The relation between the traditional construction and the sustainable development

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ABSTRACT: The use of passive solar systems in the traditional construction should become a current application in order to establish a tool which may reach the main goal of development: the sustainability.

The analysis of the huge climatic and ethnological diversities of Cape Verde archipelago allows the study of different constructive techniques and systems implemented by the several cultures that had a strong influence in this country.

The understanding about the efficiency of the thermal parameters of these systems allowed its identification and relates them with the minor or major environmental impacts. The comprehension of the local architecture can be considered as a first step towards the implementation of the sustainability in the construction sector. The work was developed taking into account this subject.

The work was developed taking into account this subject. The analysis of techniques and systems frequently used in the studied local, with tested results and knowledge, allows the increase of its performance through the creation of a better constructive system with the adaptation of the technological evolution in these traditional solutions in order to bring benefits and is an important contribution to the sustainable development.

Conference Topic: 8 Traditional solutions in sustainable perspective

Keywords: Passive solar systems, sustainable development, traditional construction

1. INTRODUCTION

In the Brundtland Report (1987) the sustainable development was defined as a “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. [1]

Since the origin of the human civilization, the construction has been thought according to an environmental context and framework. Several examples of this can be found in the vernacular architecture.

In the beginning of the 70’s, a growing attention towards the environment and its maintenance took place, namely in what its preservation is concerned in face of the technological progress. This subject has been increasing along these years which led to the creation of documents by important organizations such as the Agenda 21, as a result of a conference in Rio de Janeiro (1992) of the United Nations, with guidelines to the sustainable development.

2. SOLAR PASSIVE SYSTEMS – A BRIEF APPROACH

2.1 Passive solar systems of heating

The passive solar systems of heating consist in the captivation and distribution of solar energy without the need of using mechanical ways, which demand external energy for their functioning. Although small mechanical devices may be incorporated in these systems, as a way of increasing its efficiency without leading to significant consume raises, generally inferior to 2\% of the received energy. [2]

It consists in two ways in using the solar energy: through the direct and indirect gains. To allow the direct gains the system should be composed by glazed surfaces, thermal inertia and isolation (to avoid losses to the exterior at night). The use of a storage surface between the space and the solar radiation is necessary to the indirect gains.

The implementation of indirect gains can be done with the use of many types of systems, as the storage walls, water walls, greenhouses and convection circuits. [2] [3] [4]
2.2 Passive solar systems of cooling

The passive solar systems of cooling consist in the use of natural ways (ventilation, vegetation, etc.) and constructive elements (windows, shading elements, constructive elements of great inertia, etc.) with the aim of producing the housing cooling or avoid its overheating.

One of the most significant factors in the cooling process of an interior room is the ventilation. This parameter must be studied in face of windows location according to the zones of higher and lower pressure and the interior walls position. Other factors are also relevant as the shadowiness, radiation, evaporation and dehumidification and, finally, the thermal inertia (this process involves ventilation at night to remove the heat released by the storage surfaces). [2] [3] [4]

3. SUSTAINABLE CONSTRUCTION

3.1. Main aspects

The first step in a Sustainable Development way was accomplished with the creation of the Agenda 21. The numerous environmental accidents in the 60’s gave origin to many manifestations and a new conscience about the world impact of the current use of land and resources. The understanding of the natural sources characteristics, its limits and its scarcity, namely after the oil crisis in the 70’s, produced a new world overview. However, the need of changes in the world’s life style is a great challenge: how can it be possible to change the costumes of so different cultural, traditional, economic, political and social communities? There is no doubt that it has to be the local government to encourage and provoke this change in reality.

The impact of the civil engineer industry, at social and environmental levels, deserves a first and careful analyse. In the European Union this industry contributes with 11% of the GDP, 26 million employees and around of 40% of the total energetic consume. [1] The “Agenda 21 on Sustainable Construction” makes clear the guidelines to the civil engineer sector in face of the quite large number of agents in the process. The document involves all the construction steps, namely the industry activity to the production of materials, the use and maintenance of buildings and, finally, its deconstruction and residues destination. This makes clear the importance of a sustainable built environment.

3.2. Relation with local resources

The strategies should be specifically adapted to each region, in face of its environmental, social, economic and cultural characteristics.

