Haiti Schools Project

On January 12, 2010, a magnitude 7.0 earthquake struck Port-au-Prince, the capital of Haiti, and reverberated throughout the country. The earthquake destroyed or damaged large parts of the built environment, including 300,000 houses, leaving 1.5 million people homeless. It also destroyed or damaged over 4,000 schools, including most of the schools in Port-au-Prince and 60 per cent in a large area of Haiti's southwest. In a country where 50% of the population is illiterate, the loss of so much of Haiti's educational infrastructure was particularly devastating.

In response to this disaster, a group of four engineering firms – Blackwell Bowick, Halsall Associates, Quinn Dressell and Read Jones Christoffersen – answered a call from Finn Church Aid, a Finnish NGO, to help rebuild Haiti's destroyed schools. Recognizing we could make a bigger difference if we banded together, our four firms created a joint venture to provide pro bono engineering services for FCA's Haiti Schools Project.

The goal of the joint venture was to develop and build at least two prototypes for permanent, durable schools that could be replicated throughout Haiti depending on the local conditions. We also aimed to transfer knowledge and skills to local Haitian engineers and contractors to ensure that future projects built in Haiti after our departure would be better designed to withstand natural disasters such as earthquakes and hurricanes.

The project team made a significant commitment to this project – on a financial as well as professional and personal level. We agreed to have at least one field engineer present in Haiti for the first year, and a team of designers in Canada to back up the field presence. A total of six engineers travelled to Haiti to ensure the project's smooth execution. These included Dan Carson of Halsall Associates; Christian Bellini, Michael Hopkins, Tim Joyce and Kenneth Cryer of Blackwell Bowick; and Shane Copp of Read Jones Chistoffersen. Shane spent the better part of 17 months on the ground in Haiti, not only overseeing the structural work but also assisting with project layout, demolition, scheduling, safety issues, quantity calculations, civil works, architecture, plumbing, electrical work, quality control, training of the site staff and project administration.

The team held weekly coordination meetings via Skype or teleconference to discuss the project and distribute the design work. Throughout, the Canadian engineers liaised not just with FCA, but also with local construction professionals, school principals, teachers and other members of the local communities to ensure their needs were being met. Jointly, we estimate we have contributed over 3500 person hours to this project, starting in September 2010 when we first formed the joint venture.

Rebuilding the schools in Haiti presented considerable challenges. In addition to a basic lack of infrastructure (which was compounded by the devastation wrought by the earthquake), issues included material shortages and/or expensive materials, lack of access to typical North American building supplies, a narrow supply chain, and the necessity to achieve results without being able to resort to costly machines and equipment or skilled labour. For example, gravel is often produced by crushing stones by hand, which is a slow and laborious process.

A significant challenge was the remoteness of some of the school sites. St. Joseph School in Embouchure, for example, was located in a remote area, reached by a rigorous two-hour hike down a hillside and across a riverbed. This meant that the building materials chosen for rural schools had to be as lightweight and efficient as possible. It also meant the construction process was significantly slower than we would typically find in North America.

Haiti Schools Project (cont'd)

Designs and drawings also had to be as simple as possible because the local engineers and contractors had little experience reading drawings and little knowledge of good construction practices. For example, if a design called for 33 nails in a connection, to avoid any construction errors, our drawing had to show all 33 nails in the correct locations. We also invested time and effort in training the local staff on how to understand the drawings and build exactly what the drawings showed.

Other challenges included the absence of a Haitian national building code and lack of access to conventional material testing facilities. To overcome the first, we followed guidelines issued by the Haitian Ministry of Public Works and Ministry of Education to provide designs compliant with the National Building Code of Canada (NBCC) and local architectural requirements. For the second, we designed our own tests (for example using local materials to perform a modified concrete slump test).

Despite the challenges, the results exceeded all expectations. In just over a year, two prototype schools were built: St. Matthieu, a heavyweight structure of reinforced concrete columns and shear walls with rubble masonry infill for areas accessible by road, and St. Joseph, a lightweight alternative for rural areas where materials must be transported by foot. The lightweight prototype has a timber stud wall construction with plywood shear walls. St. Mattheiu opened on September 25, 2011, and St. Joseph opened on October 15, 2011. Nine more schools are in various stages of completion. Using our team's prototype designs, FCA intends to build 50 schools in all.

The Haiti schools project demonstrates how, through collaboration, creativity and innovation, buildings of quality and excellence can be produced even in the aftermath of one of the world's largest natural disasters and in the absence of any locally established, adopted or enforced building code.

