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Reshaping the *suburbs* of Maputo

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Abstract

This paper takes the urban space of the so-called underdeveloped countries as its main scenery. The concepts of sustainable development, architecture and environmental design will be at its core.
A case study in the context of Maputo – Mozambique, presented as a design project for an elementary school was both starting and end point for a theoretical and practical investigation that presents a methodology that looks into conciliating the demands and pressures of globalization, with a growth that respects cultural values, traditions and local conditions, whilst educating towards sustainability when intervening in informal settlements.
Starting by an environmental and social analysis of three neighbourhoods in the outskirts of Maputo it was understood that to intervene in such settlements it is crucial to understand their genesis, the actors and the relation between formal and informal city.
The school proposes a methodology that looks into design as a flexible process where the community is engaged in its self-enhancement and, common knowledge is referred to when educating towards a more sustainable society.

Keywords: Sustainability, Design, Education, Passive Strategies, Africa

1. Introduction

The growth of urban poverty in the context of rapid urbanization and the inability to answer through formal ways to economical, spatial and social problems has resulted in a generalized and organic expansion of the informal sector. According to UN-HABITAT (2007:188), in 2001, 42.7% of the urban population in the underdeveloped countries lived in informal settlements, and the average annual growth of these areas was 2.37%. Among these, the countries of sub-Saharan Africa present themselves in the most unfavourable situation, with an estimate that the percentage of informal settlements in the region was 71.9% in 2001, growing annually at an average of 4.35% (ibid.).
Because of their physical characteristics, informal settlements have a major negative impact on the environment. Oppenheimer and Raposo (2002:2) underline situations like erosion, flooding and contamination of groundwater. Barrow (2005: 134&141) and Forjaz (2005:13) also underline problems of deforestation that occur n green areas peripheral to these urban settlements and of air quality associated with the intensive use of wood for construction but also for cooking. Wood, together with coal are the two main sources for cooking and water heating.
The promotion of environmental quality is therefore dissociable from other problems that affect informal settlements like poverty and social segregation.

1.1 Maputo, Mozambique

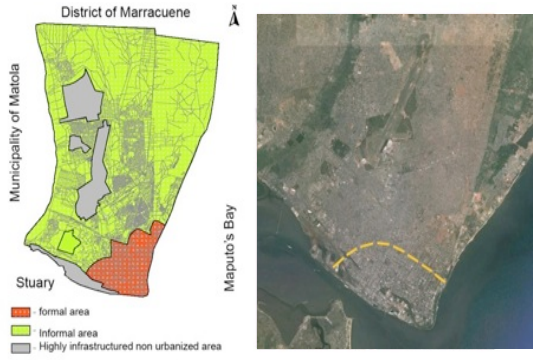
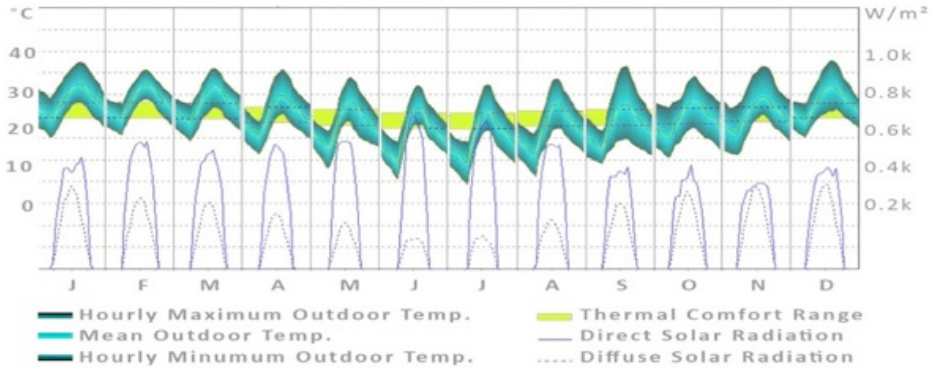


Figure 1: Map of Maputo, Mozambique

Located in the south of Mozambique, Maputo is the capital city with a Latitude of 25º58'S, a 32º35'E and the largest urban centre in Mozambique with 300km^2.
According to the last census it has 1,099.102 inhabitants, about 70% of who lived in informal settlements and about half lived in absolute poverty (Oppenheimer and Fox, 2002: 11&23). The figures show the current relationship between the formal and informal areas of the city.