The way to achieve a sustainable built environment can be find through the vernacular architecture principles which respect the local characteristics of a region, such as the climate, the constructive solutions, the materials, the technical skills, the culture and the tradition, as well as the ancient dialogue between the building and the surrounding.

The respect by these matters will stimulate a new constructive approach towards the interior comfort and health. The interior air quality becomes a great worry in face of the decrease of pollution levels in the exterior air and the increase of the pollution in the interior. This fact led to a new discussion based on the life style and the fact of people stay 90% of their time inside their homes, in an ambient with lower levels of health.

4. ANALYSE OF CAPE VERDE CLIMATE

4.1. Climatic description

Cape Verde islands are located in the Atlantic Ocean, at 500 Km from the African Coast, in the arid climate zones. The rain occurrence is almost insignificant along the year; sometimes the occurrence in one day is equivalent to the total in the year. Figure 1 shows Cape Verde location. [5]

The archipelago presents great differences between the islands; the ones located nearer to the African Coast are the hottest; even in the same island the climatic behaviour depends on the altitude and location.

Cape Verde is classified as a BWh zone, according to Köppen graphic. In this evaluation method, the aridity is characterized by taking under consideration three aspects: total annual rain, annual average temperature and rain distribution in the periods. Table I presents the parameters used to the qualification.

<table>
<thead>
<tr>
<th>symbol</th>
<th>description</th>
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<tbody>
<tr>
<td>B</td>
<td>Dry climates</td>
</tr>
<tr>
<td>W</td>
<td>Annual average rain &lt; 250 mm</td>
</tr>
<tr>
<td>S</td>
<td>Annual average rain &gt; 250 mm</td>
</tr>
<tr>
<td>h</td>
<td>Month average temperature &gt; 0°C</td>
</tr>
<tr>
<td>k</td>
<td>Average temp. (at least in one month) &lt; 0°C</td>
</tr>
<tr>
<td>k</td>
<td>Annual average temperature &lt; 18°C</td>
</tr>
</tbody>
</table>
The Cape Verde qualification is equivalent to the desert climate features, with a dry climate (B), an annual average rain inferior to 250mm (W) and an annual average temperature superior to 18ºC (h). The monthly average temperature is around 22ºC, only superior in the rainy months – from September to November – with 26ºC.

4.2. Passive solar systems adapted to Cape Verde

The analysis of two islands (Sal and São Vicente), which are characterized by the aridity, makes possible to identify the passive solar systems with better results to be applied.[6]

This analyse was developed with the Analysis 2.0 Bio software, developed by Federal University of Santa Catarina – Brazil, and its aim is to define the passive solar solutions which are more effective in each circumstance, from the analysis of the climate data of the place where the building is to be located. The work methodology consists in over putting the given climate data to the psicrometric chart to calculate the percentage of the time of the year in which thermal discomfort or comfort occur and the percentages in which each strategy is more appropriate.

The following Table (see the Table II) presents the results to the São Vicente Island in face of the discomfort and comfort periods per month.[6]

### Table II: São Vicente results

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Ago</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfort</td>
<td>27.3</td>
<td>26.1</td>
<td>48.1</td>
<td>30.0</td>
<td>21.0</td>
<td>53.2</td>
<td>11.0</td>
<td>40.8</td>
<td></td>
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<tr>
<td>Discomfort Solar passive strategies</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passive solar heating/ thermal mass</td>
<td>40.0</td>
<td>42.9</td>
<td>36.9</td>
<td>46.2</td>
<td>46.2</td>
<td>36.4</td>
<td>37.5</td>
<td>25.0</td>
<td>25.0</td>
<td>40.0</td>
<td>46.2</td>
<td></td>
</tr>
<tr>
<td>Ventilation</td>
<td>6.0</td>
<td>2.5</td>
<td>2.5</td>
<td>17.5</td>
<td>10.5</td>
<td>9.0</td>
<td>7.5</td>
<td>2.3</td>
<td>5.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passive solar heating</td>
<td>25.3</td>
<td>25.0</td>
<td>21.9</td>
<td>15.4</td>
<td>15.4</td>
<td>12.5</td>
<td></td>
<td>13.3</td>
<td>7.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Artificial heating</td>
<td>3.3</td>
<td>3.6</td>
<td>3.1</td>
<td></td>
<td></td>
<td></td>
<td>1.1</td>
<td></td>
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<tr>
<td>Air conditioning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>18.5</td>
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</tbody>
</table>

Figure 2 shows the results of the application in face of the passive solar strategies to resolve the discomfort periods per year.

