# Lessons from Léogâne: Case Studies From Haiti

On the morning of January 12th 2010, a magnitude 7.0 Mw earthquake struck the island of Hispaniola, destroying, or badly damaging, over 290,000 homes. More than 200,000 people lost their lives and a further 300,000 were injured. Many factors contributed to such a large loss. Poverty, inadequate building codes, and lack of knowledge all played their part.

**Mark Taylor**
University of Illinois at Urbana-Champaign

The call to "Build Back Better" was a mantra adopted early in Haiti's reconstruction effort. To achieve that goal requires incremental improvement through every stage of the building delivery process. This essay focuses on three projects constructed in Léogâne, the epicenter of the earthquake. Each project reveals what incremental improvements are possible.

Six months after the earthquake an estimated 10,000 people were concentrated in makeshift shelters at three locations around the town: the town's soccer field, beside the market, and in the town square. Transitional housing, donated by the numerous aid organizations working in town, were appearing on lots that had been cleared of rubble. Some roads in downtown Léogâne had been paved prior to the earthquake, allowing a visitor to sense that order and beauty were present at some point in the town's past. A few historic structures that mixed influences of French and Haitian architectural styles, dating back as far as the 1800s, remained standing. Buildings of heavy masonry construction, either contemporary or historic, in general did not perform well.

The earthquake affected every sector of the built environment: government buildings, hospitals, schools and individual homes. Within weeks after the quake temporary hospitals were established at three locations around Léogâne. The impact on local and national government was severe. The presidential palace collapsed, and the Léogâne mayoral offices were unsafe to inhabit. Presidential elections originally scheduled for February 2010 were not held until November of that year, and it was not until March of 2011 that a clear winner was announced. This uncertainty of leadership drastically affected the early stages of the recovery effort. To ensure some form of normality was restored at a local level, Haitian communities petitioned Nongovernmental Organizations (NGOs) to help rebuild schools so children would have safe places to continue their studies.


1

Figure 1: Collapsed Private School.

Access to education in Haiti has historically been difficult. State-funded institutions educate less than 10% of those attending school.[1] Private International, Church-run and For-Profit schools have stepped into the huge void, to satisfy the desire Haitians have to receive an education. Unfortunately, the largest subset of for-profit education providers are "run by entrepreneurs, with little pedagogical under-standing, precarious physical facilities, few or any books, and untrained teachers and school directors."[2]

Prior to the earthquake, dozens of small schools were operating out of inadequate buildings in the Léogâne area. Poor construction and lack of oversight in this sector resulted in many building failures during the earthquake (see figure 1). One estimation of the number of schools destroyed in the Léogâne area, was as high as 300.[3] With little chance of receiving a state-funded school, local communities appealed to the NGO sector to provide buildings to replace what had been destroyed. Following the earthquake, All Hands, an NGO that recruits volunteers from around the world, became one of the most prolific builders of schools in the for-profit sector of education provision in the Léogâne area.

## TRANSITIONAL CONSTRUCTION

The construction methods used by All Hands were very suitable for those with limited construction knowledge. The system was light and ductile in nature and drew on vernacular building practices, while adding structural rigor. The walls of the schools were formed with 2x4" stud framing, anchored to a concrete slab with bolts. The roofs were formed from wooden trusses with large gusset plates secured to the studs with hurricane straps. An innovative stucco treatment was applied to the walls. Chain-link fence

2

served as a lath. It was secured to the stud walls, before removable formwork was attached to the outside of the building. A mix of sand-cement stucco was applied to the lath by hand in a manner similar to traditional parge applications that have been applied on modest structures in Haiti for generations (see figure 2). A second finished coat applied with a trowel and float completed the inside, before the exterior formwork was removed. The 3/4" base coat provided enough of a key for a finish coat to be applied on the outside of the building (see figure 2a).

Classrooms were sized to fit small lots. The spacing of studs two feet apart dictated the structural logic of the building, which typically comprised of three classrooms 20' wide by 28' long. Each site had unique challenges, remoteness, site topography, or the need to remove collapsed buildings, so costs varied from school to school. However, material costs for a 560-sq/ft classroom averaged approximately $4,850. With sufficient volunteer labor, rebuilding could take place relatively quickly. A construction crew of approximately ten volunteers could complete a three-classroom school in about nine weeks. Haitian construction staff were hired to help coordinate volunteers on site and apprenticeship training was offered to local volunteers could take the principles of this light, ductile and affordable form of construction and apply it to their own building needs.