2. Climate

Maputo has a moderate warm climate that allows for mild temperatures in the dry season between March and September, warm temperatures during the rest of the year with high levels of precipitation and high wind speed and high solar radiation throughout the year, never going below 100Kwh/m^2. The average year round temperature is as warm as 22ºC, with the maximum average temperature of 27ºC occurring in January and the minimum average temperature of 15ºC occurring in August.



As the temperatures are fairly warm all year round the adaptive comfort approach will be focused on ensuring comfortably cool temperatures, shade and appropriate air ventilation levels all year round.
The comfort range values were calculated using De Dear.

3. Fieldwork

Slums in sub-Saharan Africa are not simply mud shacks in a row. They are highly complex areas that vary according to cultural, social, historical and environmental factors, as well as their origin.
Built and unbuilt space in the informal settlements of Maputo show a complex variety due to the mix between new and old, colonial, post independence and new arrivals. Space evolves through time and the buildings can be compared to living organisms that reflect the life its inhabitants.

3.1 Case studies

Figure 2: Map of Maputo, with the location of Mafalala, Hulene B and Mangoanine C

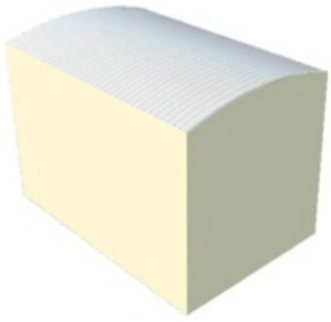
Mafalala is one of the oldest of the indigenous neighbourhoods that grew on the outskirts of the so-called 'cement city'. Its prime location regarding the city centre allows understanding its growth and densification throughout the years.
Hulene B grew and expanded mainly during the civil war from 1982 to 1992. Having grown around the main street that connects the city centre and the airport it is very well connected for those who need to commute daily to the city.
Mangoanine C was designed from scratch after the floods in 2000 and again in 2008 in order to accommodate hundreds of families hit by the natural disaster. Though it has some infrastructure and planning, primal amenities such as electricity or drinkable water drew many other Mozambicans into this area.
The visit to these sites allowed a better understanding of how these neighbourhoods work – each building is an independent construction built on the main front of a plot that evolves through time according to the needs and possibilities of the individuals who own it. And even if provided with little resources and skills the inhabitants build and adapt themselves and their spaces. Taking this into consideration it is believed that providing a school with a simple design that can be built in a flexible and participatory way will help to regenerate the environment and communities in theses areas.

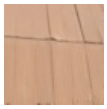
Figure 3, 4: School in Mafalala built in 1930s

Figure 5, 6: School in Mangoanine C built in 2000s

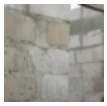
4. Analytic Work

In addition to literature research and the fieldwork outcomes, a theoretical experiment using a 7m x 9m x 2,5m 'shoebox' model. This simplified "box"-like structure was placed on site to test design theories in a simplified manner.
This simplified model enabled the understanding of how the existing schools could be improved through simple changes to construction methods and materials. It also provided input regarding the practical application of the system and its limitations.





corrugated metal sheet (roof) – 5.88W/m^{2}K

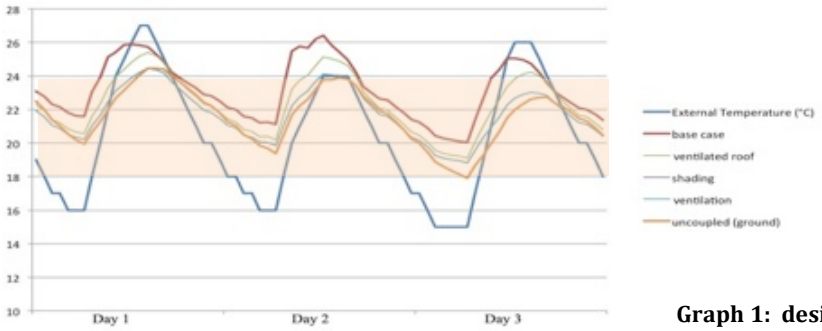


plaster cement block (walls) – 1.02W/m^{2}K

cement blocks (flooring) – 0.28W/m^{2}K

Figure 7: design strategies (1 base case, 2 shading, 3 ventilated roof, 4 earth decoupling

Tas simulations were conducted to test the performance of the free running building with the construction materials set above, using a representative warm week. The outcome was then compared against cooling strategies such as implementing a shading system, a ventilated roof, cross ventilation and earth decoupling.



