Sustainable reconstruction in Jacmel, Haïti
Project “A Roof, A Future”

ARCHITECTURE & DÉVELOPPEMENT ’s conceptual and technical input
RECONSTRUCTION OF A SUSTAINABLE HABITAT USING CONFINED STONE WALL TECHNOLOGY

Context
This project constitutes phase 2 of the "A Roof, A Future" programme. On 12th January 2010, an earthquake of magnitude 7 on the Richter scale, struck Haiti causing considerable damage. More than 200,000 people died and a further 1.3 million lost their homes. Several months after the immediate disaster-relief phase, A&D (in a technical role) partnered with Planète Urgence to implement a programme of reconstruction of rural habitats. The local context is integral to our approach to re-development, which utilizes stone gabion wall technology. The project should provide re-housing for 100 families in the Jacmel rural zone, La Montagne. The approach is based on a local farmer organization implemented since 2004 in the area, Opadel.

Objectives
• Provide a reliable and sustainable response to the housing and amenity needs of the most vulnerable people, through an integrated approach respectful of local development.
• Educate artisans and self-builders on simple hurricane and earthquake-resistant technologies. Provide accessible know-how on sustainable reconstruction, by introducing stone-wall gabion technology.
• Develop stone-wall gabion technology for self-help construction, with the aim of creating a new building sector that covers both rehabilitation of existing structures and new construction.
• Value the usage of local materials.
• Enable the local population to access a bioclimatic and economic habitat.

Approach
The project offers a global approach to reconstruction through provision of appropriate and accessible technology - which can be taken on by local entrepreneurs and craftsmen - and a new resource centre for habitats and sustainable, bioclimatic construction. The project also includes prototype control buildings, construction ‘schools’, a workshop to produce building materials and two community hurricane refuges. Together with educating locals in self-help construction, this gives a new impetus to rural areas.

TECHNICAL OVERVIEW
july 2012 - nov 2013

Project roles
• Assistance to project promoters
• Education – construction schools
• Site supervision

Process
• A&D expert coach on the ground for 6 months
• Construction of prototype buildings as a teaching exercise
• Creation of a workshop, which prefabricates stone-gabion wall frames and cages
• Collaboration with the buildings’ end-users
• Prefabrication of hurricane-resistant structures
• Technical supervision and provision of construction manuals

Expected results
• Initiate a local supply chain for stone-wall gabions
• Awareness of sustainable construction practices
• Improved habitat resilience to extreme weather
• Economical and environmental housing

The project in numbers
• 1 reproducible prototype house using stone-gabion wall technology
• 35m³ of stone per house
• 55 new 35m² houses
• 60 tradesmen skilled in stone-gabion wall technology
• 4 km of galvanized steel wire per house
• Construction cost 85€/m²

Personnel
• Ludovic JONARD, Architect
• Aurelio DOUAY, Timber expert
• Guy BESACIER, Seismic engineer

Project partner

Financing
Origins of the technique
The concept of and technical introduction of stone-gabion wall technology in the project “A Roof, A Future” stem from A&D’s ongoing investment and technical research in post-disaster re-housing in Pakistan, since 2005. The main goals were to reduce production costs and environmental impact and to increase the socio-economic performance of reconstruction aid programmes. After a research and development stage involving the construction of two prototype houses in Morocco (2010), A&D developed for Planète Urgence a housing model combining wood and stone-gabion wall technology, which achieves exemplary and innovative construction performance.

An anti-seismic device
Stone-gabion wall technology utilizes the rigidity of a mass of stones and the flexibility of metal cages to create a structure whose natural frequency sits within the optimum 0.3s-1s range. The Laboratory of Civil and Mechanical Engineering at INSA, Rennes, used the computer code, Cast-3M – created by the CEA (Centre of Atomic Energy) - to numerically model and understand the behaviour of stone-gabion walls. Under Eurocode 8, stone-gabion wall buildings can resist earthquakes of magnitudes greater than 5.5 and a maximum ground acceleration of 3m/s² (Seismic Zone 4).

Using Local Resources
The most interesting aspect of this technology is the use of stones collected on site, thus benefitting from local materials and limiting the need for imported materials (and their associated transport costs and environmental impact). The site is dry, masonry is not required. Consequently, cement and its associated problems are avoided.

Self-help construction
Investment in the project by the beneficiary families is fundamental. Each family must collect 35-38m³ of stones that can be placed in the woven metal cages, which form the bedrock of the house. Construction of the walls (with no foundations) is very easy and requires 1 mason, 1 skilled worker and 3 beneficiaries. This technology is reproducible due to the simplicity of construction. It can therefore be appropriated by unskilled workers (self-help builders). The beneficiaries’ financial contribution also guarantees their ‘ownership’ of the project. Due to their involvement from the start of construction, they know how to maintain the building into the future.

Development of a new supply chain
At the same time, the project aims to develop a local supply-chain by training craftsmen and teaching them alternative building techniques. The creation of building material workshops and a construction school ensures this training and knowledge transfer. This is the most delicate but also the most crucial aspect of the projects’ long-term success.
THE 7X7 HOUSE OF TIMBER AND STONE-GABION

Effective Architectural Design
A&D developed the model of a 4 to 5 person family house. The compact, rectangular plan facilitates arrangement of the stone-gabion cages and timber bracing structure, on which the anti-seismic roof sits. This assembly guarantees the stability of the structure in extreme weather and provides improved thermal comfort.

A quick and safe construction
• Construction of the walls (with no foundations) is very easy and requires 1 mason, 1 skilled worker and 3 beneficiaries. The site is dry, no masonry is required. The structural walls are comprised of cages filled with stones collected locally.

• The cages are fabricated from a woven mesh of galvanised steel. These are cut, folded and assembled as elements to form the containment for the walls.

• The cages are filled in bulk, by hand to a height of 1.2m. The individual elements of the stone-gabion walls are linked together. The timber framing that sits above is inserted into these elements.

• The hurricane-resistant timber framing is bonded into the stone-gabion walls, forming a seismic-resistant assembly. The roof is of corrugated iron. The walls are finished with earth and lime.
An economical and sustainable building
The 35m² house - combining wood and stone-gabion wall technology and utilizing self-help construction - costs approximately €3000 (supply and installation). Compared with 18m² T-Shelters or standard construction costs in Haiti of €300/m² this is an excellent low-cost model for durable and comfortable housing. Combined with a simple architectural form, the stone-gabion wall technology is efficient to implement and reduces production times.

Hurricane and Seismic-resistant construction
A light-weight timber frame is fixed above the seismic-resistant stone-gabion walls. This braced frame uses local construction techniques. The light-weight roof comprised of 4 panels also suits local typologies. Bonded to the walls, it forms a seismic-resistant assembly.

Sustainable and bioclimatic construction
The finished, stone-gabion walls provide the house with a good thermal performance. The 50cm deep walls comprise stones and voids with no other special apparatus. The stones and earth/lime finish provide good thermal mass and the air trapped in the voids improves the envelope’s thermal resistance. Natural ventilation is provided through shutter openings and ventilation grilles with detachable wooden doors.
Acknowledgments

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  - Recommendations and structural dimensioning
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The goal of “stone-gabion wall” technology is to significantly reduce sensitivity to climatic risks and to provide a long-term housing solution at good value for money. These self-help housing projects do not claim to strictly comply with international seismic and high pressure regulations. However, they help raise awareness of better building practices for post-disaster reconstruction.

The “stone-gabion wall” technology for sustainable housing has been designed and developed by A&D since 2005. It is currently being implemented in Morocco, India and Haiti. Though not patented, this process is guaranteed only through A&D expertise and support during the implementation.