Using this construction method, All Hands completed 20 schools in a 25-month period.[4] The reliance on imported treated lumber to form the structure of the buildings was unavoidable, given that the country has been heavily deforested. The buildings are also considered to be transitional

Figure 2 and 2a: Temporary School Constructed by Volunteer Labor.

2a

structures, with an estimated lifespan of only ten to twenty years. However, routine maintenance will extend the life of these low-cost buildings. Typically located in the more remote rural areas, the schools also served as good examples of a construction method that could be adapted to address the local need for affordable housing. The technology was widely adopted by the NGO community. For example Cordaid used this form of construction to supply semi-permanent houses in rural communities surrounding Léogâne. The cementitious exterior gave a similar level of security that a concrete wall would provide, but at the fraction of the cost and at greatly reduced weight. The wood framing was simple to construct, ductile to resist lateral forces, and with sufficient strapping could be engineered to resist high wind events. Homeowners were encouraged to participate in the assembly and completion of their home; this helped ensure all required details were completed as designed.[5]

3

**PERMANENT SCHOOLS**

Between June 12th and 18th 2010, a team of ten architects and engineers from the US traveled to Haiti to assess eleven public schools that had been impacted by the earthquake in the Léogâne area. All but one of the eleven structures, which should have served as a community refuge, failed during the earthquake.[6] During the brief six-day trip, site measurements were taken, and interviews conducted with the school principles to define classroom, offices and canteen requirements. For smaller schools, it was possible to develop schematic designs and schedule return visits. Receiving feedback on floor plan arrangements while still in Haiti helped keep the design process moving forward very quickly. In the weeks following the trip, a schematic design for one of the smaller remote schools, École National Fond de Boudin was developed.[7] The design was handed on to a structural engineering firm to ensure that the building could be built to satisfy the requirements of a Seismic Design Category D rating in a coastal region where 3-second gusts of 135 mph are possible.

The reconstruction of the École National Fond de Boudin was funded in part by Schools for Children of the World, who appointed an American architect to project manage the first phase of the reconstruction of the eleven public schools. The second partner who financed the construction costs was the Spanish Red Cross. As the school would eventually fall under the control of the Haitian Ministry of Education, their approval also had to be granted. A preliminary set of structural drawings was produced approximately four months after the initial site visit. At that stage, the Haitian government was still receiving advice on how to formulate a building code, which up to that point in history had not recognized the seismic, and hurricane hazards present in Haiti. In April 2011, a complete set of drawings, identifying critical rebar sizes, spacing, overlaps, and concrete performance criteria were ready for review by all parties. It took a further nine months before the Ministry of Education approved the design, and for the Spanish Red Cross to appoint the main contractor. At the time, the delays were frustrating, but in retrospect they provided the required controls to ensure competent building

Figure 3: École National Fond de Boudin under construction with oversight from American Architect and Haitian Engineer.

professionals were appointed to complete a building designed to last a minimum of fifty years.

As part of the bidding process the Spanish Red Cross required each potential contractor to perform a number of tests to ensure they could identify critical details on drawings, estimate quantities of building material, and work safely. In addition the Red Cross hired Haitian engineers to be on site every day during the construction of the schools they were financing. These engineers gained valuable experience overseeing the construction of a well-engineered building. Their work in turn received the oversight of the American architectural project manager, and Spanish engineers. This model for reconstruction sets the highest standards. The design and engineering of the building complies with internationally recognized building codes, the next generation of local engineers receives valuable onsite experience, and the main contractor is trained in best construction practices (see figure 3).

### THE REALITY OF RE-BUILDING

The two previous case studies highlight what is possible with external support from well-established international NGOs. The final case study focuses on the construction of the Kay Fanm Yo (Women's House), a midwifery-training center built on the hospital campus of a Haitian based NGO called CAMEJO.[8] The study sheds light on the daily challenges Haitians face when attempting to "Build Back Better".