For the new schools, we carefully chose a type of construction that would fulfill the requirements of the NBCC and enable us to use locally available construction materials. For example, the rubble masonry walls in the heavyweight prototype use recycled rubble from buildings destroyed by the earthquake. In the design we employed well-connected plywood diaphragm roofs that attract lower seismic loads because of their small mass and have demonstrated high resistance to lateral loads. In addition, we used a well defined, uniformly distributed system of shear walls made either of reinforced concrete or timber to support the roofs. All of the school projects incorporate a biogas waste treatment system (to treat sewage and produce methane gas for cooking) and solar technology, helping to reduce their impact on the environment and make them self-sustainable.

This project has had a tremendous positive social and economic impact in Haiti and beyond. It has given hundreds of Haitian children safe and comfortable buildings in which to learn. It has provided work and income to Haitian engineers and labourers, many of whom are parents of the school children. It has transferred important skills, knowledge and practices to the local engineering and construction sector. It has helped to strengthen FCA's reputation as a credible NGO that can be relied on to deliver results. And it has established connections between Haitian and Canadian engineers, offering a model of cooperation to a domestic engineering industry that typically focuses on competition rather than collaboration.

Perhaps most important, as one school principal told us, the Haiti schools project has provided "hope" – not only for a better future for Haitians, but for the significant difference that a small-scale, volunteer engineering effort can make in improving our world.

Haiti Schools Project

Submitted by
Blackwell Bowick
Halsall Associates
Quinn Dressell
Read Jones Christoffersen

May 8, 2012

Countryside path en route to St. Joseph school.

Haiti Schools Project

PROJECT DESCRIPTION

Planning and Management

Many engineers from countries around the world contributed their skills toward assisting Haiti after the disaster. Haiti was a prevalent story in the media, as the country was affected by a cholera epidemic, homelessness and a dire need for reconstruction efforts.

Our project began September 2010. The initial idea to team up on this project came from Liz Oldershaw of Halsall Associates. Oldershaw's friend, David Korpela, works for the organization Finn Church Aid. Finn Church Aid (FCA) had already planned a long-term (five-plus year) project aimed at developing more schools in Haiti to provide education for Haitian youth and had prepared a reconstruction concept report. The report contained the preliminary design of a single-storey school building composed of steel roof trusses, reinforced concrete columns at regular intervals around the perimeter and reinforced concrete slabs on grade. It also featured many 'green' environmental concepts that were to be incorporated into the project plan.

They were ready to start work — all they needed were the engineers. *A Globe & Mail* article from March 2011 quoted Liz Oldershaw: "[David] said … they had a lot of money given to them, but they couldn't find anyone to do the professional engineering services." Halsall contacted three other engineering companies — Blackwell Bowick, Read Jones Christoffersen and Quinn Dressel — to ask if they would sign on to apply their skills and experience towards helping Haiti recover. Everyone said yes, recognizing the urgent need and the opportunity to make a difference.

Formed in 1947, FCA is now the largest non-governmental organization in Finland working in development cooperation and the second largest in humanitarian assistance. The organization was ideally poised to deliver highly valuable aid following the disaster in Haiti, considering their strong history, extensive network, humanitarian philosophy and capable profile. As the organization with the overall plan and budget, FCA was responsible for managing the project — allocating the budget, overseeing the phases of the design and construction work, coordinating

St. Matthieu School construction.

local details such as housing, transportation, travel and security. They also provided valuable information regarding Haitian practices and regulations and added understanding of the project's social, political and economic context.

FCA also helped form the overall approach to the project. Everyone on the team knew that a "standard" overseas project approach — namely visiting, working and leaving — would not benefit Haiti over the long-term and also didn't fit the model of sustainability that FCA aims to achieve. After discussions, the four companies agreed to commit to have at least one engineer on the ground in Haiti for one year as well as a team of designers backing up the field presence on a pro-bono basis. This was the model that the firms thought would be achievable and would contribute the most value.

Design

After receiving the initial school layouts from FCA, our team started to design the school buildings. From the outset, FCA decided that after its initial outlay of temporary (or transitional schools), our group would be tasked with building permanent schools — simple yet robust structures using durable materials sourced locally whenever possible. Our goal was to design several prototypes that could be replicated in various conditions present in Haiti. In total, FCA intends to build 50 of these designed schools around the country.

The design of the final prototypes was a shared effort between Blackwell Bowick, Halsall Associates and Read Jones Christoffersen. The team held weekly coordination meetings via Skype or teleconference to discuss and distribute the design work. These meetings included the onsite construction engineer in Haiti.

St. Matthieu School in progress.

We all became apprised of the design constraints, namely material shortages, remote access, different construction practices, lack of access to typical North American building supplies and limited equipment. What emerged from the process were multiple prototypical buildings, constituting both heavyweight and lightweight school designs that respond to the needs of particular school communities and the dictates of each site. In general, the heavyweight schools are used in areas accessible by road, and the lightweight schools are used in rural areas where there is no road access and materials have to be carried in to the site by foot.

