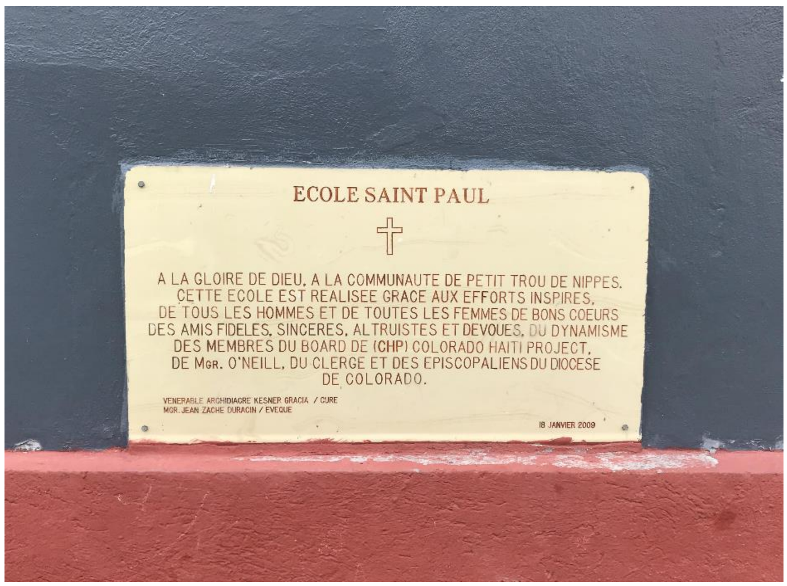


Colorado Haiti Project: Saint-Paul School Structural Improvement Report

Build Health International

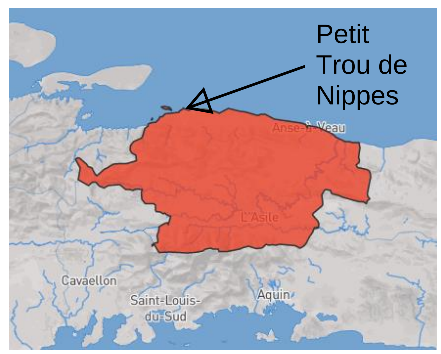
100 CUMMINGS CENTER, #120H, BEVERLY, MA 01915 | 1 (978) 969-0920
INFO@BUILDHEALTHINTERNATIONAL.ORG

Introduction:

Report Objective:
The objective of the structural improvements report is to provide Colorado Haiti Projects with recommendations for structural improvements based on BHI site visit and structural analysis. This report will build upon the initial findings report and provide a summary of the structural analysis, BHI recommended improvements, a phased/scheduled approach to implement improvements and a rough cost estimate for proposed improvements.

Work Description:
This report was developed using information and structural values collected during the BHI assessment visit. BHI used this information to model the structure and identify failures of structural components in the existing building. Additionally we used local seismic values specific to Petit Trou de Nippes. The model simulates the forces and movement that impact the structure and identify expected structural issues based on the location and quality of construction and materials. Using this analysis BHI has recommended necessary structural improvements to the building.

Location:
Petit Trou de Nippes is located in the commune of the Anse-à-Veau on the southern peninsula of Haiti. The Enriquillio-Plantain Garden fault runs through the commune and the region is classified as medium risk earthquake zone based on the current information available. This classification is defined as having a 10% possibility of seismic activity in a 50-year period. Additionally the seismic values found in table 1 express the ground acceleration rates, which informed the structural simulation BHI used to analyze the structure.



Data		
Building Type	School	
Risk Category	II	ASCE Table 1.5-1
Importance factor (Ie)	1	
Respond Modification Factor R	6	
Over Strenght Factor (Ω)	3	ASCE table 12.2.1
Location	**Haiti**	
Site Category	D	Table 20.3.1
S1	0.33	g
Ss	0.88	g
Fa	2.5	
Fv	3.5	
Sds	0.674667	
Sd1	0.55	
Seismic desing Category	D	ASCE table 11.6.1

Table 1

Structural Analysis:

Existing Structure:

The existing structure was modeled and analyzed using software designed to identify and calculate structural integrity of all components of the building. The structure has several characteristics that led to failure in the building including:

