Haiti: post-earthquake lessons learned from traditional construction

JOEL F AUDEFROY

Joel Audefroy is a Senior Lecturer and Researcher at the ESIA–Tecamachalco Campus, Instituto Politécnico Nacional (IPN) of Mexico, and also a consultant with Habitat International Coalition, Latin America Office (HIC–AL). He is an architect by training, holds a doctorate in Ethnology, and is a member of ICOMOS Mexico and the National System of Researchers.

Address: ESIA–Tecamachalco, Av. Fuentes de los Leones 28, Colonia Tecamachalco, Naucalpan de Juárez, Estado de Mexico C.P. 56500, Mexico; e-mail: takatitakite@gmail.com

Acknowledgement: The author would like to thank the following institutions: Caritas Mexico and Haiti, for allowing the implementation of a post-disaster identification mission in Haiti; Habitat International Coalition, Latin America Office (HIC–AL) and the Centro Lindavista of Mexico for their role in organizing the mission; and the Instituto Politécnico Nacional (IPN) of Mexico for financing the research.

ABSTRACT This paper considers the potential contribution of traditional construction techniques and materials to rebuilding in Port-au-Prince and other areas in Haiti that were devastated by the 2010 earthquake. Based on different examples of housing that collapsed or was damaged by the earthquake, it shows how traditional construction systems often demonstrated better resilience to earthquakes than buildings constructed with modern materials. But it also describes the erosion of traditional knowledge and the pressure on those with traditional building skills to work with modern materials and techniques. It highlights the need to better understand and draw on traditional knowledge while also recognizing that this knowledge needs to evolve and innovate. This includes, where appropriate, the use of modern techniques and materials to help rehabilitate traditional structures and thus combine safety with preservation of a rich architectural heritage.

KEYWORDS disasters / earthquake / Haiti / heritage / housing / traditional knowledge / vulnerability

I. INTRODUCTION

The Caribbean region of which Haiti forms part is vulnerable to earthquakes. The fact that there had been none in the region for several decades led Haitian authorities to affirm that earthquakes had never occurred before the great disaster of 12 January 2010. In reality, the history of earthquakes on the island shared by Haiti and the Dominican Republic, known as Isla Española, demonstrates a recurrence of quakes: 1502, 1562, 1673, 1684, 1701, 1751, 1761, 1770, 1842, 1860, 1887, 1904, 1911 and 1946.(1) The January 2010 earthquake, which measured 7.0 on the Richter scale, devastated a large part of the city of Port-au-Prince, as in 1751 and 1770. The effects on Haiti, the poorest nation in the Americas, have been devastating. More than 150,000 bodies had been recovered by 25 January and the official number of dead eventually reached 200,000. More than 250,000 people suffered often devastating injuries and 1.2 million people were left homeless. The 2010 Haiti earthquake is considered one of the largest humanitarian catastrophes in history. Post-disaster evaluations have revealed that the majority of the destruction was caused by the poor quality of construction materials, which proved too structurally weak to resist the lateral and horizontal forces unleashed by the earthquake.

The increased vulnerability of the structures may be attributed to various factors such as poor construction quality, lack of maintenance, absence of building codes, and improperly implemented modifications

1. Semesterly Newsletter of l'Observatoire Météorologique du Séminaire College St Martial, quoted in Suarez, Gerardo, Virginia García Acosta and Rogelio Altez (2010), "Un desastre más allá del Terremoto", *Letras Libres* Año XII, N° 135, March, Mexico, pages 20–23.

and additions. In the majority of cases blame has been attributed to the vernacular structures, "built without architects" using traditional construction materials and techniques, perceived as outdated and weak and which in the post-disaster reconstruction phase will be replaced by so-called "modern" construction systems and materials. These "modern" systems, using concrete, were first introduced in Haiti in the 1920s, with the construction of public buildings such as Haiti's National Palace by the architect Georges Baussan in 1924.