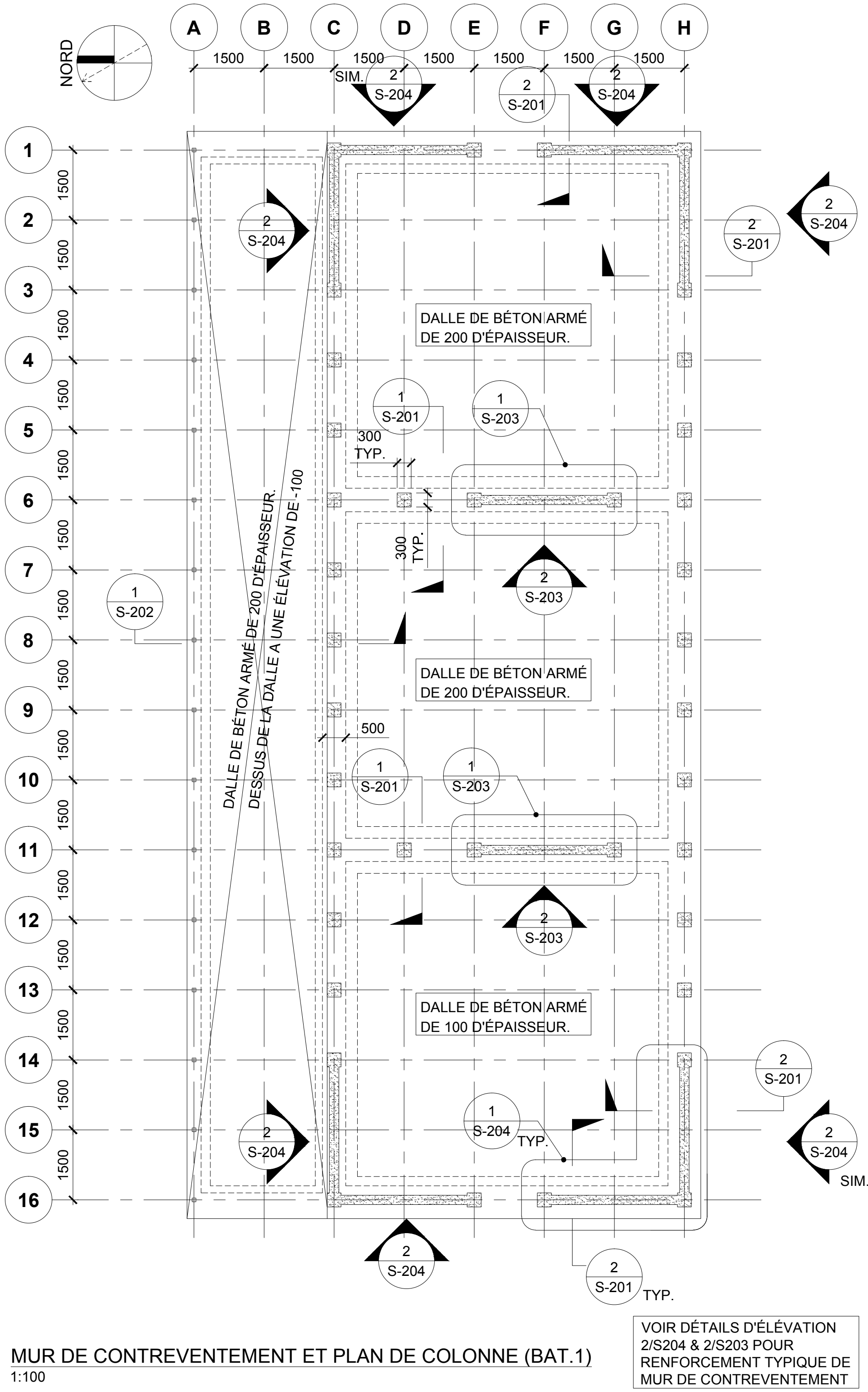
The two main prototypes are:

- Lightweight structures: timber stud wall construction with plywood shear walls. (The St. Joseph School in Embouchure, which won the WoodWORKS! Award in 2011, is a "lightweight" building.)

- Heavyweight structures: reinforced concrete columns and shear walls with rubble masonry wall infill. (The St. Matthieu School, which won the Humanitarian Award from the Consulting Engineers of Ontario in 2012, is an example).

The final design of the lightweight structure features a plywood diaphragm on wood trusses, with plywood gusset plates on load-bearing shear walls. A built-up wood ring beam is used to distribute diaphragm loads to the shear walls beneath it.

The final design for the heavyweight structure features reinforced concrete shear walls and columns, a reinforced concrete ring beam and infill walls made up of rubble masonry.



Drawing for St. Matthieu School.

Design Codes
In the absence of an officially-adopted building code, the Ministry of Public Works in Haiti agreed to accept designs from four codes, which included the Canadian and American codes. We chose our construction type based on the local construction materials available and then designed to meet Canadian Code.

