TRADITIONAL, VERNACULAR AND NEWLY DEVELOPED CONSTRUCTION TECHNOLOGIES APPLIED TO THE SLAVE DESCENDENT WOMEN CLAM GATHERS COMMUNITY OF POVOAÇÃO DE SÃO LOURENÇO IN PERNAMBUCO, BRAZIL

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Abstract
The costal tropical areas of Northeast of Brazil, where manual labor is of utmost importance due to the irregular landscape in the sugar cane plantations, still maintains a vast tradition of vernacular housing in the wattle and daub (*taipa*) construction technique. This paper, addresses this historical building methodology in the village of *Povoação de São Lourenço* in the county of Goiana, State of Pernambuco, as the introduction of a new Technological Vocational Center, CVT, in part funded by the Brazilian Ministry of Science and Technology, starts to impact the local housing and building tradition. Yet, it appears that much of the local earth construction knowledge could and should be preserved. In existence for at least 4 centuries, this slave descendent population of 2,500 has the church of *São Lourenço*, the second oldest church of Brazil. Bordering the Goiana River, the geographical boarder between the States of Pernambuco and Paraíba, the local population impacts greatly the environment by the cutting of the remaining of the tropical forest and mangrove trees and bushes for cooking and wood for building. The introduction of alternative energy technologies (solar and high efficiency wood stoves), adobe and lime/cement stabilized earth blocks, along with vault and dome construction options can efficiently reduce the local forest and mangrove wood consumption, in an area that has been identified to be a forest sanctuary to preserve.

Construction and building methods in Northeast Brazil were comprised by the technology brought in by the Portuguese and adapted to the locally found materials during colonization, knowledge brought in by the slaved Africans, and the construction methods of the Indian populations in the occupied lands. Stone is scarce in the Northeastern Brazilian shoreline. Colonial churches and public buildings made use of great volumes of reef material, abundant and very near or on the beach. Cities as Recife and Olinda are great architectural colonial examples of how rocks from reefs, sandstone, and calcareous deposits were used in the foundations and decorative elements of historical buildings. Meanwhile, the aristocracy and trade's men lived in fired brick homes that used a mixture of clay, sand and lime as mortar and plaster. The general population, however, lived mostly in small wattle and daub dwellings. The inauguration of the Technological Vocational Center, CVT, in the women clam gathers community of *Povoação de São Lourenço*, which has a very low human development index, opens the opportunity of bringing together traditional and contemporary construction methodologies to the applied practice, as training masons learn how to improve or replace their

own *taipa* houses incorporating traditional and contemporary construction technologies with new materials developed in AERPA laboratories.

This paper presents the efforts of the partnership among the NGO AERPA, the Federal University of Pernambuco, UFPE, and the Ministry of Science and Technology of Brazil, MCT. The basis of a sustainable community is being fostered, as renewable energies, earthen architecture, micro water distribution and decentralized sanitation and housing betterment are being pursued in a region that deserves the preservation of its natural resources.

1. INTRODUCTION

The great metropolitan area of the City of Recife still has a few examples of 19th and early 20th centuries wattle and daub single-family buildings. They have been preserved mostly by their continued use (Fig.1), and by not being in the main path of the aggressive Brazilian construction industry. There are no City Hall planning or public policies to preserve earthen building structures (Fig.2), and there is no saying to the future existence of the few examples that have come down in time to us by pure stubbornness. As a matter of fact, new construction enterprises and the cement industry mock at the existence of earth buildings, as they are seen as primitive and unhealthy. But all of the structures that we had access to, that are still habitable, show fine examples of craftsmanship in construction, great details and stucco made of lime plaster, are very cool and comfortable in the inside and have been in usage for over an average of 150 years. Also, it is very interesting to observe the state of preservation of wood in the core of the wattle and daub walls – as in the absence of air, within the clay wall, oxidation is rather retarded and the wood presents itself quite fresh, mimicking the behavior of wood that is preserved underwater in archeological finds.

Fig.1 Wattle and daub 19th century train station in the old district of *Macacos* (now called Guabiraba, Recife.) A lime plaster outer layer protects the external walls from the tropical rains. The building has been preserved by the constant use of the original station keeper's family and is now a residence. (Credits: Plínio Santos-Filho, 2007)

Fig.2 This 19th century wattle and daub family home came down after thieves took its roof. It stood many years of neglect due to family estate litigations. This fine example of earth architecture has now been totally lost after the 2009 rains that turned it into a pile of rubble. County of Casa Forte, Recife. (Credits: Plínio Santos-Filho, 2008)

