Resilient Structures and Sustainable Construction
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PRESERVING TRADITIONAL CONSTRUCTION TECHNIQUES AND MATERIALS AS AN ANSWER TO FUTURE ENERGY-FUEL CRISIS

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Once a highly skilled and experienced professor told us: the future of architecture is in its handcraft past. We were not able to completely understand him at that time. Looking forward to the future where architecture and engineering professionals will perform facing energy fuel crisis and global warming, an endogenous approach, working with what is available, may be a subsistence tool. Preserving and further development of traditional construction materials, methods and techniques now has become a must, not form the cultural heritage stand point but as a survival instrument. In this paper we will analyze three different roofing systems, two of them ancestral techniques; toquilla leaf roof and straw thatch roofs, using them in real contemporary construction circumstances by incorporating them into the professional life through real construction projects and the educational system through *Con lo que hay*[1], a design-build class room in architectural school in Ecuador, facing them with conventional zinc metal roofing. This study will show the impact of recovering these techniques and materials within the academic, the professional, scientific development and on the local economies.

Keywords: Heritage, Preserving culture, Endogenous, Ecuador, Zinc metal roof, Straw thatch roofs.

1 INTRODUCTION

Once a highly skilled and experienced professor told us: the future of architecture is in its handcraft past. We were not able to fully understand him at that time. Design, architecture, engineering have much to do with envisioning and projecting for what is to come. Sometimes it is like an act of witchcraft in which we project a specific design to solve a specific problem. "The ancient craftsmen were the technologists in the pre-industrial era and learned a great deal from centuries of trial and error, using acute observation to analyze causes and so to guide corrective action. There is much we can learn from ancient skills and technology" (Feilden 1981). When trying to envision the environment in which future construction professionals will work in, both architects and engineers, fuel crisis and global warming come to mind.

This study will explore the necessity of preserve ancient local construction techniques in order to train future professionals to face the energy crisis with endogenous techniques. First, exploring the probable future environments within the energy crisis and the socioeconomic

[1]*Con Lo Que Hay* (CLQH): With what is available, academic workshop thought by Ensusitio, hands on experience for college students. A pre-professional opportunity where academic knowledge is applied in a specific community. A participatory design process to evaluate a real need followed by a consensus based design process and community construction of the infrastructure.

endogenous approach in order to face it. Based on the principles of thinking and acting with what is available, we define the pertinence of preserving the ancestral construction methods not as a mere cultural heritage, but as a survival tool. By using two case studies, traditional roofing systems, within two different environments, the Ecuadorian Andes and the jungle, we will show their impact within the professional and academic fields as well as the community by comparing them with conventional roofing construction systems using metal zinc roofing.

Thinking about energy crisis, "energy constraint and global warming are the biggest challenges confronting the planet. (…) The analysis carried out by the US Energy Information Administration (EIA) estimates that, by 2030, global energy consumption will have grown by over 70% (EIA 2007)" (Foruzanmehr 2008). Also having in mind that "the building industry is a giant amongst energy consumers; its use of energy is divided between the production, operation and demolition phases of buildings, and amounts in total to no less than 40% of all energy used in society. Sustainable construction is thus one of the most important challenges we face." (Berge 2000). Choosing carefully the material of a building is one of the biggest challenges, "it is thus becoming clear that the issue of building materials is in fact as important as the issue of reducing operational energy use in buildings." (Berge 2000). Other than the ecological footprint and the monetary cost, think of a future environment where there will be almost no possibility to move materials, having to use what would be available. Are we being trained and are we training professional capable of reacting to this probable future?