One of the first design challenges that we faced was to determine the environmental requirements/factors for wind and earthquake loads, so that we could determine the design loads specific for the project locations in Haiti.

For earthquake loading, Dan Carson of Halsall obtained a preliminary US Geological Survey (USGS) seismic hazard assessment of Haiti following the earthquake. Matching the USGS seismic data with a paper written regarding converting the USGS data allowed us to use values that could be used directly in the Canadian Code.

The Ministry of Education guidelines for school construction suggested that the schools should be able to resist a category 3 (Saffir-Simpson scale) hurricane, that corresponds to a 130mph, one minute sustained wind speed. This value had to be converted into hourly sustained wind speeds that correspond with the way wind pressures are calculated by the Canadian Code.

Design Considerations
Design-wise, we tried to keep the structures for each prototype school as simple as possible to ensure the drawings could be easily understood by the contractors and built correctly. We wanted the structures to be safe, affordable and buildable with as minimal skilled labour requirement as possible.

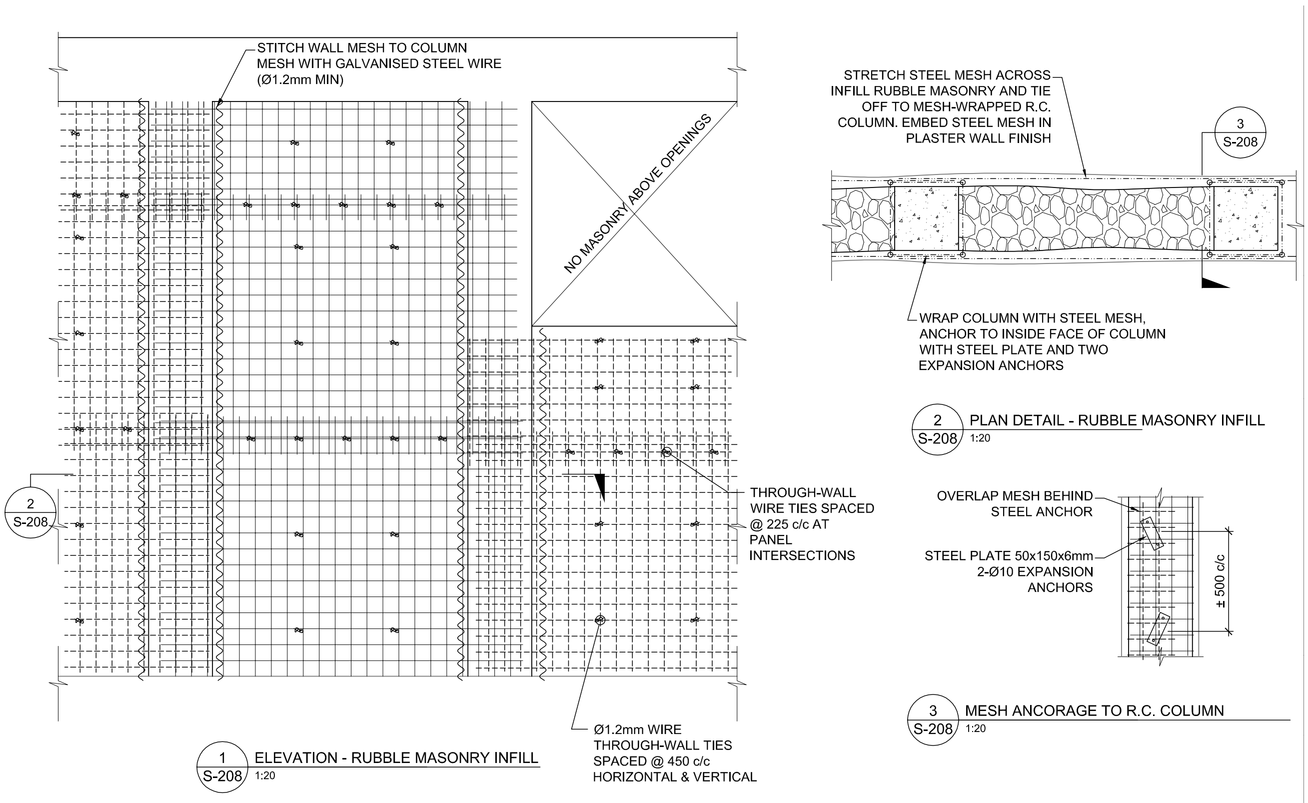
The “standard” type of construction for Haitian buildings is of low quality and doesn’t typically stand up well to the large seismic forces prevalent there. Technically speaking, most existing buildings in Haiti use “confined masonry” as the lateral load resisting system, which is not allowed by the Canadian code, due to the elevated earthquake risk in Haiti. We opted to move away from this typical construction practice, as it is an inherently poor system for resisting large horizontal loadings.