The same application was made to Sal Island, the hottest of the Cape Verde archipelago. The results per month in face of the different periods are shown in Table III.[6]

Throughout the year, Sal Island presents the following values of discomfort, which are divided by the passive solar techniques to reach the comfort, and comfort (Figure 3).

### Table III: Sal Island results

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Ago</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfort</td>
<td>90.0</td>
<td>90.9</td>
<td>90.4</td>
<td>90.4</td>
<td>82.2</td>
<td>58.8</td>
<td>66.1</td>
<td>40.8</td>
<td>19.4</td>
<td>39.0</td>
<td>59.2</td>
<td>36.4</td>
</tr>
<tr>
<td>Discomfort Solar passive strategies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passive solar heating/ thermal mass</td>
<td>10.0</td>
<td>9.1</td>
<td>8.3</td>
<td>8.3</td>
<td>17.8</td>
<td>9.1</td>
<td></td>
<td>13.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ventilation</td>
<td>13.7</td>
<td>9.1</td>
<td>11.9</td>
<td>33.9</td>
<td>20.7</td>
<td>13.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ventilation/Mass</td>
<td>4.6</td>
<td></td>
<td>8.5</td>
<td>27.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling thermal mass</td>
<td>5.8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Air conditioning</td>
<td>11.0</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ventilation / mass / evaporative cooling</td>
<td>1.3</td>
<td>1.3</td>
<td>24.4</td>
<td>23.8</td>
<td>4.5</td>
<td>28.0</td>
<td></td>
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</table>

Figure 3: Different periods per year to Sal Island

According to the results presented is possible to conclude about the passive solar solutions capable of reducing the discomfort periods due to the arid climate:

- Passive solar heating – through the direct and indirect gains – these solutions makes imperative the use of materials and constructive solutions with storage behaviour;
- Thermal inertia – its application demands analyse of the delay and damping factors (the time and quantity of energy that reach the interior space through the heat flow). This solution is used to promote heating as well as cooling, the ventilation is absolutely important in the last one;
- Ventilation – the ventilation is fundamental to endow the building with better interior conditions (even exterior in some cases) in respect of relative humidity and temperature values.
- Cooling by evaporation – the presence of water provide conditions to evaporation and,
consequently, incite the cooling process due to the heat necessary to its evaporation. This solution will reduce the temperature and increase the relative humidity.

These solutions were presented one by one. The use of combined systems can guarantee an improved environment, and correct two or more parameters.

5. CAPE VERDE CONSTRUCTION: AN OVERVIEW

5.1. Cape Verde Construction Frame

Nowadays, the construction characteristics in Cape Verde Islands are very similar to the European ones. The framework of new construction adopted materials, solutions and techniques used in countries with climatic characteristics diverse of the archipelago.

The Portuguese influence, in view of the fact that it is responsible by the colonization of the islands, is clear in Santiago Island (Figure 4). The Portuguese construction applied in a temperate climate, which presents great thermal amplitude between the two most important seasons, winter and summer, should be updated, when applied in Cape Verde, to supply the needs due to the climate, the tradition, the culture and, finally, the social relations.

The importation of foreign methods and techniques can be a risk that will provide an overload by the environment. The discomfort in these buildings will be compensated with the increase of the energetic demand and, inevitably, the increase of environmental impact.

Understanding the vernacular construction through the observation of traditional applications by the natives makes possible to identify the main aspects that respect the local features. Some examples of this construction are shown in Figure 5.

However, other aspect deserves to be mentioned: the local sources. The sustainable construction clarifies the need of exploring the resources of the region through its use. This choice consists in several vantages:

- Control of economic cost;
- The knowledge of the materials and techniques;
- The use of materials tested in local constructions, with proved results;
- The respect by the culture and tradition;
- The return to the construction in dialogue with the climate;
- The valorisation of the local resources, easily accepted by the local population.