An important part of our current efforts is in *Povoação de São Lourenço*, located 70 km North of Recife, in the County of Goiana, State of Pernambuco, Northeast Brazil. Runaway slaves from sugarcane plantations between the 17th and 19th centuries founded it. The current population is about 2,500 individuals strong, and growing fast. Mother's with more than 6 children and teenage pregnancy is not uncommon. Women are mostly responsible for the small clam gathering that provides the families incomes. The male population works in the sugarcane fields or local industry, in activities that

are seasonal. During the off months, while the sugarcane is not ready for harvesting, there is hunger in the community and male alcoholism reaches its highest marks. Income for the poor families is mostly from federal subsidy programs, which require parents (usually single mothers) to send their kids to school in order to receive the Brazilian Government family scholarship (Pres. Lula's Bolsa Família Program.) It is estimated that the average family income does not exceed US$ 200/month. Also, there are the months when clam gathering is not permitted due to the reproductive cycle of the indigenous species. The Goiana River divides the States of Pernambuco and Paraíba. It's delta still maintains strips of the original vegetation and native tropical forest first found by the Portuguese settlers. Housing, outside *Povoação de São Lourenço* only main street, is rather simple and mostly made of the 30 m2 (330 ft2, on the average) homes (Fig.3), that are built using the local clay and a very thin and straight delta river mangrove plant, in a very primitive wattle and daub – *taipa* – manner.

Fig.3 Typical wattle and daub house in the community of Povoação de São Lourenço. There is very little finish to either internal or external walls. Wood is extracted the mangrove sanctuary down hill, causing great environmental impact. The floor plan is a rather standard 5 m x 7 m outer shell, with one division for a bedroom and no bathroom. Usually there are no bathrooms, and when they do exist, they are external to the house and consist of an uncovered hole in the ground. Usually there is a very primitive wood stove, African style, behind the house. (Credits: Plínio Santos-Filho, 2009)

The Agência de Estudos e Restauro do Patrimônio – AERPA, is a not-for-profit and non-governmental organization. We started working with the clam gathering women of *Povoação de São Lourenço* at the end of 2007. Local women had heard that we where conducting mason and craft courses in the city of Goiana, some 30 km away. We were invited to visit the *Povoação* back then, and after many stories and moons we are now firmly conducting mason classes that are beginning to build family homes, bathrooms, micro-water distribution systems and a small hotel that will train the local youth in the hotel industry trade.

In June 2009, we finished the construction of our Vocational Training Center (CVT) (Fig.4), a two story two building facility, that now houses classes and community meetings, and is being prepared to receive a 10 m2 mirror for the solar kitchen in the rear building concrete roof. AERPA social programs and its partnerships aim for social inclusion. We have approved 2 projects with the Ministry of Science and Technology of Brazil, MCT, in 2008 for the community, through the Project *Imaginário Pernambucano*, Department of Design and Development of Products, Federal University of Pernambuco - UFPE.

Fig.4 The two buildings of the Technological Vocational Center (CVT) in the clam gathering community of *Povoação de São Lourenço*, County of Goiana, State of Pernambuco, Brazil, were inaugurated in June 12, 2009. The architectural style remounts to 17th century Pernambuco constructions and was chosen because of the proximity to the Saint Laurence's Church (2nd oldest church in Brazil) that is 200 m away. The construction elements, i.e., its arches, columns, doors and windows are of molded lightweight concrete and imitate the aesthetics of the historical period retro-chosen. The building in front has two 6m x 12 m classrooms. Administration is on mezzanine top floor. The building behind will house the solar mirror on its rooftop, solar kitchen food processing on its first floor and ceramic shop on the ground floor. In between the two buildings a 1 m3 of usable volume gas/biomass kiln is planned to be in operation by the end of 2009. (Credits: AERPA, 2009)

2. MATERIALS AND METHODS

Northeast Brazil has a wattle and daub tradition for housing that remounts to the native Indian traditions before the Portuguese colonization. Current examples, still largely utilized for self building of homes in rural areas, are a mix of Indian and African knowledge and traditions brought together by the Brazilian mix of these cultures. The current cost of manufactured common construction materials as fired clay bricks, cement and coarse sand, along with their transport to *Povoação de São Lourenço* puts these materials out of the buying power of the majority of the local households. In this cash economy, on the other hand, by digging a couple of cubic meters right at a building site, one finds a soil rich in clay that has 70 % fine sand content. Poor houses in *Povoação de São Lourenço* have been built for centuries using clay and mangrove wood wattle and daub methods, without much artistic refinement or embellishments.