What is so-called "vernacular architecture"? If we revisit the definition established by Paul Oliver in the *Encyclopedia of Vernacular Architecture of the World*, we find that it very accurately describes the traditionally constructed vernacular home in Haiti:

> "Vernacular architecture comprises the dwellings and all other buildings of the people. Related to their environmental context and available resources, they are customarily owner or community built, utilizing traditional technologies. All forms of vernacular architecture are built to meet specific needs, accommodating the values, economies and ways of living of the cultures that produce them"(2)

However, several studies in seismic regions(3) have revealed that many so-called vernacular structures (the house: *la kay)* have demonstrated highly acceptable behaviours during earthquakes as a result of traditional construction systems developed over the course of long periods of time. Yet despite this, the majority of these structures have become more vulnerable due to various factors, including a gradual loss of local traditional knowledge. This article explores the reasons for this loss of knowledge and this vulnerability in the context of the regions affected by the recent earthquake in Haiti.

The challenge therefore is how to return to traditional knowledge in a way that fits within a contemporary construction context. This paper seeks to outline critical paths to achieve an adaptation of traditional knowledge to the contemporary structures necessary for a sustainable future.

II. HAITI: A COUNTRY VULNERABLE TO DISASTERS

The last earthquake to hit Haiti prior to January 2010 was in 1946, more than 50 years ago. The population had therefore forgotten that the country, and Port-au-Prince in particular, was vulnerable to earthquakes. Both "modern" and "conventional" structures suffered grave damage, causing great loss of human life and property. Many of the country's cement constructions (RCC) did not comply with basic construction norms, for example very heavy concrete slabs spanned clearings more than three metres long between supports (Photo 1). In other cases, floors and roofs were built with no reinforcements and the weight of the slabs brought buildings tumbling down like houses of cards (Photo 2). In some structures, walls that were built too thinly could not resist strong tremors or the weight of the slabs. In other instances, concrete beams were not well enough secured to the concrete columns and were unable to withstand the lateral movements of the earthquake.

Some vernacular structures built of wattle and daub failed to resist the earthquake due to the poor quality of the materials used. Stones were set

2. Oliver, Paul (1997), *Encyclopedia of Vernacular Architecture of the World*, Cambridge University Press, UK, three volumes, 2,500 pages.

3. See works by FUNDASAL in El Salvador, Craterre and ITDG in Peru, and several publications by the ICOMOS network, including *Heritage at Risk*. See also Jigyasu, Rohit (2008), "Structural adaptation in South Asia: learning lessons from tradition", in Lee Bosher (editor), *Hazards and the Built Environment*, Routledge, London, pages 74–95; also Revi, Aromar, Rajendra Desai et al. (1993), *Action Plan for Reconstruction in Earthquake-affected Maharashtra*, TARU, New Delhi; and Sanderson, David and Anshu Sharma (2008), "Winners and losers from the 2001 Gujarat earthquake", *Environment and Urbanization* Vol 20, No 1, April, pages 177–186.

PHOTO 1
Heavy concrete slabs spanned clearings longer than three metres, Port of Prince, Haiti

© J Audefroy

PHOTO 2
The weight of the slabs caused buildings to collapse like a house of cards, Port of Prince, Haiti

© J Audefroy

PHOTO 3
A lack of maintenance weakened walls, contributing to their collapse, Decoville, Haiti.

with poor quality mortar and a lack of maintenance weakened the walls, contributing to their collapse (Photo 3). An absence of reinforcements (buttresses) in the wooden structures of wattle and daub walls also weakened the structure of the walls and their resistance to lateral forces. The corners of wattle and daub walls were insufficiently reinforced and some were compromised, although this did not always result in their collapse (Photo 4).

Earthquakes have always occurred in Haiti, but this was the first to take place in the context of such high population densities in the city of Port-au-Prince. One could question why so-called "modern" concrete and block constructions did not respect current construction norms? And the answer would be because these norms do not exist in Haiti.

The key principles for building a home that is resistant to both earthquakes and hurricanes have been presented in various publications, which unfortunately have been poorly distributed. The ISDR[4] has published a booklet on housing improvements in Haiti, specifically to optimize hurricane resistance. It details more than a dozen specific sensitive points to be reinforced during housing construction, for example that wooden posts should be anchored to the foundations and that roof beams should be anchored to the wooden structure. In the case of earthquakes, the specialized literature emphasizes that buildings are subjected to torsion effects, vibrations and rotations. Recommendations are made regarding designs that lean towards regular configurations, to favour symmetry and to balance the distribution of structural elements to impede horizontal and vertical movements. But in the case of earthquakes, the quality of the

4. ISDR: International Strategy for Disaster Reduction.

PHOTO 4
The corners of the wattle and daub walls were insufficiently reinforced, Decoville, Haiti.