Within this possible future two courses of action are expected: endogenous and exogenous approaches. The "endogenous development: a development by and for local communities, focused on building a community of interest in production and consumption, where economic exchanges are "embedded" in proximity social relations." (Dissau 2014), in other words it deals with acting and thinking local, not denying the current technology environment. In contrast the exogenous sees development as continuous growth which in face of the energy consumption projections, mentioned before, might be disastrous. Comparing monetary systems, an exogenous approach leads to an accumulation monetary system, where there will be shortage, competition, continued growth, individualism, power concentration and conquest or colonization, in the other hand, endogenous approach leads to no accumulation, sufficiency, cooperation, sustainability, dispersion of power, unkeep and maintenance.

For ages the meaning of cultural heritage had been associated with the past and the value of preserving our memory, but looking forward thinking local might be a survival tool. In fact, "the term 'cultural heritage' has changed content considerably in recent decades, partially owing to the instruments developed by UNESCO. Cultural heritage does not end at monuments and collections of objects. It also includes traditions or living expressions inherited from our ancestors and passed on to our descendants, such as oral traditions, performing arts, social practices, rituals, festive events, knowledge and practices concerning nature and the universe or the knowledge and skills to produce traditional crafts." (UNESCO 2017) Furthermore, "fragile, intangible cultural heritage is an important factor in maintaining cultural diversity in the face of growing globalization. An understanding of the intangible cultural heritage of different communities helps with intercultural dialogue, and encourages mutual respect for other ways of life." (UNESCO 2017). Preserving not only the product but the process it has been made is a must in order to train future professional and communities to act endogenously.

Traditional construction systems are in danger because new imported technologies are cheaper and faster to build. It is important to say that the endogenous standpoint does not deny technology or its development. The idea is to have a proper analysis of each technology and its pertinence for each environment where it would be implemented; this means an appropriate technology transfer process where the product is not only the outcome but also the process itself.

It is a process in which the technology evolves and incorporates technology because it is more effective. "Appropriate technology is a grass roots approach to technology that builds a strong sense of community and encompasses benefits that span across social, environmental, cultural, economic, and spiritual facets. Appropriate technology is not a one size fits all approach, but rather adapts to best fit the community in which it is developed. Appropriate technology best fits with the community it serves because it is created by the people to meet a need. Therefore, the communities are placed at the center of decision making and create technologies that will best serve their communities in the long term." (Margolus 2011). By having this appropriate technology transfer and development another important aspect of construction come to mind**,** social fabric "… fabric is a component of behavior that unites and allows the identification of individuals as part of a group, culture, tradition or nation or allows the establishment of rules conditioning of the interaction." (Ciudadana 2011), most of the exogenous technology also imports man power leaving local manufacturers with no work, most of the times the process of building with local and ancestral technologies, although it takes more time and effort, strengthens the communities and its links.

Three examples will be used of roofs in Ecuador in order to illustrate the impact of each one in social fabric, comfort and environment. The first two processes taken from the course "*Con Lo Que Hay*" (with what is available) where the idea is to work with a specific community and with a group of students on a design built project. The rule is to work by hand and with what is on hand in order to create, for the students, the professionals and academics involved and the communities, the consciousness of the importance of thinking first about their own resources and the impact that they might have on their infrastructure and in their communities.

2 ANDEAN STRAW THATCH

Since the beginning of the settlement of Ecuadorian territory, the Andean inhabitants use straw thatch roofs. "The evidence of the integration period, from 500 A.C. to 1500 B.C. consists of remains of villages and homes built on mud and straw roof, which were built surrounded by stone walls." (Adventure n.d.). At the present time, Andean dwellings are built with block and zinc even if these materials are not favorable for climate conditions. See Figure 1.

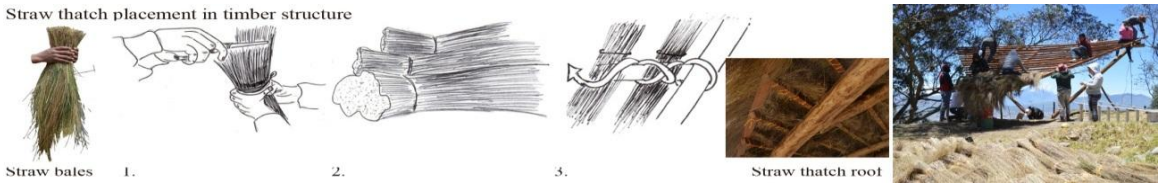

Figure 1. Straw thatch roof construction process. *Con lo que hay* drawings. Ambatillo Project.