Graph 1: design strategies (Source:Tas)

The performance of the shoebox allowed understanding that certain improvements to materials and construction techniques would highly improve the comfort of the occupiers while allowing for their adaptive comfort just by applying a well thought design brief and therefore building envelope.

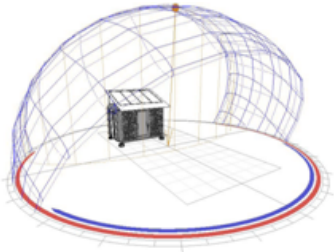


Figure 8: Sunpath diagram (Source: Ecotect)

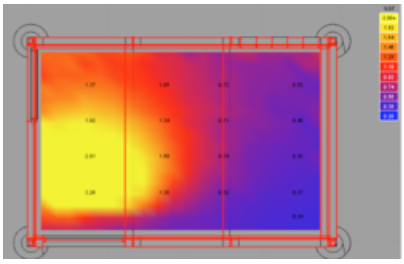


Figure 9: Daylight Factor % (Source:Ecotect)

Parallel to the tests run in Tas and taking into account the importance of minimum lighting requirements inside classrooms (300lux) tests were conducted regarding solar exposure and the Daylight factor inside the classroom areas. The orientation of the classrooms on site, as well as the dimension of shading systems and openings, was tested in order to find the most favourable design option.

5. Research outcome

5.1 Design approach

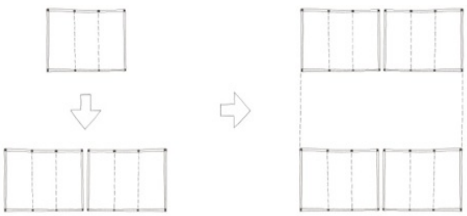


Figure 10: Modular Classroom System diagram

The shoebox analysis was instrumental in the identification of the design strategies that could maximize the performance of the school building. As observed earlier, the application of concepts like ground decoupling, ventilated roof and shading devices considerably affects the building's ability to create more comfortable indoor conditions.

The design process for the school is explained in the diagram above. The design

evolved in response to the environmental parameters already referred and the very specific conditions of applying the design to an informal settlement.
The design brief considered the school space as a flexible area, the built units such as the classrooms should be flexible, not only to hold different functions throughout the day or year as well as evolve according to the needs of the community. Therefore the school was conceived following a modular system (diagram above).
The objective was also to capitalise on the know how of the local community and the available materials in the area. Thus, while making sure that the climatic responses were integrated a choice of a simple construction system, that could be assembled on site with little skills and without heavy machinery allowing for community participation was not compromised.

5.2. Classroom design

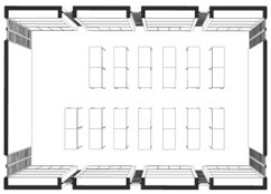


Figure 11: Classroom layout

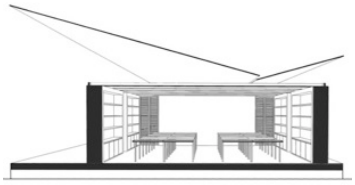


Figure 12: Classroom section

Similar to the shoebox, the individual classroom has a shallow layout that allows for better daylight, ventilation and flexible usage. The openings are vertical from floor to ceiling with manually controllable louvered shutters to improve ventilation. The walls integrate shelving units that increase the thermal mass of the building and help reduce acoustic problems. Each classroom has the 7m x 9m x 2,5m.
Natural ventilation was a main consideration in this design. Classrooms contain north/south-oriented openings that allow for the prevailing winds to pass through and create a more comfortable internal environment.