© J Audefroy

soil plays an essential role, and well-constructed apartment buildings in Haiti collapsed because they were built on soft landfills.

III. WHAT HAPPENED TO THE TRADITIONAL CONSTRUCTION SYSTEMS?

An inspection of the regions around Port-au-Prince affected by the January 2010 earthquake revealed several examples of good quality traditional constructions that were not affected by the earthquake. We found structures that used the wattle and daub technique (a wooden structure filled with stone and bound together with a mix of lime and earth) called *clissage* in Haiti. These structures responded much better to the telluric movements than the modern structures in downtown Port-au-Prince. Good examples of such constructions may be found in the village of Noailles, in the Croix des Bouquets neighbourhood, which

PHOTO 5
Residences of artists and craftspeople in Noailles, Croix des Bouquets, Haiti.

© J Audefroy

is an old village that now forms part of the outskirts of Port-au-Prince. Croix des Bouquets owes its origins to a disaster. The old village of Cul de Sac, located downriver, was the main settlement of the central district and plains region. The old part of the city was washed away in 1751 and the population transferred to the new village of Croix des Bouquets. The Spanish who crossed the region from the east customarily deposited flowers at the foot of a large cross built on the spot, and from that practice the place came to be known as La Croix des Bouquets.

Approximately 1,500 families live in the village of Noailles and the centre is occupied by close to 100 families of artists. Since the creation of the village in 1953, a group of some 15 notable individuals has assumed responsibility for organizing a land ownership promotion operation. Plots or small homes, generally consisting of one four-square metre room and a terrace, are rented or sold. However, the neighbourhood is severely deteriorated and necessary maintenance has not been kept up. The artists and craftspeople live with their families a short distance from their workshops, in traditional style homes without running water or sanitation systems. The highly deteriorated habitat consists of wattle and daub housing, designed along the traditional Haitian model of twin-sloped roofs and a front porch. The situation of the community's inhabitants worsened following the January 2010 earthquake, which damaged 25 per cent of the village's homes and destroyed the workshops and residences of seven artists and craftspeople in Noailles (Photo 5).

Another traditional construction system consists of wooden homes with the traditional twin-sloped roof, and walls formed by horizontal

PHOTO 6
A wooden house with the traditional twin-sloped roof, Decoville, Haiti.

© J Audefroy

wooden boards. This design can be found in the Las Cahobas region. The roofs are generally made of corrugated sheets that do not add weight to the construction; however, they offer little resistance to hurricanes (Photo 6). There are also wattle and daub houses in the region, again with twin-sloped roofs and front porches (Photo 7).[5] The pediment of the roof is made of wooden boards. The conception of the traditional Haitian home means that in addition to being more resistant to earthquakes, it also uses local materials and responds to the tropical climate conditions of the Caribbean. For example, evidence exists that the wooden homes in Port-au-Prince have long resisted hurricanes and earthquakes, given that we may still find today homes built in the early twentieth century. In fact, all of these risk factors play a significant role in the evolution of the vernacular architecture in several locations.

Regarding the materials employed, lime and sand mortar is traditionally reserved for graves, the definitive housing of the ancestors, while the more ephemeral homes use white or coloured lime only as a finishing coat for walls or on the floor of the drying area.

5. The porch appears to have been introduced to the colonial home in the nineteenth century. See Arrington Phillips, Anghelen (1975), *Gingerbread Houses: Haiti's Endangered Species*, Impr. H Deschamps, 92 pages.

IV. TRADITIONAL AND LOCAL KNOWLEDGE FOR DISASTER MITIGATION

In light of what we found in the aftermath of the Haiti earthquake, it seems important to discuss the nature and reach of traditional and

PHOTO 7
Wattle and daub houses with twin-sloped roofs and front porches, Decoville, Haiti.

© J Audefroy

local knowledge. This locally developed knowledge has demonstrated technological levels developed by skill factors. However, this is the result of much practice, and is culturally rooted more than holistically directed. One theoretician of this local knowledge is the English anthropologist Paul Sillitoe, who describes this knowledge as follows: "*Local people think and manage their general environment as a whole system*."[6] The tangible manifestation of this local knowledge can be seen in the housing construction process, while the skills and cultural practices constitute the intangible element. An inseparable bond exists between the cultural and social practices and local knowledge.