The pressure on the local native mangrove forest, along the Goiana riverside, as a wattle and daub wall-building component is enormous. Environmental Brazilian laws now prohibit any use of these woods as firewood or construction material. As part of AERPA' housing and decentralized water and sewage initiative, for the community, we started experimentations with alternative adobe bricks that were made with common shredded supermarket plastic bags (SSPB) (none biodegradable polyethylene, various grades and types) as substitution for the regular straw in the adobe. Also, 3-meter long braids made of SSPB are proposed as reinforcement elements for foundations and walls. Plastic braids are applied as replacement for reinforcing steel bar (rebar.) (Santos-Filho et al., 2009)

Social technologies we arrived thus far:

1) We have developed adobe bricks where the straw is replaced by shredded supermarket plastic bags. The contracting clay brick encounters a plastic fiber that hinders fissure development.

2) We have created and applied plastic braids made out of interwoven strands of supermarket plastic bags. 3 meter long braids are shrunk in the open fire of a wood stove (in our case a " Rocket type Stove" with very small wood consumption) or are shrunk inside a solar oven. The plastic braid shrinks and gains rigidity with the thermal treatment. The incorporation of this plastic rope horizontally within the adobe, rammed, or wattle and daub wall, strengthens the entire wall structure and can be used as a replacement for rebar.

3) We have deployed a 120 family micro water distribution system in *Povoação de São Lourenço* at cost. The homes served by the system no longer need their women and children carrying water buckets.

4) We have developed a 32 m2 popular house that is a hybrid of earthen and fired clay brick construction techniques. The walls can be rammed, adobe or wattle and daub, but foundations and roof, which is a catenary arch, are os fared clay bricks (Fig.5.) The architectural project is shown in Fig. 6. Much has been learned from Auroville (Auroville Earth Institute.)

We consider our brick arch technology as transitional. Lightweight open hole bricks are very common in Brazil and are affordable. 1000 bricks cost around US$ 100 these days, or the same as 10 cement bags of 50 kg. The inverted gravitational catenary arch, which is purely compressive, is made out of standard 8 holes Brazilian fired bricks. The local population considers the use of fired bricks in the construction of their homes as an improvement of life style and wealth. Our construction point of view regards the bricks arched roofs as practical and straightforward. Once the metal form was made (Fig.5), putting bricks arches up was simple and quick.

Fig.5. The 3.50 m roof span of the house is covered by an inverted gravitational catenary arch, and made out of standard 8 holes Brazilian fired bricks. (Credits: Plínio Santos-Filho, 2009)

The metal form, Fig.5 on the right, was carefully made after the catenary curve of a hanging chain. It is 1 m wide. In a day's work, the metal form can be placed twice and covered with bricks and mortar. One has to be careful to wait at least 4 hours to replace the metal form, to allow for the initial curing of the cement in the mortar. Also, a small amount of plaster of Paris can be added to the sand and cement mix mortar (3:1) to speed the hardening of the mixture. Newspapers can be used as release agents between the metal form and the placed bricks. Nylon cloth also works very well as a separation layer, as it does not allow the mortar to stick to the metal form and can be used over-and-over again, as one covers the length of the building. Once fully cured, after at least 3 weeks, the brick arch is covered with a layer of lime plaster (0.5 to 1.0 cm thick) for waterproofing. Nylon fiber can be added to the lime plaster for strength. The whiteness of the lime plaster will reflect the solar rays very effectively; extra thermal insulation for the roof is also achieved by the holes of the arch bricks – and the ceiling feels rather cool at all times. Courses of bricks in the arch can be spaced to accommodate plastic tubing for wires and lighting. If this spacing is over 5 cm, we suggest placing a ¼ " (or 5-8 mm) rebar as reinforcement in the bottom 1/3 of the opening, which is fully filled with the mortar in use.

In Fig.6, the design aesthetics makes use of the *Fibonacci Number* (Phi = 0.618) to obtain the floor and height proportions. For instance, the height of the arched roof is Phi x height of supporting wall. Other measurements follow the same logic, as we searched for the beauty implicit in the use of the *Golden Rule* proportions. Foundation is 0.80 m deep and is done with gravel and masonry waste – it is also elevated 0.30 m above ground. A mezzanine can be put above the single bedroom, thus, doubling the sleeping quarters. Also, the living room can turn into another bedroom. This house does not use any wood in its final state of construction. All doors and windows are made out of lightweight concrete that has been mixed to have a density near to that of the Brazilian hardwood *massaranduba* (1,260 kg/m3). The arched roof is made out of common (19 cm x 19 cm x 9 cm) 8 holes fired bricks and weighs a total of 1,800 kg when plastered on both sides. This implies that only 900 kg rests over the 8 m extension on either side wall. As a fact, the two horizontal forces are only 6,250 N, or 780 N per linear meter of supporting wall. These two linear forces have been counter acted by a 15 cm thick by 10 cm height tie beam that has two 10 mm diameter rebars for reinforcement. The foundation has also been reinforced by a similar tie beam. The walls are rammed earth of 15 cm of thickness. In *Povoação de São Lourenço* the soil is 30 % clay and 70 % very fine sand which makes for great adobes and also ram compacting.