5.3. Construction and material proposal

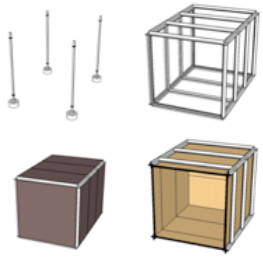


Figure 13: Construction

papercrete (floor,ceiling,walls)– 0.88W/m^{2}K

louvered shutters (apertures) – 1.29W/m^{2}K

corrugated metal sheets (roof) – 5.88W/m^{2}K

In order to comply with the principles laid out on the design brief, local and traditional construction systems were looked into as well as available local materials in order to present a sustainable, economic and simples construction process that would use and re-use as much as possible local and on-site materials.
As analysed before, Maputo is built on sandy and swamplands, which do not allow building with earth, reason why existing constructions are made of concrete blocks, corrugated metal sheets or reed.
The fieldwork made evident the accumulation of waste all around the informal settlements and the city, being that tires and paper were among the huge amount of garbage that filled all available areas. This knowledge, informed by the literature led to the decision of using papercrete blocks as the main construction material as well as tires to fixate the structure to the ground as well as lift it to prevent eventual flooding.

Paper improves the U-value of the rather sandy cement blocks as well as their resistance. The ventilated roof allows for cooling of the interior space of the classroom at the same time as it creates a filter to the otherwise noisy corrugated metal roof.

5.4. Passive strategies

Due to the high temperatures and the amount of solar radiation one of the objectives is to protect the internal space from the harsh outdoor sun whilst achieving an even DF of circa 4% inside the classroom and an average temperature of 22ºC.

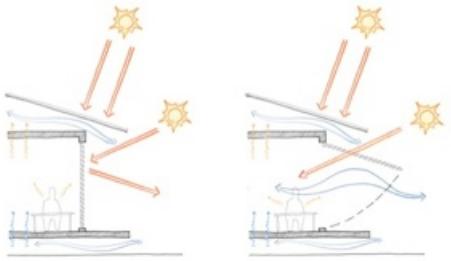


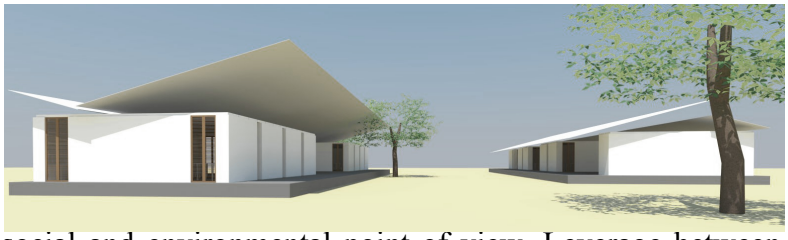
Figure 14: Passive strategies

5.4.1. Shading strategy – In order to avoid unwanted glare and direct sunlight a louvered shutter was created with fixed horizontal fins that allows for a simple but effective daylight and shading strategy.

5.4.2. Ventilation strategy – as to provide adequate opportunity for natural ventilation he classrooms include apertures on south and north facades in order to provide cross-ventilation.

5.4.3. Cooling strategy – taking into account the internal heat gains from an average of 35 occupiers inside a classroom for 6hours a day a passive cooling strategy adding to the natural ventilation was considered. So that the internal heat would be easily dissipated and the direct solar radiation would not contribute for the heating gains a ventilated double roof was proposed as well as decoupling the floor from the ground allowing for ventilation both under the flooring and in between the roofing system.

Conclusions



This research offers an approach to the regeneration of informal settlements that not only is aesthetically appealing but also successful from a social and environmental point of view. Leverage between a surgical approach and a social and environmental intervention was sought, and by using simple construction methods, materials and a modular system, it was guaranteed that the proposal was flexible and adaptable to different locations and able to evolve according to the community's needs. Analytical work and design proposal were conducted carefully to create an environment that complied with the aspirations of the local community and also recognized there skills and input making them part of the design process, under the belief that education as the regeneration theme for informal settlements can be seen as a mean to an end.

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