This knowledge is constantly evolving, being assimilated and adapted to needs, obstacles and aspirations. It has been experimented with over long periods of time and integrated into a broader cultural context. For example, the so-called "Caribbean home" can be found in Venezuela, Cuba, Jamaica, Haiti and other Caribbean islands. During this long process, new materials, techniques and architectural designs have been assimilated into various models and vernacular forms. Given that this knowledge is in permanent evolution, it is not possible to profile a model of traditional knowledge that has been frozen in time.

The physical manifestation of traditional knowledge is generally found in the vernacular structures. Subtle variations in and adaptations of traditional knowledge must be observed according to the diverse typologies of the vernacular environment in which applications are found. These typologies are developed based on diverse factors such as

6. Sillitoe, Paul (1998), "The development of indigenous knowledge. A new applied anthropology", *Current Anthropology* Vol 39, No 2, pages 223–252.

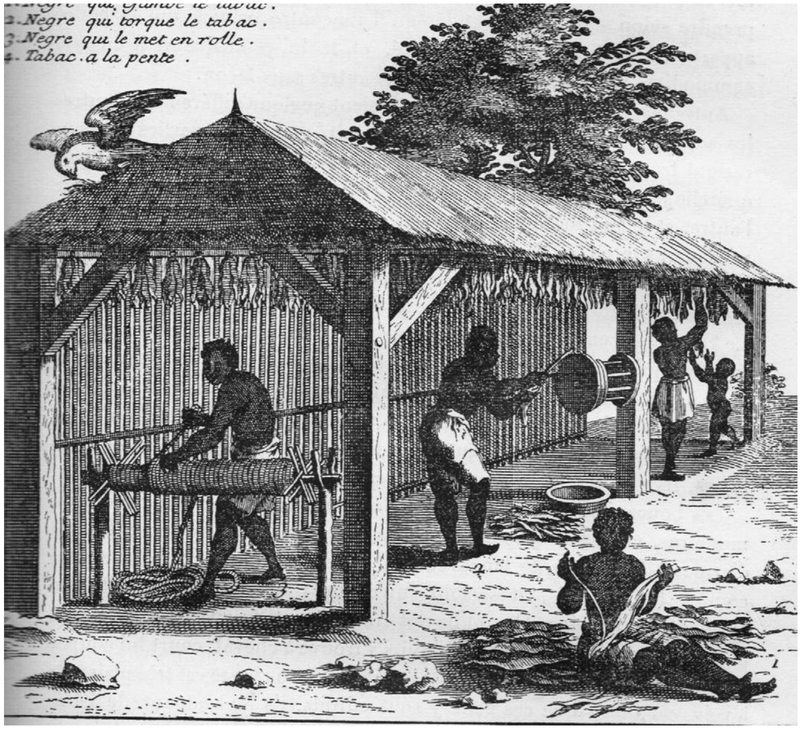

PHOTO 8
Buildings used to process yucca and tobacco

SOURCE: Oexmelin, Alexandre (1930), *Les Aventuriers et les Boucaniers d'Amérique*, Editions du Carrefour, Paris, page 280.

geographical location and the social or economic contexts that translate into different families of variables that correspond to distinct structural and architectural elements. However, it would not be very pertinent to affirm that the mitigation of hazards is the only criterion for the evolution of traditional knowledge, which is, in fact, the conscious or unconscious result of multiple factors.

A clear distinction must also be made between authentic traditional constructions and hybrid vernacular forms. For example, Ramón Gutiérrez notes that the Haitian sugar plantations for the French and the slave trade for the British were key for the respective economies up until the early nineteenth century, and both influenced the forms of human settlements.(7) The hybrid forms are the result of a whole set of variables, and there is no doubt that, in the case of Haiti, the constructions for the sugar plantations and those for processing yucca influenced the vernacular housing design that the black populations had brought over from their respective African countries. A book by Oexmelin published in 1930 includes some illustrations of buildings used to process yucca and tobacco. A comparison of these drawings with traditional Haitian housing designs reveals some clear similarities (Photo 8). It is pertinent to

7. Gutiérrez, Ramón (1994), "Los ingenieros militares en las fortificaciones del Caribe", in Ramón Paolini, *El Caribe Fortificado*, Editorial Escala, Bogotá, Colombia, pages 31–49.

ask whether these buildings were in fact adapted to the hazards particular to the region.[8]

8. Oexmelin, Alexandre (1930), *Les Aventuriers et les Boucaniers d'Amérique*, Editions du Carrefour, Paris, 370 pages.

V. SOME CRITICAL ISSUES REGARDING THE VULNERABILITY OF VERNACULAR HOUSING

a. Loss of traditional knowledge

Over the past 10 years, production of traditional housing has fallen considerably due to a large number of factors. The consequence is that buildings are becoming increasingly vulnerable to disasters and, in some cases, vulnerability has further increased as a result of inadequate reconstruction programmes. The motives behind this loss of traditional knowledge need to be more thoroughly examined.