We also provided customized site planning to suit the specific locale of each school planned, in terms of landscape. This was done to minimize earthworks, which can be time-consuming when dug by hand. In Haiti, even schools accessible by road may have very poor access, and often heavy equipment cannot get to the school, so minimizing the need for heavy equipment is paramount to keeping a project to schedule.

Our designs for the heavyweight structures employ reinforced concrete as a basic construction material. Concrete was chosen for its strength, durability, local availability and because local people have experience working with reinforced concrete and formwork.

The design criteria for lightweight schools called for lightweight and easily adaptable materials, which meant that wood was the natural material choice. Given Haiti’s mountainous landscape, some school sites are only accessibly by foot. The site of the Embouchure School was a rigorous two-hour hike down a hillside and through a riverbed, so it was important that building materials be as lightweight as possible and as efficient as possible. Wood was selected because it is a lightweight material and can be used in a reasonably low-tech environment. Hammers and nails are readily available in Haiti, and in remote communities there is no electrical power. Timber was the material that made sense in this context.

In selecting wood as the preferred building material for the lightweight structures, resistance to hurricane and earthquake forces was a crucial consideration. The lighter the structure is, the lower the seismic forces. There is a big advantage to using wood because the structure



Drawing for St. Matthieu School.

itself is significantly lighter, with correspondingly lower seismic loads, than if it were built using more typical concrete and masonry construction.

Another advantage of wood construction in remote areas was the ease of onsite construction. Truss and wall elements were designed and pre-cut and carried in and assembled on-site. Wood is a material that allows for small changes and adapts well to site conditions.

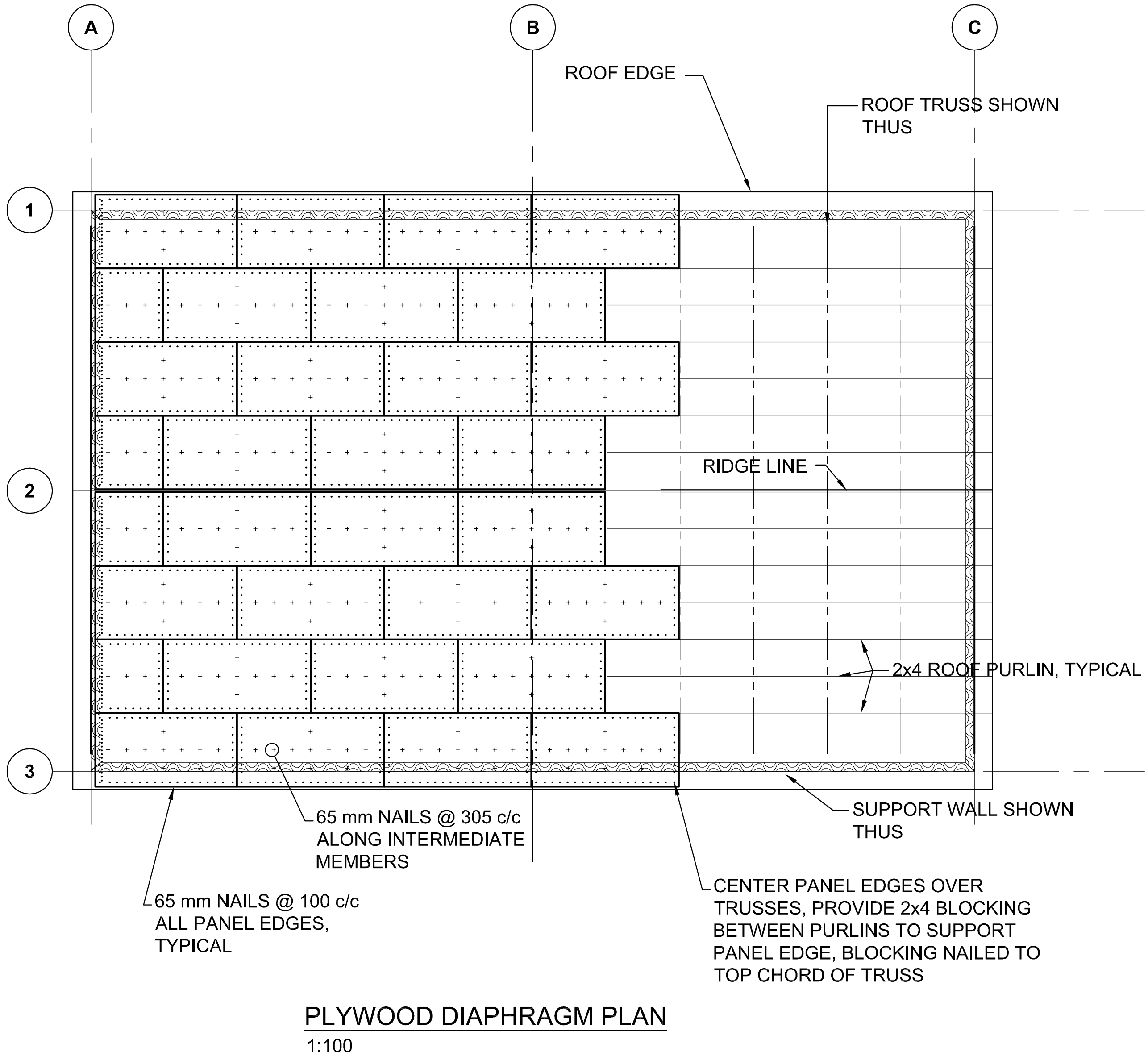
Both prototypes were developed using well-connected plywood diaphragm roofs, which attract less seismic load because of their small mass and have been shown to perform well under lateral loads. The roof was then supported with a well-defined uniformly distributed system of shear walls made of either timber or reinforced concrete.