Prior to the earthquake CAMEJO was in the process of completing a 14,000 sq/ft two-story hospital. During the quake that building suffered a partial collapse. Fortunately no one was injured during the structural failure, however CAMEJO were left in a predicament that many faced in the region: could a partially collapsed building be repaired and saved, or should it be torn down and rebuilt from the ground up. [9]

The design of the two-story hospital was ambitious beyond the knowledge of the engineer that drew the plans. There was little structural logic and confused load paths in the design. The rectangular shaped building had over nine different bay sizes on the ground floor. The abilities of local contractors were also less than required to build safely in a seismically active region. Poorly formed columns and beams supported a heavy concrete roof. Shear failures occurred at the junction of nearly every second floor column and beam connection, due in part to the heavy mass of the structure. Concrete masonry walls were not connected to the structure in any way, and fell out during the quake. It was fortunate that the building did not suffer a complete catastrophic collapse. After the quake the ground floor of the building remained standing, however, to make the building even moderately safe required employing the original construction crew to remove the top portion of the building by hand with sledgehammers (see figure 4). Insufficient funds were available to remediate the hospital, however CAMEJO were committed to providing maternity care, and welcomed a project that could function as a demonstration of improved construction practice.

The Kay Fanm Yo (Women's House) is a simple 1,200 sq/ft building that could be divided internally to accommodate different program needs.[10] The building was developed as a prototype for replication in the rural areas of Haiti where maternity healthcare is acutely lacking. In Léogâne the building was

designed to function both as a classroom and a maternity center, however, the building could easily be adapted to function as a small clinic or by Haitian standards a modest middle-income home. The critical aspect of the design was that it could be built to satisfy the requirements of a Seismic Category D rating in a location susceptible to 3-second wind gusts of 135 mph.

The Kay Fanm Yo was built less than a hundred feet away from the partially collapsed hospital. The remnant of which exposed numerous inadequacies that are common in many structures built in Haiti. The poorly constructed columns of the hospital, and the limited availability of skilled labor, gave the designer little confidence that a building reliant on column and beam

Figure 4: Partialy collapsed hospital being demolished by original construction crew.

connections could be built well enough to resist the seismic hazards in the area. Instead a floor plan was developed based on the principles of reinforced masonry construction. The logic behind this decision was; reinforced masonry construction relies more on the performance of shear walls, rather than on column and beam connections. To build a safe concrete framed building requires accurate engineering design, high levels of skill to assemble, and verifiable materials to construct, three commodities that are hard to find in Haiti. Concrete Masonry Units (CMUs) or blocs as they are known in Haiti, by contrast, are ubiquitous. Small, medium and large scale producers manufacture blocs by the side of the road, or on the job site, with one of the few raw materials that is readily available in Haiti; sand. It is true that the quality of blocs varies considerably and further work needs to be done to ensure the market is supplied with building materials that will perform as needed.[11] However until alternative lighter ductile materials are accepted in Haiti, bloc construction, of some form or other will be the method of choice for most Haitians. The benefit the designer saw in building with a reinforced masonry system, as opposed to a confined masonry system, which was also promoted after the earthquake, was interlocking corners negate the need for any formwork to build the walls. For domestic scale building the majority of the mixing of concrete and mortar is carried out by hand in Haiti. To help the material flow, and blend during mixing it is common for excessive amounts of water to be added to the mix. In column and beam construction this can significantly impact the performance of the cured members. However, in a reinforce concrete wall, if enough control can be given to the ratios of, sand, cement and fine aggregate a fluid grout mix is what is required.

The foundation of the Kay Fanm Yo was dug by hand, and re-bar carefully set, to ensure it would sit vertically in the middle of a cell in each required bloc. This was possible with careful measuring and close supervision. To reduce the quantity of re-bar required and to provide a strong connection, only one overlapping splice for all vertical rebar was specified. The required overlaps of a No.4 bar and a No.5 bar are 28″ and 36″, respectively. There was a concern that the masons would have difficulty lifting a CMU high enough to thread it over the re-bar. The 7′ lift was higher than the masons were used to, but it was achievable, even for the shortest member of the construction crew (see figure 5).

During the construction of the walls, it soon became obvious why so many walls had failed during the earthquake. Obtaining sand that was clean and well graded was extremely difficult. Sand sourced in the mountains was finely crushed limestone powder, with little or no bearing capacity, while sand taken from riverbeds was not finely graded and often contained significant amounts of organic matter. The skill of laying CMUs was in general below the standard required to ensure a good bond between blocs. To overcome the presence of ¼″ stones in the mortar mix, masons would lay thick beds, rather than invest time in sieving the sand onsite to remove pea-sized gravel. Tuck-pointing was rarely attended to as the walls were built. The attitude was the gaps between blocs would be filled with a stucco parge, once the wall was built.