First, economic factors tend to motivate inhabitants in the selection of construction materials. For example, wood used to be one of the primary housing construction materials in various earthquake-prone regions in Haiti, and when properly combined with stone rubblework helped increase seismic resistance. However, over time, wood became expensive and its quality deteriorated and people began to make modifications to structures, which in many cases resulted in constructions that were more vulnerable to earthquakes. For example, in Decoville, near the border with the Dominican Republic, people have built modified wooden structures with no vertical or horizontal reinforcements (Photo 3), making them very vulnerable to seismic movements and to hurricanes.

The loss of traditional knowledge is also linked to underdevelopment and poverty, which results in lack of maintenance, lack of traditional resources and erroneous perceptions of the local context.

b. Subjective perceptions of the use of traditional materials

The so-called "modern materials" are currently considered to be the optimal solution for housing construction; for example, the use of cement rather than traditional materials such as earth and stone, which are widely perceived as "weak", dangerous or outdated. Despite this, no consideration is given to the fact that some of the modern materials' specifications are not applicable in certain tropical areas. For example, it is impossible for concrete to set thoroughly in flood-prone areas, and the use of cement flooring is inappropriate in areas where soils have a high clay content. However, the lack of resources forces people to make poor choices regarding construction.

In many cases, and not only in Haiti, once the rubble from earthquake-damaged homes has been cleared away, people tend to re-build with modern materials, despite the fact that the traditional constructions withstood the seismic movements better than the modern structures, which suffered more complete collapse. After an earthquake, people are generally left on their own, without technical assistance and with no options to choose from. They may be provided with a minimal roof as quickly as possible but with no possibility of completing a home and they are left with even poorer housing than they had before. These constructions, often built in a very short timeframe, are made of materials foreign to the location and do not take into consideration the local cultural models in terms of design. They are also often designs that do not allow progressive development and hence prevent any subsequent expansion of the housing.[9] Replacing traditional local materials with concrete and cement blocks is economically unsustainable given that these materials are very expensive for poor families, who are unable to continue the housing construction through their own means. As a result, people re-build as best they can themselves, with local materials but without applying anti-seismic technical specifications. These considerations remind us of the importance of long-term reconstruction, given that short-term reconstruction does not take into account existing networks, local know-how and existing civil or religious organizations that could play a role in long-term reconstruction. However, not all NGO reconstruction projects use traditional materials, although one is doing so – the German agency MISEREOR is building 22-square metre homes in Rivière Froide at a cost of US$ 2,350 (not including design and supervision costs). Other Catholic organizations are using modern construction systems, with cement blocks and concrete columns.

Currently, the situation in Port-au-Prince is even more dramatic for the populations living in the camps, many of whom did not own but rather rented their homes. The municipality is now pressuring to expel them, but there is no clear place for them to go. The mayor of Delmas (a neighbourhood of Port-au-Prince) announced that this is part of a new campaign to evict internally displaced persons (IDPs) from public spaces.

9. See reference 3, Sanderson and Sharma (2008).

c. How can modern and traditional materials and technologies be integrated?

The introduction of new materials such as concrete and cement blocks has led to a failure to take advantage of the original resistance of traditional materials, thereby affecting the capacity of vernacular structures to withstand earthquakes. Materials such as brick and concrete, which have now been introduced in seismic regions, are being combined randomly with traditional materials such as stone and wood, including in post-earthquake reconstruction, thus affecting the resistance of the structures. On the other hand, replacing traditional materials with modern ones, especially concrete, has not reduced the fragility of structures; in fact, it has made them more vulnerable. Vertical supports may be placed directly on the ground, or brick walls may be built separate from the supports (Photo 9). We have found few cases where traditional materials such as stone are combined with concrete supports, which could be a good solution if specifications for the use of concrete in housing construction were properly respected.