Environmental Considerations

Building 'green' schools is a priority for Finn Church Aid's school reconstruction program. In alignment with this goal, we incorporated environmental considerations into all aspects of our design. All of the construction materials for the schools are locally available with the exception of the wood. The wood for the projects is imported – reflecting the importance of conserving Haiti's dwindling forests. A borate solution was used as a preservative treatment for the timber where necessary, rather than a conventional pressure treatment, as almost all scrap lumber available is used as fuel in homes for cooking. The borate treatment is also non-toxic and not harmful to the environment or the occupants of the schools.

Rubble masonry walls, using recycled rubble from buildings destroyed by the earthquake, were detailed for the non load bearing walls for

St. Joseph school under construction.



Drawing for St. Joseph School.

St. Matthieu School. Initially, FCA's concept for the schools contained an interesting feature: gabion walls using rubble infill to use some of the rubble that was widely available following the earthquake. Conceptually, this design would work as the rubble is plentiful and cheap and there is an abundance of unskilled labour on the market in Haiti. However, after the first building was constructed with the gabion non-load bearing walls, the concept was changed to rubble masonry walls. Rubble masonry walls had the advantage of using readily available materials and skills that Haitian masons already had, without the need to import or produce gabion baskets.

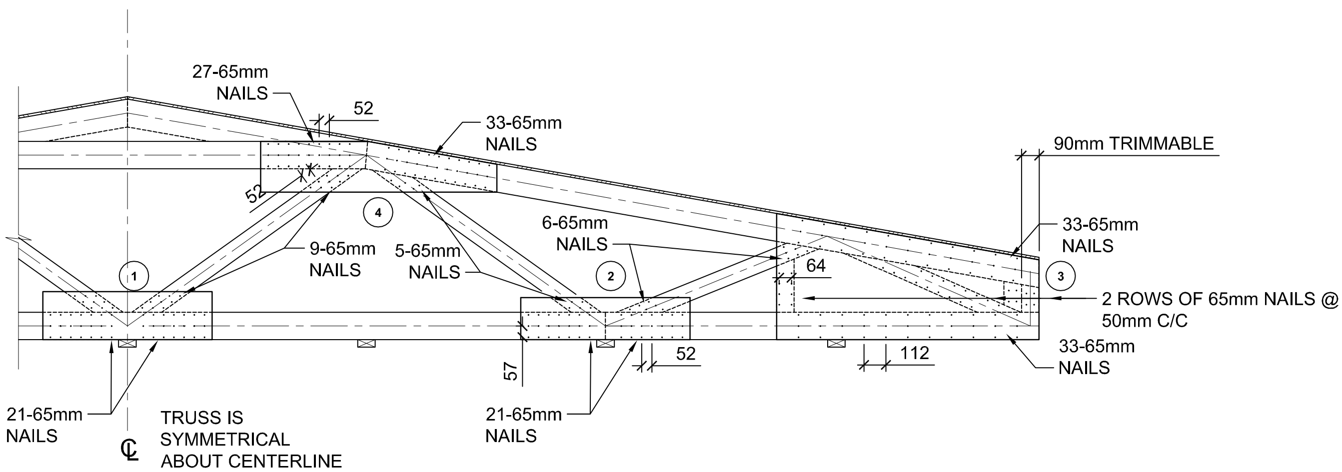
Biogas waste treatment systems, a sewage treatment system that harvests the methane gas from the decomposition of the waste was another 'green' aspect of the schools. The methane gas is collected and directed to the school kitchen for use with cooking. Typically charcoal, made from local wood, is used for cooking. The biogas systems aim to reduce the need for charcoal and hence reduce the demand on the local forests. Solar technology is also a part of the school reconstruction program to help provide them with renewable and inexpensive electrical power.

Materials

Our designs for the lightweight structures employ timber as a basic construction material. Wood was chosen for several reasons: it is readily available, lightweight to transport, and easy to work with using tools common in Haiti. These structures were intended to be used in remote locations where building materials needed to be transported to the site by hand.