- **Poor quality materials** - Many of the materials used for the construction of the building are below the specified values provided in the structural design:
    - Concrete strength in structural components are far below the specified strength
    - Rebar was undersized in columns and beams
    - CMU block was low quality
- **Lack of drainage at footing** - The foundation of the building is prone to settlement because the soil is saturated and this puts additional strain on weak structural components. If not drained the building will continue to sink and settle and cause additional damage to the building.
- **Demand over capacity** - The contractor installed a concrete roof but the building was designed to receive a light sheet metal roof. The added demand created by the weight of the roof has led columns to be over capacity, which has resulted in structural failure. The failure of columns has resulted in six beam failures, the structural frame is compromised, and additional seismic activity could cause significant damage.
- **Lack of expansion joint** - The building was designed as two separate buildings but was built in a single "L" configuration. The buildings were designed to move independently and due to this connection the movement of the structure is strained and causing additional cracking at the intersection. This connection will cause additional issue if there is seismic activity as the increased torsion created by this connection could result in additional damage.

Structural Failures:

Poor construction has led to failures in the structural frame of the building. Failure does not mean that the building will collapse but it does mean that the weight and pressure of the building itself is over the capacity of the structural component given the inadequate strength of the concrete and the undersized rebar. The failure of these components is amplified by the saturated soil and the lack of expansion joints, which has resulted in cracking of the walls and roof throughout the structure. The following structural components have failed or are at the limit of capacity and are located in diagram 1.

- 16 columns (7 first floor and 9 second floor) are over capacity and are in a state of failure
- 7 columns (5 first floor and 2 second floor) are in high demand and at the limit of capacity
- 6 beams on the first floor are over capacity and are in a state of failure