In this context, it is important to highlight the importance of so-called "appropriate technologies", which have been developed over the past decades by several NGOs, especially in Latin America and Asia,[10] due to the efforts of pioneering architects. The goal of these "appropriate technologies" is to optimally combine modern and traditional elements. However, it is important to recognize that "low cost" is not the only criterion for determining which technologies to use. Factors such as environmental impacts, climate effects, social adaptability and cultural compatibility all contribute to the sustainability of technologies and merit consideration. It is also important to take into account that both

10. See Audefroy, Joel (2010), "Post-disaster emergency and reconstruction experiences in Asia and Latin America: an assessment", *Development in Practice* Vol 20, No 6, August, pages 664–677.

PHOTO 9
Brick walls are built separately from the supports, Port of Prince, Haiti.

© J Audefroy

technology and design aim, at the same time, to improve the resistance of the vernacular structure. The traditional knowledge systems, considered as a "package of products" for rapid reproduction and transfer, are also in danger of falling into the same trap if they are perceived in a static manner.

Both "modern" and "traditional" technologies for disaster mitigation have their respective merits when considered in the context of their specific objectives and in relation to the distinct contexts in which they are produced. In fact, it has been found that the use of modern materials in Haiti has not been very efficient. As one observer noted:

> "Rampant corruption in Haiti virtually assured that even buildings constructed in the formal sector had little engineering input and sub-standard construction. The high rates of damage and collapse of formal building stock were clearly a function of corruption among high level officials, who turned a blind eye to these irresponsible practices that resulted in the total destruction of 13 of 15 federal ministry buildings."[11]

11. Oliver-Smith, Anthony (2010), "Haiti and the historical construction of disasters", *NACLA Report on the Americas* Vol 43, No 4, July–August, pages 32–42.

d. What is happening with local resources?

With the changes in materials and technologies, traditional craftspeople find it increasingly difficult to use their knowledge. For example, local masons who are trained to cut and work with stone are not always capable of building brick and concrete walls. While they are incapable of using the new materials adequately, their traditional knowledge of stone masonry has degenerated considerably, in large part due to the decades-long lack of demand for stone masonry, forcing them to carry out other jobs. As a result of this process, the new generations have been unable to learn from the master builders. The master masons dedicated to block and concrete construction are sometimes unable to reach the level required for this type of construction because they never acquired the skills to make precast, post-tensioned or reticular slabs, and they do not know how to correctly place the buttresses in beams or the rods in slabs. The rising demand prior to and after the earthquake for non-native masons, who are unfamiliar with traditional construction practices, makes it even more difficult to organize reconstruction projects using traditional processes. In the capital city of Port-au-Prince, when the reconstruction process comes around, the masons hired may not necessarily be trained in modern construction. The little national recognition given to local craftspeople (and guardians of traditional knowledge) is a significant contributing factor to this situation. One clear example is the ironwork craftsmen of the village of Noailles, who receive no national recognition for their extraordinary creations.

VI. THE VALUING OF TRADITIONAL KNOWLEDGE IN CONTEMPORARY CONSTRUCTION

In the countryside, traditional palm leaf and vetiver grass roofs have been gradually replaced by metal sheeting. In the cities as well, the roofs of homes are now made of metal sheeting, even while the sharply sloped wooden structures that support the sheets continue to follow the style of those previously covered with tiles imported from France. Wood, which is highly resistant to hurricanes while also being isothermal and light, was prohibited for many years in Haitian cities as it was considered a fire hazard, although it remained widely used for walls in *creole* homes in the countryside. It is now rarely used because of its high cost and the scarcity of forestry resources on the island. The wood now available in Haiti is imported and therefore very expensive. For example, materials for a 50-square metre house with a wooden structure and stone filler using the traditional system now cost US$ 5,733.[12]

12. Cost calculated by the Haitian NGO, GARR, for its housing budget in Las Cahobas, Haiti.

a. Identifying the scientific aspect of traditional knowledge

While the "experimental" aspects of traditional knowledge have been demonstrated, and as such have been considered to be "scientific", it is not enough to demonstrate the scientific aspects of traditional knowledge. First of all, it is not knowledge founded on mathematical calculations but, rather, on trial and error, and it is more practical than theoretical knowledge. This type of knowledge stands out when people undertake their own experimentation, or when they are capable of drawing conclusions from experience and from this experimentation. This continuous process of experimentation, innovation and adaptation also allows traditional knowledge to mix with science and technology.