The materials used in the construction were sourced locally wherever possible. As the availability of materials can be quite variable in

Women from Embouchure carrying water from the river up to the school construction site.



1 / S-301a — WOOD ROOF TRUSS GUSSET & NAILING DETAILS

1:30

NOTES:

1. FULLY-SHEATHED TRUSS ENDS MAY BE TRIMMED TO SUIT AS-BUILT SITE DIMENSIONS, MAXIMUM 90mm EACH END.

GUSSET PLATE SCHEDULE

MARK	THK	SIZE	COMMENTS
1	15	864x246	
2	15	864x215	
3	15	1338x645	IRREGULAR
4	15	1205x258	IRREGULAR

Drawing for St. Joseph School.

Haiti, we had to invent many innovative solutions to compensate for shortages.

Construction

After our two school prototypes were designed to our team's approval, the construction phase began.

Shane Copp from Read Jones Christoffersen spent the better part of 17 months in Haiti, and Tim Joyce and Michael Hopkins of Blackwell Bowick were onsite for six weeks. Together, they contributed project management, construction oversight and training to the local engineers. Shane's involvement and commitment, in particular, ensured the successful outcome of the project. He is acknowledged by the entire team as a praiseworthy leader with tremendous spirit.

These Canadian engineers were involved, not just in structural work, but in all levels of construction. In order to ensure that each project was well coordinated and built to required standards, the Canadian field engineers also assisted with project layout, demolition, scheduling, safety, quantity calculations, architecture, civil works, plumbing, electrical work, quality control, training of the site staff and paperwork.

Since material testing facilities in Haiti are scarce, we came up with our own reliable testing methods while onsite. For example, we performed a modified slump test for local concrete by making use of locally available materials.

Construction in Haiti is slow going compared to North American standards. This is to be expected, considering the human and environmental factors inherent in the project. It is also due to the many challenges faced in construction projects in the country: expensive materials, narrow supply chain, limited infrastructure and the necessity to achieve processes without the use of (costly) machines. Gravel is often produced by crushing stones by hand with local labour. Materials are carried, by hand or with the help of donkeys, to remote sites.

All the contractors working on the project were highly engaged in helping this country. Tim Joyce said of Yves, the contractor he met on site, "Yves was born in Haiti and had been successful in the United States, but he returned to Haiti to start a construction business even before the earthquake." Labour workers for the school projects were members of the local community, often the parents of children attending the schools. This initiative was of vital importance to the community and all of those participating demonstrated a high level of personal investment and pride in the school projects.

Our engineers overcame many challenges to get the schools built and operational. The Haitian contractor's site staff and the local engineering staff were inexperienced in reading drawings and were not aware of good construction practices.

We took extra care to ensure that our drawings were perfectly clear. For example, if the drawing called for 33 nails in a connection, our drawing showed all 33 nails in the correct locations to avoid construction errors. In an effort to guarantee that the schools were built properly, we trained site supervisors and tradespeople to recognize good practices, to understand

St. Matthieu school complete.

the drawings and to build what was shown on the drawings. Through commitment and collaboration, we were able to see two schools come to life within the first year, and open their doors to hundreds of local children in time for the beginning of the Haitian school year.

OUTCOMES

Our efforts have exceeded our expectations with regard to this outcome. After eighteen months in Haiti, this project has resulted in two new schools built to date and nine more in various stages of completion. In addition to being safe, permanent structures, these schools will promote learning, by providing a comfortable environment for children and youth. We handed over a suite of prototype classroom designs, which can be adapted to suit future sites by the local team who assumed the project. Once all of this work is completed, hundreds of children per school will have access to education.

To recap, the outcomes anticipated for this project were:

1. School buildings better equipped to withstand weather conditions such as earthquakes and storms

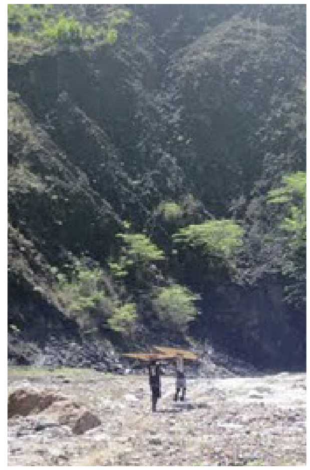
2. Sustainable contributions to Haitian communities

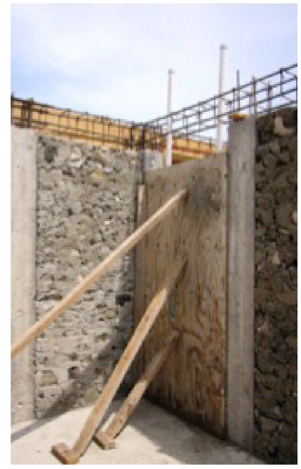
3. Skills transfer: training for local engineers and others involved in the project

4. Learning for the Canadian teams in conducting overseas projects

Better School Buildings

This project also demonstrates that innovation and qualities of excellence in building are not impossible in underdeveloped countries in the aftermath of a natural disaster. We designed and oversaw construction of both prototype schools to Canadian standards in a country with no established, adopted or enforced building code.