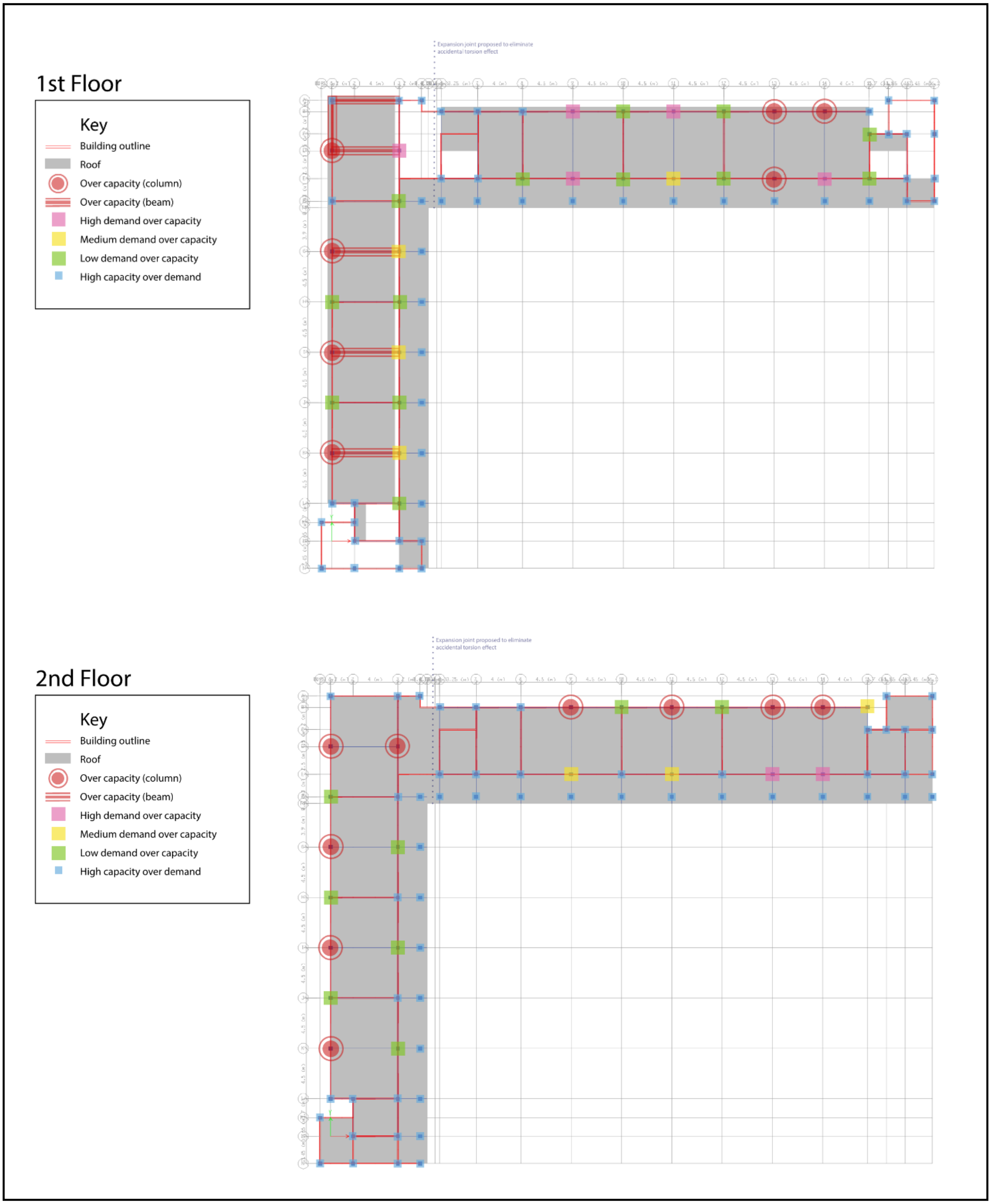

1st Floor
Key
Building outline
Roof
Over capacity (column)
Over capacity (beam)
High demand over capacity
Medium demand over capacity
Low demand over capacity
High capacity over demand
Expansion joint proposed to eliminate accidental torsion effect
2nd Floor
Key
Building outline
Roof
Over capacity (column)
Over capacity (beam)
High demand over capacity
Medium demand over capacity
Low demand over capacity
High capacity over demand
Expansion joint proposed to eliminate accidental torsion effect

Diagram 1

Structural Improvements:

Recommended Improvements:

The buildings structural frame has failed and issues will continue to degrade if the components are not reinforced. Further failure caused by seismic activity could cause catastrophic failure and BHI recommends immediate repairs. Despite the structural failures, the building can be salvaged by making the following improvements:

1. **Site and Foundation Drainage** - Groundwater and rainwater are collecting at the foundation and undermining the structure and causing the building to settle. BHI recommends installing French drains around the building to move water away from the foundation. Poor site drainage is also causing rainwater to settle around the building and additional sitework will be needed to drain rainwater to proper catchment areas.
2. **Reinforce Structural Frame** - The columns and beams that have failed will need to be reinforced by excavating and pouring new column footings and installing steel columns and beams to reinforce the existing structure. The columns will be located inside the existing columns (A typical detail for this type of reinforcement can be seen in image 1). The steel will be connected to the existing concrete columns with threaded rod, which will be epoxied into columns on either side of effected rooms. A new steel beam will be connected across these columns and carry the additional demand across the failed beams. The columns on the second floor will also need similar reinforcement but further review will be necessary to determine a final design for reinforcement. The steel structure will reinforce the failing concrete columns and beams and improved footings and drainage will eliminate settlement issues. Diagram 2 shows the locations of the proposed steel reinforcement.

