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ADAPTING PORTUGUESE ARCHITECTURE TO FORMER AFRICAN COLONIES CLIMATE CONDITIONS

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ABSTRACT

The Portuguese architecture is borderless due to the colonialism period. Many African countries can testify this influence and the cities still sprawling around remaining old buildings. These constructions are characterized by using local resources and adapting Portuguese architecture to the climatic characteristics and answering local natural hazards. The work developed presents a systematic approach about the constructive changes, identifying the solutions adopted for answering climatic demands. The passive solar systems used were categorized and some examples were selected according to examples found in African cities with Portuguese influence as Beira (Mozambique), Lubango, Namibe and Luanda (Angola) and Praia (Cape Verde). This analysis encompasses strategies to improve thermal behavior of buildings, as ventilation trough the analysis of ventilated roofs or windows geometry, shadowing devices as large eaves, brises and second facades, among other issues. The local construction was also analyzed in order to find out traditional techniques for cooling buildings in a natural way.

Keywords: Passive solar systems, bioclimatic architecture, thermal behavior, traditional construction, Portuguese Architecture, Africa, African development

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Introduction

The Portuguese construction spread around the world through the Portuguese discoveries period, starting in the XV century. After the proclamation of the Republic in Portugal at the end of the first decade of the XX century, the former colonies have their interest invigorated with improves in its educational and economic system, namely with incentives to agricultural activities.

During this period, a lot of Portuguese people moved to countries as Mozambique, Angola and Cape Verde, all of them under Portuguese governmental control. Inherently, the Portuguese culture arrived to these countries, and the construction activities were one part of this local influence. The main goal of this work is to identify the main changes in Portuguese construction, specifically the aspects that were adapted according to climatic conditions of Portuguese speaking African countries in order to promote the interior comfort.

The Portuguese Construction

Portuguese construction is characterized by specific aspects as the systems adopted (walls systems as "tabique" and "frontal"), the materials used (wood, stone, mortar with sand and lime) and the techniques applied [1].

Table 1. Portuguese construction – main characteristics of structure.

	Exterior stone walls made with local resources and decreasing the wall thickness according to the floor location (as high as thinner)
	Internal walls and floor in wood structure. The walls can present several constructive systems and techniques, maintaining the use of wood and lime and sand mortar
	The roof has a wood structures and the covering is made with ceramic tiles

All these aspects can be found in the countries mentioned, but normally adapted according to local conditions. Some examples of this are presented in Table 1 and in Table 2, in which it is possible to observe the openings and its protections, as well as the materials used and its geometry.

Table 2. Windows typology.

	Wood windows with simple glass and interior protection
	The interior protection, in wood, present some openings that allows it open partially
	The windows geometry can vary and is possible to observe different types of openings and frames

The Challenges for Interior Comfort in Tropical Countries

Adapting Portuguese Traditional Construction

The Portuguese traditional architecture represents not just the culture but also the local conditions and resources availability, namely the climate and materials. The housing buildings in Portugal present small windows and large walls, combining the thermal inertia with air leakage and solar incidence. The stone goes changing around the country, been always used the available resources.

The windows protection are interior with wood shutters and the framing, also in wood, can present different geometry with simple glass. The interior walls are made with wood structure filled with mortar and stone or ceramic remains. The roof is made by wood structures and covered with ceramic tiles.

This construction had to be rethought in order to face the challenges for a comfort building in tropical countries. The climatic conditions and availability of materials were responsible for these changes and guided the new architecture that came up.

Angola – Cities of Namibe and Lubango

The climate in Angola vary according to the area analyzed, but can be classified as Aw in Köppen-Geiger climate classification, that means a tropical climate with a dry season when the sun is lower (located in the opposite hemisphere) and the days are shorter. Considering some thermal parameters from Lubango, a city located in the Huila province, interior of Angola, and using the Analysis Bio software, it was possible to identify the passive solar systems more accurate to be implemented in order to achieve the interior comfort. Table 3 show the results gathered in terms of discomfort hours per year.