After a process held with *con lo que hay* workshop in the Andean community of Ambatillo (3,200 m above sea level), in the construction of the "Ambatillo Lookout", the immediate answer from locals was a mixture of longing and surprise at seeing the ancestral technology in use again. Luis Moreta, community president, commented: "Thanks for the work done here; I think it is visible and that it's what the parish needed. For the first time – and I am from the highland –I see this type of straw mooring and the wood work that my ancestors used to build." During both the design and the construction processes the community and students were involved and in order to build the project fast and economically it was decided to use what was available: wooden structure and a straw thatch roof. This process required more effort, harvesting the materials brought together students and community and strengthened the social fabric.

The final product is a touristic lookout built mostly using ancient techniques applied in a contemporary environment and with a contemporary design.

3 TOQUILLA STRAW ROOF

In the book La Ecoarquitectura (Izquierdo 2000), the first references about *Los Huaorani* (Amazon inhabitants of Ecuador), dates from the XVII century. Since then, the traditional dwelling was built with *Guadua* for the structure and a diversity of vegetable layers such as toquilla leaf for the roof. Since 1940, Ecuador faced a new stage in its economy, many oil enterprises entered Amazon territory, and introduced new technologies such as metal roofs. Nowadays, Amazon communities are in danger of losing ancestral building technologies because of the use of foreign materials. See Figure 2.

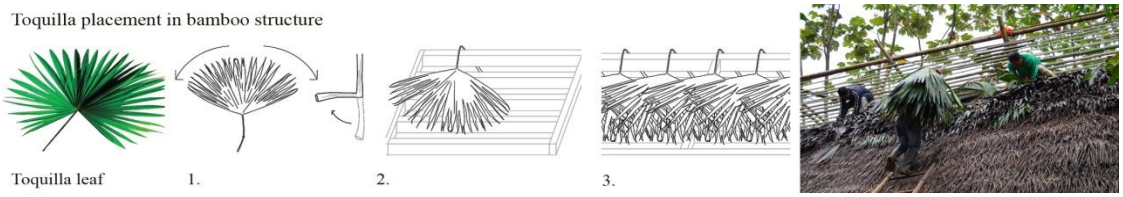

Figure 2. Toquilla Straw roof construction process. *Con Lo Que Hay* drawings. Cocoa Cabin Project.

After a year of work with a *Con lo que hay* workshop in the building of the "Cocoa Cabin" in an Amazon community, the president Bolivar Alvarado, manifested, "I thank the workshop "*con lo que hay*" and Pacari chocolate company who have brought us this project and in which we have worked together, community and students, sharing and making an important support for the good of Santa Rita and its families. Never in my life have I seen such a big construction for the enrichment of the community becomes a reality. Thanks to this construction, the community has changed. For the first time people have come and made an effort to work together with the community and give valuable input. The project we are receiving is a first step forward, and in this way we grow strong as Santa Rita Community".

Students and community shared the design and construction processes and in order to make the project monetary cost cero the choice was made to work with bamboo and toquilla straw because those materials are endemic in the area. This process took longer and involved most of the families of the community because of the harvesting process which strengthened the necessary social fabric.

The final product is the Cacao Cabin, a place for the interchange of knowledge based on the cacao culture. It is a building that incorporates ancient techniques applied in a contemporary environment and with a contemporary design.

4 ZINC ROOF

As in Ecuador, "metal roofing in Kota Kinabalu practically became the norm for low-cost houses, considerably contributing to heat gain and increasing the indoor temperature. Such roof system requires particular attention, since it is the most envelope building part exposed to solar radiation." (Harimi *et al.* 2005).