Image 1 – Structural Steel Reinforcement

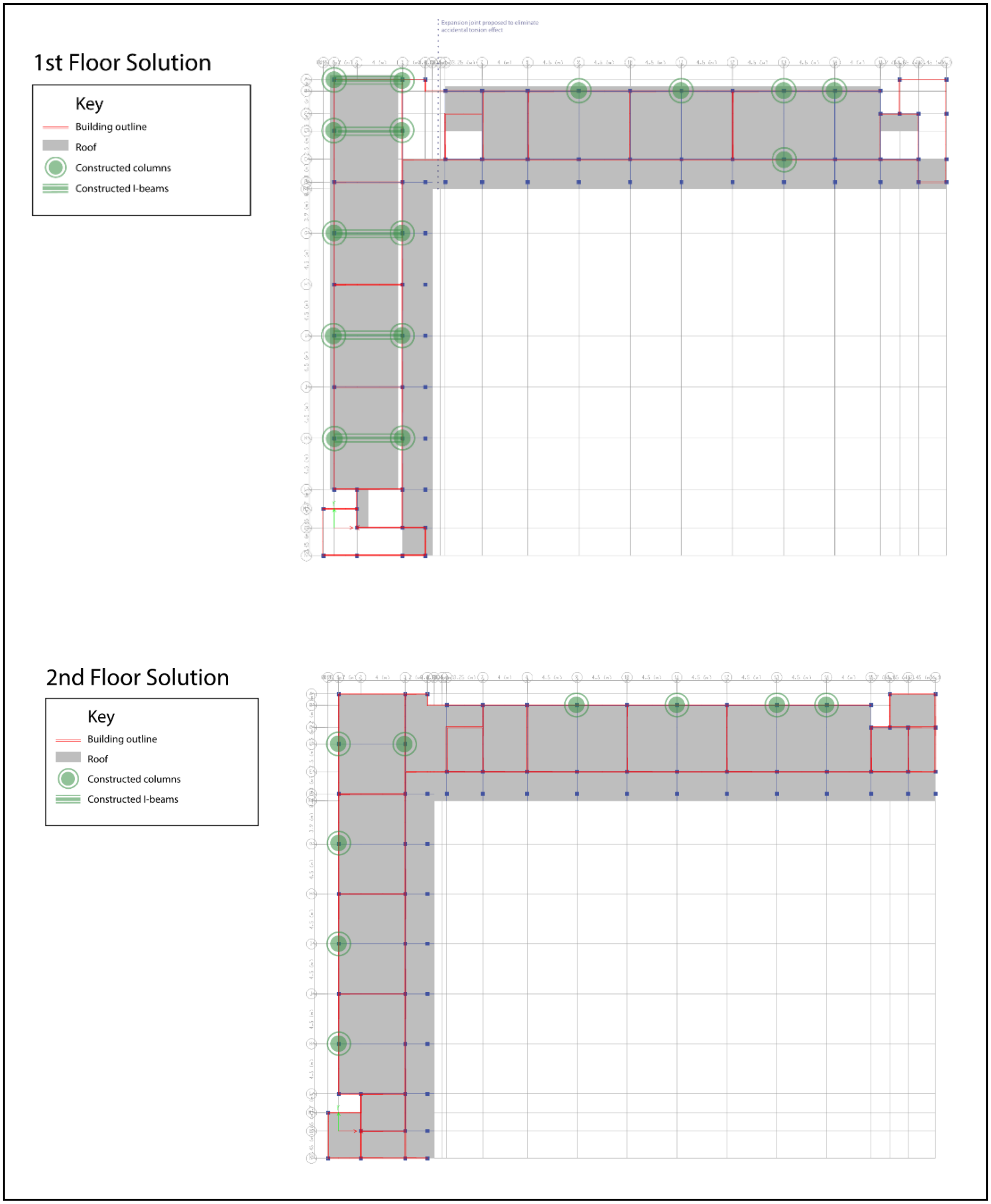

1st Floor Solution
Key
Building outline
Roof
Constructed columns
Constructed I-beams
2nd Floor Solution
Key
Building outline
Roof
Constructed columns
Constructed I-beams

Diagram 2

3. **Expansion Joint** - A 2”-4” expansion joint needs to be cut at the intersection of the buildings throughout the entire structure to allow for independent movement (Expansion joint location can be found on diagram 2). This will reduce torsion and help prevent cracking of walls at connections in normal conditions. It will also help prevent extreme failure caused by added torsion in a seismic event (A typical expansion joint detail can be seen in image 2).