Table 3. Analysis Bio results after applying to Lubango – Angola.

Strategy/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Comfort	89,25	86,58	89,25	97,21	100,00	91,67	84,62	91,67	90,91	90,91	100,00	100,00
Ventilation												
Evaporative cooling	10,75	13,42	10,75	2,80		8,34	7,70	8,33	9,10	9,10		
Thermal inertia												
Thermal inertia							7,70					
Passive solar heating												
	Percentage of hours per year											

Mozambique – City of Beira

Similarly to Angola, Mozambique has most of its territory with the same classification, Aw - a tropical savanna climate. Table 4 shows the air temperature average along the year. Considering the winter from May to August and the average minimum temperature around 18°C, we can state that the main comfort issue is related with summer months and the need of cooling interior spaces.

Table 4. Average temperature to Beira - Mozambique.

Air average temperature >10m (ºC)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Beira	26,3	26,1	25,6	24,2	22,8	21,5	21,2	22,3	24	24,7	25,5	25,9

Cape Verde - Praia

The Cape Verde archipelago is well known by its severe climatic conditions, being classified as Bwh in Köppen-Geiger climate classification, that means and arid country with poor rain (classified as desert in the precipitation criterion) and hot. The country is located about 500km from the African coast (the Boa Vista Island is the closer one from the continent) and it has the influence of the winds coming from Sahara desert.

The rainfall register is almost null in some islands, as Sal, Boa Vista and Maio, and they also present higher temperatures when compared with the remaining islands of the archipelago. The air is more humid in Santo Antão and Brava islands as they both are characterized by regular rain.

We can observe in Table 5 the results from Analysis Bio application and the main passive strategies to accomplish the required comfort conditions (considering Portuguese Buildings Thermal Behavior Code – 25°C for summer and 18°C for winter).

Table 5. Analysis Bio results after applying to São Vicente Island.

Strategies / Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Comfort	27,29	26,09	48,10	35,98	20,97	53,18				74,15	33,39	40,78
Ventilation	6,04	2,48		2,48	17,50	10,46	50,00	75,00	75,00	6,23	2,31	5,38
Passive solar heating	23,34	25,00	21,88	15,39	15,39		12,51				13,34	7,70
Air conditioning										18,52		
Artificial heating	3,33	3,57	3,13							1,10		
Passive solar heating/ Thermal inertia	40,00	42,85	26,90	46,15	46,15	36,37	37,50	25,00	25,00		40,00	46,15
	Percentage of hours per year											

Passive Solar Systems Adopted

General Approach

The passive solar construction is characterized by the use of constructive elements: walls, windows, roofs and floors, which collect, store and distribute the thermal energy provided by solar radiation and also preventing the overheating. The heating flows happen mainly through the natural mechanisms of conduction, convection and radiation instead of using mechanical equipment, which carry energetic wastes. The objective is to control these energetic flows and make available comfort conditions in the housing construction zones in any season of the year [2] [3] [4] [5].

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 integrated in these systems as a way of increasing its efficiency, without leading to significant consume raises, generally inferior to two percent of the received energy. [6]

The passive solar systems of cooling consists in using 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.

The applicability of solar systems technology is based on its indirect use through the optimisation of the construction elements, which consists, for instance, in using thermal parameters that express solar passive performance in current properly designed constructive solutions.