The use of materials and techniques from foreign countries can enlarge the errors in the construction sector during the construction stage due to the different technical domain. This situation can increase the pathologies and compromise the building’s life cycle.

6. CAPE VERDE CONSTRUCTION ASPECTS ACCORDING TO THE CLIMATE

6.1. Arid climates’ urban planning

The need of thinking in an urban planning integrated with focal preoccupations at the sustainable level is a premise to the design project. It’s unquestionable the influence of the surrounding definition in the final behaviour of the building; even the microclimate in a specific local should be controlled to avoid consequences in the interior comfort.

According to Olgyay [7], some principles can be taken under consideration, as the use of water mass to reduce thermal amplitudes and increase the relative humidity, also the urban settlement must be compact to provide the shadowiness, the presence of a central garden in the block, the use of vegetation to offer a fresh environment due to the absorption and evaporation properties, the buildings with one floor benefit with the cooling air flow near to the ground, the use of small glazed surface to avoid the entrance of solar radiation but allowing the ventilation.
6.2. Principles to adapt the construction to the climate

The design process according to the climate needs to obey to four steps: [4]
- The analyse of the local climatic elements;
- The evaluation of the climatic influence on the physiological aspects;
- The study of the constructive solutions that are proper to each problem in order to achieve acceptable comfort levels;
- The evaluation of the results of the up-mentioned three phases and the application of the conclusions to a specific location.

These four steps were presented in previous paragraphs and some guidelines can now be established in order to clear some aspects.

6.2. Construction guidelines

The construction in Cape Verde must obey some aspects in order to create an identity according to the local characteristics. Face of the elements presented in point 4 and 5 in this article is possible to choose some more relevant aspects. The following paragraphs describe them.

The location of the windows and its measures will influence the air flow and the solar radiation that reach the interior. As stated already, the Cape Verde climate is arid, although some discomfort periods can be resolved with the passive heating. This incongruity can be explained due to the fact that the temperatures in the dry months are around of 18ºC. The comfort zone of passive heating can be verified around of 11ºC to 20ºC.

The use of materials with storage characteristics through analyse of its thermal inertia and, consequently, delay and damping factors. This passive solar system will provide benefits to the heating and cooling process. This parameter needs to be used according to a less density to avoid the overheating due to the “Harmatão” – a dry and hot flow from the Sahara desert – and, in the hottest months, when the solar radiation is minor.

Pay attention to the dominant wind direction and velocity in a way to improve the ventilation in the buildings and the surrounding.

The use of water in the exterior should be motivated due to the increase of the comfort conditions around the building and, consequently, it’s interior.

The ground cover must be done with natural elements due to the increase of temperature caused by the pavement surfaces.

Housing rooms less used can be located in order to provide the overheating due to the “Harmatão” – a dry and hot flow from the Sahara desert – and, in the hottest months, when the solar radiation is minor.

The South surfaces of the building should be spread with light colours to provide the reflection of the foremost part of the solar radiation incident.

CONCLUSION

The decision about the use of constructive materials and techniques should be based upon the specific analyse of each location parameters characteristics, according to the cultural, economic, climatic aspects. The application of foreign predetermined constructive methods, with quite different characteristics, will lead to the conception of unfit buildings to the local context, with severe consequences from the point of view of the constructive systems efficiency (at the thermal performance level as well as the materials suitable performance).

Cape Verde presents adverse climatic characteristics, which is usually considered as an inhibition factor to its economic performance, mainly due to its pluvial instability. The thermal amplitudes are very little and, in general, the archipelago presents temperatures within the comfort zone. The discomfort zones are overcoming by using simple and easy-implementing passive solar solutions.

We can conclude that the comfort, in most part of the year, can be achieved by using a common strategy, with the isolated construction and urban planning. The executions of an integrated planning, which respect the climatic, social and technical demands, will contribute to find solutions to solve users comfort issues.

The concern about the built environment provokes a critical vision about the construction currently. The countries with instable economic situation and great growth potentialities have an increase responsibility in order to guarantee a new built sustainable environment. The respect by the tradition and culture is fundamental to encourage identification between the construction and the people.

This aspect is very important; the construction should be a guide map or manual with capacities to tell us the history of a people and a place. We should learn about some region history through its paths and buildings.

REFERENCES