Instead of creating categories that divide traditional and scientific knowledge into mutually exclusive fields, it is preferable to recover the scientific aspects of traditional knowledge and the "traditional" aspects of scientific knowledge. While the first will allow traditional knowledge systems to be easily understood by the professionals, the second would call for the translation of diverse scientific concepts into locally understood communication systems.

Nevertheless, prior to generalizing a theory on the efficiency of traditional construction techniques, it is necessary to carry out "scientific experimentation" to evaluate their specific efficiency in relation to the vernacular structures in which they are integrated. These experiments have been carried out in part in Latin America by the Ibero-American programme known as CYTED XIV,(13) with adobe, mud, earth, cement and wattle and daub earthquake-resistant housing. Project XIV–5 "WITH ROOF" (1999, 2005) is inserted in this process with two objectives: to respond to specific roof-related problems, and to provide technological information for distinct technological forms of intervention. To achieve this, the 10 x 10 programme undertook the construction of 100 experimental homes (10 homes in 10 Latin American countries) using wood, reinforced earth, hardened earth, brick, ferro-cement, mortar, concrete and steel.

13. CYTED (1995), *Recomendaciones Para la Elaboración de Normas Técnicas de Edificaciones de Adobe, Tapial, Ladrillos y Bloques de Suelo-cemento. Sistematización del Uso de la Tierra en Viviendas de Interés Social*, RED TEMATICA XIV–A: HABITERRA, La Paz, Bolivia, 80 pages.

Without a rigorous process of experimentation and improvement of traditional techniques, as was undertaken by the organizations that worked with the XIV–5 CYTED–HABYTED project, traditional techniques are not effective in resisting earthquakes because people continue to use them without truly understanding their basic principles. Important efforts have been made to disseminate these improved traditional techniques in several Latin American countries, including Cuba. There is a similar problem with modern structures that are perceived as "resistant" but that in reality are not because their specifications and basic principles are not always understood by the local builders and masons.

This scientific approach of traditional knowledge could have profound implications in Haiti. For example, following the earthquake, the German agency MISEREOR in conjunction with Caritas Haiti organized a workshop in Haiti on *clissage* housing construction (consisting of a wooden structure filled with stone).(14) This is another example of an improved traditional technology, like those developed through the XIV–5 CYTED project, and a broad dissemination of this experience could contribute to a change in perception concerning these traditional technologies.

14. The workshop was implemented by Wilfrido Carrazas de Craterre and financed by MISEREOR.

It is urgent therefore to develop research projects and dissemination efforts that include traditional techniques and materials, in particular those that use stone and wood in Haiti. This will not only help develop innovative solutions to reduce the vulnerability of buildings, but will also help to change the perceptions of engineers and builders regarding the efficiency of traditional solutions.

b. The issue of the resilience or the recovery of vernacular structures

Improving resilience in vernacular structures implies making critical decisions in relation to the role of traditional knowledge. On the one hand, should we recover traditional knowledge systems and use them exactly as they were when they were widely used? Or should we recover their essence, continuing a process of evolution that responds to new needs, using accumulated experience and preserving their meaning and identity? The latter option appears the most pertinent if we want traditional knowledge to play an active role in disaster mitigation and in post-disaster reconstruction.

However, this argument will not be accepted by anyone until we are able to demonstrate that recovering knowledge of traditional techniques for their potential in disaster mitigation is a scientifically rational option. This implies an improvement in construction practices during the prevention phase as well as during the recovery or rehabilitation phase, in two ways: first, by developing innovative and sustainable technologies for the reconstruction of new housing with traditional knowledge; and second, by developing alternatives to rehabilitate the traditional structures that were affected.

The following pertinent questions will need to be considered for future debate:

- How may poor quality or damaged constructions that use traditional systems be repaired or rehabilitated? This question opens a debate on the question of the resilience of traditional systems. Can their resilience be improved? How resilient are the traditional systems to events such as earthquakes? For example, is bamboo as resilient to hurricanes?
- How may hybrid vernacular structures be rehabilitated using traditional techniques?
- To what degree can we use modern techniques or materials to rehabilitate traditional hybrid constructions without compromising safety or heritage values?