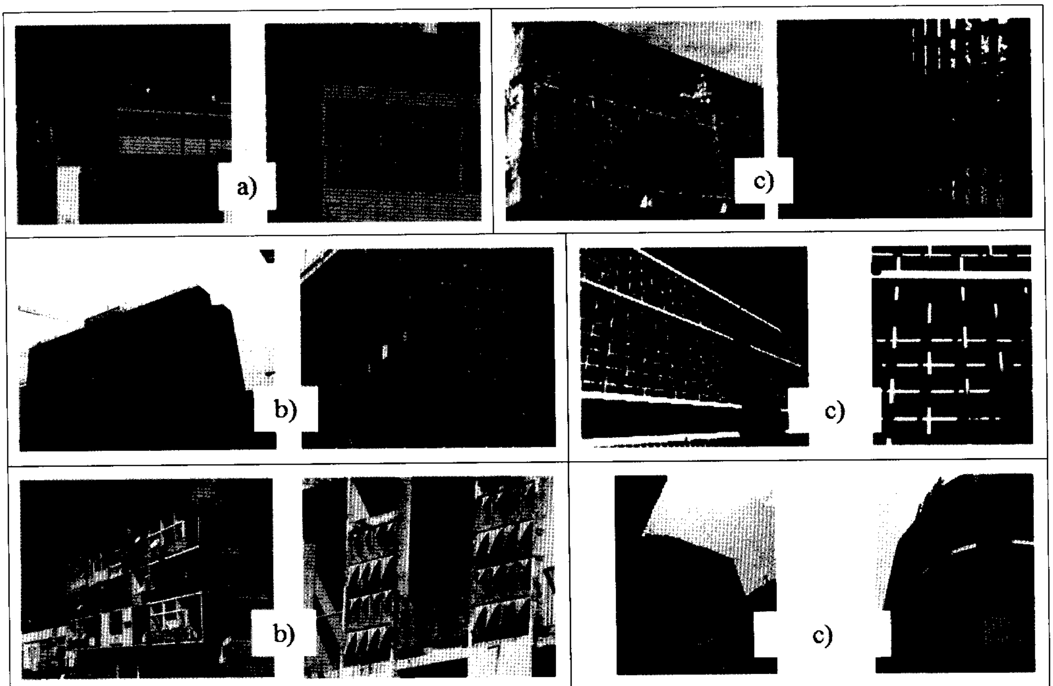
Cooling Strategies

In Portuguese construction, passive solar systems can be found as strategies to improve the interior comfort and also as resulting from the use of local materials or construction techniques. The thicker stone walls will contribute with its capacity to store energy (thermal inertia), the small windows can be found to avoid solar incidence and to control ventilation (ventilation and control of solar radiation), and the ventilated eaves will promote the roof ventilation. In the same way, Portuguese construction was adapted to tropical climate in African countries considered for this work. Some examples are presented in Figures 1 and 2.

a) Chimney effect in a building located in Cape Verde [7]

b) Roof ventilation in Mozambique

Fig. 1. Examples of roof ventilation.



Protection from solar radiation: a) Cape Verde [7]; b) Angola; c) Mozambique

Fig. 2. Controlling solar incidence.

In the previous figures, the passive solar systems for cooling can be classified as follows: 1. roof cooling system that uses ventilation to decrease the air temperature under the sloped roof or to grant that warm air can be released by chimney effect; 2. Walls protection with the use of cast walls to reduce solar incidence in house walls and windows protection with wood shutters that avoid solar incidence but allows ventilation.

Conclusions

The use of active systems to provide interior comfort was responsible for changing the design process. The fundamental aspects that in the past has guided the design phase were discarded with the use of air conditioning systems, local characteristics as climatic conditions were forgotten. Now, with the increase of energetic consume and the scarcity of non-renewable resources, the constraints by climatic conditions have been taken into account as a way to promote more sustainable and low energy buildings.

The aim of this work was to understand the guidelines for architecture adaptation to climate according to the Portuguese example. The colonization and the need to face a new place with different local conditions was mandatory to impose the changes in construction, keeping some characteristics but adapting details to improve buildings thermal behavior. The capacity was left behind along the years and is now being recovered.

The passive solar systems are present in Portuguese buildings located in African countries, the strategies to avoid solar incidence through a fake facade or the use of solar brises – with different shapes, materials and design, as a singular peace in the design process. The use of ventilated roofs to promote the air changes under the sloped roof and the windows protection, with the possibility to ventilate while shadowing the interior are more examples. All these cases show the need to still keeping the close relationship between climate and construction, both are interdependent and work each other in a sustainable built environment.

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