Top left: Trekking plywood to the St. Joseph School site.
Top right: St. Matthieu school – showing the reinforced concrete columns, rubble masonry infill walls and the reinforcing steel for the yet to be cast ring beam.
Bottom: St. Joseph School under construction.

Richard Portalus (FCA engineer), Alix (Contractor's architect and site supervisor), Jn Telcy Kinson (FCA engineer) and Shane Copp (RJC engineer) at the St. Matthieu school site.

Haitian Boys at St. Joseph School.

Sustainable Contributions to Communities
There should be no doubt that these schools are integral to their communities, as they provide a place to access education as well as a meeting place for the community. Through this project, hundreds (if not thousands) of Haitian children and youth will have a place to learn.

Many Haitians lost their livelihoods after the earthquake. These projects were able to inject some cash into ailing communities through employing local builders in a work program. Many of the laborers hired for the construction of the schools were parents of the children that will be attending the schools. The local labourers learned new skills in construction, such as properly mixing concrete, carpentry, and masonry work. Hope is another contribution of this project, not to be underestimated. One school principal met during the course of this project said after an initial assessment of his damaged school, "Our hope is with you." After suffering the consequences of a devastating earthquake, the community members involved in this project felt hope for once again having schools, and for these schools being safe. This aspect of the project affected all of us with the Canadian engineering companies deeply.

Also part of this outcome is the strengthened reputation of FCA. Having started and achieved so much in this project will further the organization's goal of building networks in Haiti, and being a trusted part of relief efforts.
The simple exchange of goodwill and the pursuit of a common goal also worked to achieve this outcome. During the course of the project, the engineers from Canada met with church leaders, school principals, teachers and other community members. Ultimately the opportunity to meet and to work together will prove a benefit in the long term to everyone involved in the project.

Skills Transfer
The team incorporated an engineer training plan into the school reconstruction project, in order to develop the capacity of local engineers while helping to rebuild. By sharing our knowledge and setting examples of good construction practices, we hope to ensure that future projects built in Haiti after our departure are better designed to resist earthquakes and hurricanes. By engaging and teaching the bright young engineers of Haiti now, our hope is that in the future, some of the tragedy of the recent past can be avoided.

Tim Joyce of Blackwell Bowick says that he "felt encouraged by the progress of the Haitian engineers" during his time in Haiti. The mentorship aspect of his role "was a rewarding part of the project for me," he says. Our teams met with many engineers, all of whom were eager for knowledge and committed to improving the built environment in Haiti. But it wasn't just engineers asking for training, onsite the Canadian engineers were teaching skills to contractors as well. The original goal of the project was to train the Haitian engineers to completely assume the project for an indefinite time. While there is work still to be done, the project is definitely headed in the right direction and has delivered a high degree of knowledge and skills transfer to dozens of project participants.

Kenneth Cryer of Blackwell Bowick remarked that he learned through the Haitian-trained engineers he met that the industry is eager to comprehend better practices, but that there is a lack of proper apprenticeship training or mentorship that we take for granted here in Canada. The training provided to the local Haitian engineers attempts to fill the gap in mentorship issue with young Haitian engineers.

Our project demonstrated work that is far and away more advanced in terms of timelines, engineering, completeness, competency and impact. This will absolutely leave a positive impression long after the project is complete.

Learning and Growth for Canadian Participants
By all accounts, the engineers' experience onsite was very positive. It is difficult to measure professional growth and learning, so we offer the following anecdotes to demonstrate this outcome.

Tim Joyce, Blackwell Bowick: "Personally, I learned to focus on what I could control, rather than the bigger picture. I also learned from FCA that it pays to be ambitious in disaster relief efforts."
Patti Glass, Read Jones Christoffersen: "Many North Americans trying to understand how to best help a country still reeling after the 2010 earthquake often ask 'what is the best way to help in Haiti?' The answer: small steps."

Kenneth Cryer, Blackwell Bowick: "I feel I contributed good examples of earthquake and hurricane-resistant construction and design."

Also, "At all the construction sites, the local workers were personally invested in the school construction and wanted only to do the best they could — that was a highlight."

We all learned that small-scale volunteer efforts can make a significant difference in the lives of Haitian children, today and for generations to come. An important component in projects of this nature is to implement a skills-transfer program, as this helps to grow the capacity of local engineers and share new construction techniques with the trades.

We now all feel strongly about contributing towards disaster relief and providing support to people who have lost their dwellings.

Haitian Girls at St. Matthieu School