During the eruption of 1995 the lava flow was relatively close, but not destroyed the nearby communities. This had destroyed the entrance road in Chã-das-Caldeiras, a handful of houses and the building of the old cellar of Boca Fonte, which was a small town where there were springs and cisterns system. Today, with the growth of the community, the destruction was far greater.

In 1995, the new eruption began at the foot of Pico do Fogo and the lava filled the most depressed area of Chã near the large cone, and the eruption in 2014 without having where to spread led to a more elongated tongue and it arrived faster to Portela, thus resulting in a river of lava branched into two spans: one went to the south and died a kilometer and such and the other was towards Portela, passing over the 1995 spill and running leaning against it.

Despite the reduced impact on existing endemic species in the protected area, the disaster did move around a thousand inhabitants of Chã-das-Caldeiras, where is the base of the volcano and considered

Natural Park, moving not only because of the lava, but also by the cloud of sulfur, however it accumulated in Cha zone of boilers, which caused a light rain, typical of this type of natural phenomena resulting in a series of respiratory problems, and other constraints.

Figura 1 – Lavas vulcânicas de erupção vulcânica 2014
[Fonte: Lusa (2014)]

The lava destroyed two villages - Portela and Bangaeira - which housed about 1,300 people, while they have been displaced to other locations, most of the old school of the city of monasteries and elsewhere to reception centers in Achada Furna and Monte Grande.

With the end of the eruption, people began to return to their dwell, or at least what were left of it. They are very attached to their roots and agricultural land is the one the only forms of livelihood. But the Cape Verdean government, says Chã-das-Caldeiras will never be inhabited, especially for having been devastated twice in 19 years, allowing only small makeshift houses, which must be provisional.

PROJECT PROPOSAL

Given the geomorphological conditions of the land of Achada Furna zone, the best orientation for new homes would be inclined to this, due to increases taking place in the north as well as the shape of the volcanic edifice that rises in the same direction, thus hindering the process of natural light during the day.

House Model

This design then is the projection of a house that has a plant of 14.5m by 15m, resulting in a total area of 217m2 and a ceiling height of 2.7m. The spaces are divided in living room, dining room and kitchen, a bathroom and three bedrooms. The module has a porch that covers all compartments, protecting the house from direct entry of sunlight and looking a bit the image of the famous oaks characteristic of the volcano´s island. There are vertical openings in all compartments of 1.5m, thus favoring natural ventilation and the extent of liabilities spaces. These openings are shaded by the extension of coverage to 0.9m end.

Figura 2 – Simulação 3D da Casa Tipo
[Fonte: Autor]

Market Model

There is no denying the feeling of own provider of men and women of Cha-das-Caldeiras community, through agricultural production and livestock. So a model was creating that provides trade in products that come from such activities and in turn boost the economic development of the community and the island then becomes indispensable.

So the propose is a structure inspired by the various green building that has been building in African Subsaheliana. Consistent Module then a 16m by 14m structure supported by pillars and girders, which provide space therein for the emergence of walls formed by sheet metal containers (containers) which delimit the space recycled for commercial activities on the market.

School Model

The school is then in a complex of six blocks and a sports card. Four blocks are classrooms, one for toilet and one for library and staff room. The rooms are enclosed by walls that have the same constitution of the walls of the house type - formed by concrete blocks combined with cement or volcanic pozzolan - and base walls are formed by local basalt rocks. The walls have vertical spans of 1.30m by 1m in the shadows is left to the occupants. All rooms have high coverage, secured by metal beams arranged perpendicular to the plane, so as to ensure proper ventilation, and accumulated heat removal in the upper rooms. These covers - metal - are inclined, directing rainwater to conduct that in turn lead to the reservoir located at the back of the bathroom.

The circulation and ventilation are guaranteed by wide aisles (1.80m) separating all rooms. In the center of the complex is a courtyard with 6.30m long and 12,7m wide. This is intended to promote natural ventilation but especially ensuring the extension of liabilities spaces inside the rooms.

Church Model

The church has a rectangular plan with 18.6m wide and 8.2m long, and a floor area of 130m2. With a single nave, the walls bounding are made of volcanic stone, except the entrance wall, made of concrete, where it sought to reconcile a local root building the modern architecture movement. It has vertical span of 2.5m by 0.6m, seeking extensive liabilities spaces and ample cross ventilation. Coverage is ceramic roof little inclination, which diverts rainwater from the roof.

PROJECT RECOMENDATIONS

The ease of actions that contribute to success in ensuring good thermal performance and in terms of lighting, makes it almost imperative that they are applied in all the buildings that exist in the country. Despite the large number of homes, mainly clandestine taking place in urban areas, Cape Verde is still a territory slightly built, so it is believed that in the future conditions doctrines of sustainable architecture are implemented, the country will experience a more environmentally healthy and urban aesthetics will improve considerably. It is crucial to attack the problem since its inception, i.e. since before the height of the building.

Therefore it is necessary: A good urban planning, with lots suitably located and pre-defined spacing between them, in order to allow cross ventilation and lighting inside the home; It is essential to recognize the role of the architect has a space designer and engineer as stability insurer of all buildings in order to avoid actions that may possibly jeopardize the city's image, or worse yet, damage involving loss of life, that which occurs mainly during the rainy season due to landslides; All buildings must have as their main purpose not only aesthetic but above all to guarantee the 100% utilization of natural lighting and ventilation, to avoid overdoing the artificial energy expenditure that is harmful to the environment and to humans; Constructers should take into account the variety of software that exist today as Revit, Energy Analysis Building, Energy Plus, Ecotec that help to simulate different options to design and how these encourage the thermal performance of buildings; For pattern must be operated all the possibilities regarding the use of local material so as to prevent import of expensive materials and contribute little to the good thermal performance of the building.