Nevertheless, these principles must be seen in the context of the local reality: a subsistence economy, limited local technical knowledge and a lack of local materials such as wood. Standards for risk management would have to be lowered to acceptable levels. This would also imply the commitment of communities to mutual aid and the establishment of dialogues with local craftspeople and professionals, and not just technological transfer. Local craftspeople are the ones who have the know-how, and they should be those to whom training workshops for the improvement of traditional buildings should be directed. In this sense, the German organization Misereor is doing a very positive job in Port-au-Prince.

VII. CONCLUSIONS: STRUCTURAL SECURITY VERSUS HERITAGE VALUES

Interventions in heritage issues and/or vernacular housing imply striking a balance between structural security and heritage values. While it is very important to implement all possible measures to improve the resistance of structures to natural hazards such as earthquakes or hurricanes with the aim of protecting lives and property, it is equally important that the authenticity of materials, structures and architectural heritage be preserved. In the aftermath of disaster, such heritage is a source of identity and psychological recovery.

However, the key challenge is to balance the inclinations of the professionals dedicated to the preservation of heritage with those of the engineers, neither of which are particularly willing to compromise on their respective professional principles, which results in a sort of mute dialogue. Both will need to adapt to the risk reduction processes and apply risk reduction measures, balancing engineering and structural aspects with heritage aspects in a creative process of adaptation to the context and needs.

It is obvious that traditional knowledge, in addition to forming part of historic roots, forms part of the current reality. It is not reserved for the élite and the researchers but, rather, pertains to the communities: rescuing this knowledge and transforming it for future generations is therefore the current challenge for researchers and professionals.

Following are some lessons learned from the Haitian experience:

- Prevention of future disasters must begin at the community level, and the families need technical and financial support.
- Reconstruction using improved traditional techniques and materials is viable and efficient in terms of cost and social acceptance, but only if done with community participation.
- The introduction of modern construction systems and innovations takes time and lengthy training so that local craftspeople and professionals may fully appropriate them.
- It is possible to combine earthquake and hurricane resistant construction with the preservation of vernacular heritage using local solutions and materials.

REFERENCES

Arrington Phillips, Anghelen (1975), *Gingerbread Houses: Haiti's Endangered Species*, Impr. H Deschamps, 92 pages.

Audefroy, Joel (2010), "Post-disaster emergency and reconstruction experiences in Asia and Latin America: an assessment", *Development in Practice* Vol 20, No 6, August, pages 664–677.

CYTED (1995), *Recomendaciones Para la Elaboración de Normas Técnicas de Edificaciones de Adobe, Tapial, Ladrillos y Bloques de Suelo-cemento. Sistematización del Uso de la Tierra en Viviendas de Interés Social*, RED TEMATICA XIV–A: HABITERRA, La Paz, Bolivia, 80 pages.

Gutiérrez, Ramón (1994), "Los ingenieros militares en las fortificaciones del Caribe", in Ramón Paolini, *El Caribe Fortificado*, Editorial Escala, Bogotá, Colombia, pages 31–49.

Jigyasu, Rohit (2008), "Structural adaptation in South Asia: learning lessons from tradition", in Lee Bosher (editor), *Hazards and the Built Environment*, Routledge, London, pages 74–95.

Oexmelin, Alexandre (1930), *Les Aventuriers et les Boucaniers d'Amérique*, Editions du Carrefour, Paris, 370 pages.

Oliver, Paul (1997), *Encyclopedia of Vernacular Architecture of the World*, Cambridge University Press, UK, three volumes, 2,500 pages.

Oliver-Smith, Anthony (2010), "Haiti and the historical construction of disasters", *NACLA Report on the Americas* Vol 43, No 4, July–August, pages 32–42.

Revi, Aromar, Rajendra Desai et al. (1993), *Action Plan for Reconstruction in Earthquake-affected Maharashtra*, TARU, New Delhi.

Sanderson, David and Anshu Sharma (2008), "Winners and losers from the 2001 Gujarat earthquake", *Environment and Urbanization* Vol 20, No 1, April, pages 177–186.

Sillitoe, Paul (1998), "The development of indigenous knowledge. A new applied anthropology", Current Anthropology Vol 39, No 2, pages 223–252.

Suarez, Gerardo, Virginia García Acosta and Rogelio Altez (2010), "Un desastre más allá del Terremoto", *Letras Libres* Año XII, N° 135, March, Mexico, pages 20–23.