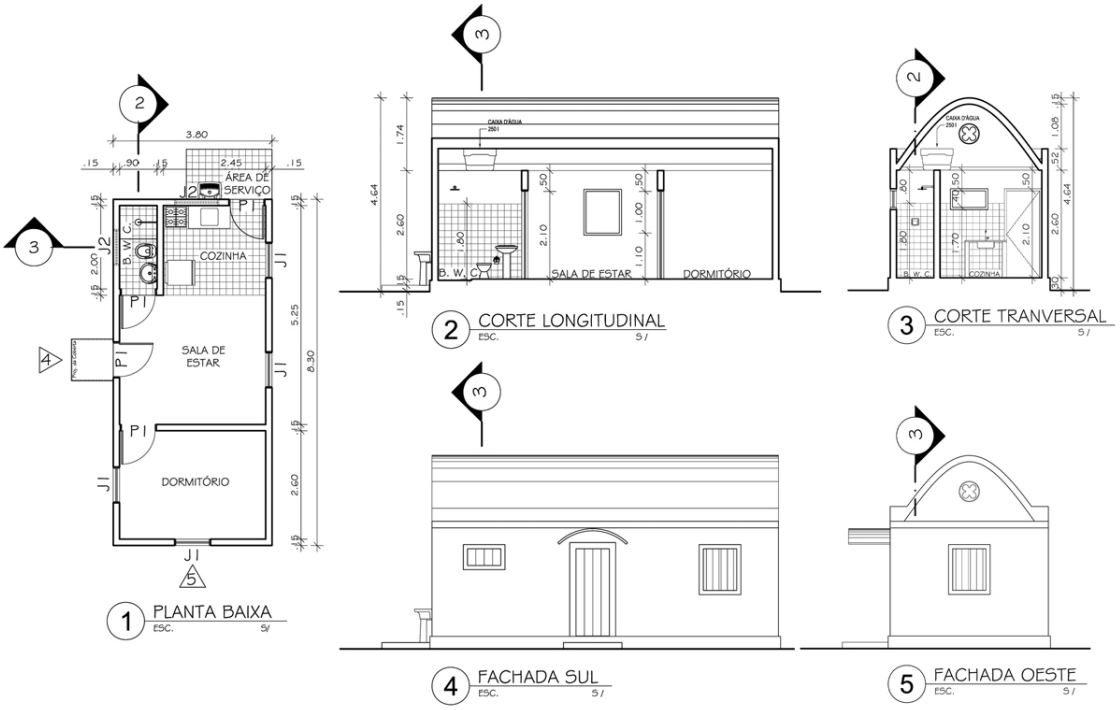

Fig.6 Ground floor and views of our 32 m2 popular residence. All measurements are in the metric system. The design aesthetics makes use of the *Fibonacci Number* (Phi = 0.618) to obtain the floor plan and height proportions. (Credits: AERPA, 2009)

Waterproofing the external walls is done by applying a mixture of coarse sand, plaster, lime and cement (proportions 6:1/2:1/5:1.) The outer layer of the roof is covered with a pure layer of lime plaster of 0.5 cm to 1 cm thick. To avoid cracking, the hydrated lime has been mixed with fine nylon fibers for reinforcement, in a proportion of 0.6 kg of fiber per m3 of lime plaster. Internal walls are left as rammed or are covered by a thin layer of earth, coarse sand and lime (2:2:1.) Lime wash covers the whole building, improving resistance to fungus and mold and reflection of solar radiation.

3. CONCLUSIONS

With the construction of the Technological Vocational Center (CVT), regular classes on artistic and functional ceramics, solar kitchen cooking of seafood and courses on adobe and stabilized earth blocks construction techniques for sustainable housing and decentralized water and sewage systems have started in the community of *Povoação de São Lourenço*. The construction of a popular house of 32 m2 as the demonstration unit and as a hands-on experience for our masonry students and community is changing the way earthen architecture is perceived by the locals and visitors. An effort has started to disseminate the technologies thus far developed to the States of Paraíba and Maranhão, also in Northeast Brazil. Having doors and windows made of lightweight concrete, made us avoid using wood in the construction of popular houses and other buildings. Having roofs made as lightweight arched structures and walls that can be rammed earth or adobe made us realize that the ideas and technologies herein presented are simple and show great promise in the road to sustainability.

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