Zinc has been used in order to build fast and cheap, in most areas of Ecuador, the Andes, Coast and Jungle use this roofing system. Zinc probably came into use around 500 BC. It has commonly been used as roofing material and later to galvanize steel to provide corrosion resistance. (…) Zinc is susceptible to aggressive atmospheres. In ordinary air conditions, one

can assume a lifespan of 100 years for normal coating; but only a few years near the sea air, in damp city air or industrial air. The use of this material is immediate and easy to install; only two people are needed. But the consequences in the long run are quite negative. Zinc does not provide thermal support, it is a carcinogen, and because of equatorial sun, its life cycle is short, making it necessary to replace, creating economic dependence. See Figure 3.

Figure 3. Zinc roof construction process.

Thinking about the production process, "When zinc is broken down, the zinc particles are absorbed in earth and water. In higher concentrations, zinc is considered toxic to organisms living in water (Berge 2000). On the other hand "Plants are renewable resources that can be cultivated and harvested on a sustainable basis. Given sensible methods of cultivation they are a constant source of raw materials. (…) The production of plant-based building materials is mainly local or regional. Energy consumption for processing and transport are relatively low, as is pollution occurring at the cultivating, harvesting and refining stages. This favorable environmental profile will be reflected in the building's overall ecological footprint, as well as by a good indoor climate." (Berge 2000). While, "metals have limited reserves and demand exceeds the maximum possible supply of scrap, for steel by a factor around two. On current statistical predictions, iron reserves will last 95 years, aluminum 141 years, copper 31 years and zinc 22 years." (U.S. Geological Survey 2007).

5 CONCLUSIONS

Social fabric and manual labor although are easy and fast when using zinc the social fabric and community links diminish in contrast with the use of local straw. Local produce and harvested construction materials strengthen the community involvement in the building process rather than the individualism; this is one of the pillars of endogenous thinking. Although zinc apparently has a low maintenance, in the long run the cost is higher because people would have to buy new material, on the other hand when using local natural straw, the local material is always there but it demands time and effort to harvest and treat. The health and comfort characteristic of natural straw versus zinc is dramatic. See Table 1.

Table 1. Comparison between straw thatch roof, toquilla straw roof and zinc.

	STRAW THATCH	**TOQUILLA STRAW**	**ZINC**
Cooperation/Social fabric	high	high	low
Installation labor	4 workers + community	4 workers + community	2 workers
Sufficiency /Accessibility	harvest/time	harvest/time	immediately available
Sustainability/Production	Sow, harvest and treat	Sow, harvest and treat	Industrial, buy+install
Maintenance	high	high	low
Thermoacoustic	high	high	low

Zinc does not provide thermoacoustic comfort but it could be hazardous, even cancerous. Thinking about a cost-effective material, zinc would be a choice for the immediate need, although in the long run it not only will be more expensive but also could harm the social links with the community and the health of the people that use it.

When students confront these facts, the way they view the construction profession changes to an endogenous focus, one that faces future challenges with a wider understanding of the process rather than one limited to a particular manufactured product.

"In the building of his shelter primitive men faced one supreme and absolute limitation: the impact of the environment in which he finds himself must be met by the building materials which the environment affords. (…) Yet primitive architecture reveals a very high level of performance, even when judged in the light of modern technology. It reflects a precise and detailed knowledge of local climate conditions on the one hand, and on the other a remarkable understanding of the performance characteristics of the building materials locally available. (…) The primitive architect works in an economy of scarcity – his resources in materials and energy are severely restricted." (Marston and Branch 1960). Thinking back on what our professor told us: the future of architecture is in its handcrafted past, not only its future but its present, by reducing the ecological footprint of most of the construction materials the environmental impact will be reduced, local economies and social fabric will be empowered.

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