The lack of attention to detail is a significant problem in Haiti's construction sector, and a challenge to remedy. There is a significant imbalance between material costs and the price of labor; this imbalance ultimately impacts the quality of construction. For example, the daily rate for a mason building the

5

Kay Fanm Yo was approximately $20 per day, an amount comparable with the price of two bags of cement, or twenty good quality concrete blocks. When labor is cheap, its value is also low. This in turn leads to a culture where additional steps to improve quality are not taken, since there is no financial incentive to do so. In this framework, poor craftsmanship unfortunately becomes the accepted norm.

## CONCLUSIONS

If "Building Back Better" is going to become a widespread reality across Haiti, a number of gaps have to be closed. Prior to the 2010 earthquake, there was a significant gap in knowledge between what was thought to be a safe building, and what it actually takes to engineer resistance against the hurricane and seismic hazards present in Haiti. Closing that gap will require the re-education of the country's building professionals. Gaps in expectations need to be addressed. The middle class in Haiti had expectations that they could have houses, which in form looked like those for sale in the suburbs of Florida and New York. However, instead of occupying efficient industrialized solutions, many lost their lives in inferior imitations built with poor Haitian craftsmanship. Closing this gap will require the middle and upper classes investing to improve the quality of building materials produced in Haiti. Reducing profit margins, and importation taxes on materials used in the rebuilding effort will also help more people afford to build resilient structures.

Throughout the first 3 years of reconstruction an information gap persisted between what was safe to build and what reconstruction typically looked like. The MTPTC (Ministère des Travaux Publics, Transports et Communications) in conjunction with a number of NGOs invested time and effort in producing informative guidelines. However, if the Haitian population has limited access to the information little improvement in building standards will be made.[12] This information needs to be more widely distributed through poster campaigns, churches, grassroots organizations, as well as through suppliers of materials to the building industry.

If adherence to standards set by the MTPTC remains voluntary, there will all ways be a gap between what is required and what is built in Haiti. At some point in the country's development, building code compliance has to be enforced. If there is little trust in central government, agreement at a local level needs to be made, so those invested in construction can work together to build safer buildings in the regions where they live.

Figure 5: Construction of the Kay Fanm Yo (Women's House). Reinforced masonary construction to resist local siesmic and high wind hazards.

Finally, the gap in earning potential between the most affluent and the poorest in Haiti has to be addressed, if a resilient community is to emerge from the catastrophe of 2010. It is unreasonable to expect a worker to consider a hazard that may occur biannually, or every fifty to one hundred years, if his daily concern is whether he can earn enough to feed his family. This adjustment will require societal changes beyond the realm of architecture. However, if change does not take place, Haiti's re-building efforts will take lives in a similar way the built environment failed the nation in January 2010.

## ENDNOTES

1 Haiti country profile. Library of Congress Federal Research Division (May 2006). http://lcweb2.loc.gov/frd/cs/profiles/Haiti.Pdf

2 Wolff, Laurence. 2008. *Education in Haiti: The Way Forward.* Washington, DC: PREAL, 2008 page 5

3 http://hands.org/2012/03/28/heres-how-we-built-20-schools-in-haiti/

4 http://www.simpleregistry.com/allhands/4.

5 http://www.flickr.com/photos/cordaid/5146462134/in/photostream/

6 DeFlon-Project-Scope_06052010_bdj.pdf, http://www.schools-forchildren.org/?cat=44

7 http://www.schoolsforchildren.org/?cat=53

8 http://openarchitecturenetwork.org/projects/kay_famn_yo_womens_h

9 Camejo Hospital - May 2012 http://vimeo.com/68167974

10 Kay Fanm Yo - Journey of a building http://vimeo.com/68167973

11 Challenges and Opportunities in the Production and Purchase of Good Quality Blocks. Build Change and Save the Children.http://www.buildchange.org/resources.php#haiti

12 Guide De Bonnes Pratiques Pour La Construction De Petits Bâtiments En Maçonnerie Chaînée En Haïti, MTPTC Ministère des Travaux Publics, Transports et Communications and MICT: Ministère de l'Intérieur et des Collectivités Territoriales,September 2010 available