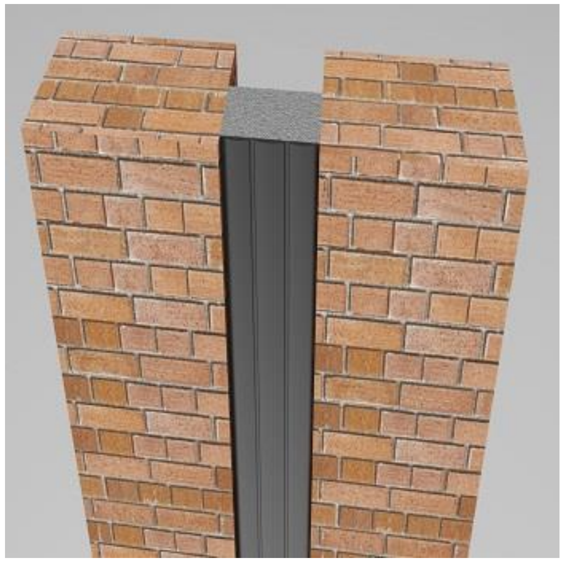


Image 3 – Expansion joint detail

4. **Roof and Wall Crack Repairs** - After improving drainage, reinforcing the structural frame and adding the expansion joint to the building, surface cracking should be chipped, cleaned and rendered. The majority of this cracking is being caused by the settlement of the building, the failure of the structural components and the torsion force caused by the lack of an expansion joint. The cracks in the roof will need to be chipped and repaired and painted with sealing elastomeric paint. The building may still have some minor settlement and some cracking may reappear but the damage will be limited and cracking will not impact the structure of the building.

Project Schedule and Phasing:

Phase 1: Design and Procurement (6 weeks)

Prior to renovation and sitework BHI will develop civil and structural construction documents. Additionally BHI will procure all structural steel and other items not available in Haiti from the US. Work in this phase includes:

- Perform drone survey of the campus
- Develop a full civil plan for the campus with drainage plan for the foundation
- Develop structural design for foundation reinforcement and structural steel reinforcement
- Develop shop drawings for the structural steel needed for reinforcement, procure and ship

Phase 2: Foundation and Site Drainage (3 weeks)

Construction will begin with moving water away from the foundations and the building. Work in this phase will include:

1. Install French drain at footings that daylight away from the building or into a soak pit
2. Grade and add necessary drainage trenches or swales to move rainwater away from the foundation of the building
3. Ensure that water draining from roofs are integrated into the site drainage system

Phase 3: Excavation and Demo for New Concrete Foundations (5 weeks)
Reinforce the existing foundations with new concrete, and install new foundations for new steel structure. Work in this phase will include:

1. Excavate trench around the outside of the building and pour new concrete to reinforce existing foundation
2. Demo the floor inside the building where new steel structure will be installed and pour new foundations

Phase 4: Erect and Detail Steel Columns and Beams (5 weeks)
Erect the steel reinforcement structure and connect to existing structure. Work in this phase will include:

1. Erect steel columns and anchor to new foundations
2. Erect steel beams
3. Detail and connect new steel structure to existing concrete frame

Phase 5: Backfill Foundations (1 week)
Once the structure has been installed and concrete has set, the foundations will be backfilled and new columns will receive concrete.

1. Backfill foundations on the outside of building and ensure that that the area is grades to site drainage
2. Pour concrete around new steel columns to finish floor height

Phase 6: Building Finishes (4 weeks)
Following structural repairs, the building will receive building finishes. Work in this phase will include:

1. Reinstall flooring damaged during structural repair
2. Chip, repair and render cracking throughout the building
3. Repair cracked roof and coat with elastomeric paint

Total Construction Time: 24 Weeks

Cost Estimate:

The cost estimate for the structural and civil renovation of the Saint-Paul School can be found in table 2. This estimate is based on an assumed scope of work and schedule and further review, design and discussion with CHP will be needed to develop a full construction budget. The estimate also assumes that BHI would be involved in the engineering, procurement, shipping, construction and project management of all phases of the project.

The estimated cost and schedule are conservative and have been developed to provide CHP with a funding target for project construction. BHI anticipates that both the project schedule and cost may reduce but cannot guarantee construction cost without additional engineering and design.

Colorado Haiti Projects Structural Renovation			Fee	
Construction	**Unit**	**Qty**	**Unit Cost**	**Subtotal**
Mobilization	LS	1	$ 10,000.00	**$ 10,000.00**
Drainage and Sitework	LS	1	$ 12,500.00	**$ 12,500.00**
Demolition	LS	1	$ 10,000.00	**$ 10,000.00**
Foundation reinforcement	LS	1	$ 15,000.00	**$ 15,000.00**
Steel columns and beams	LS	1	$ 70,000.00	**$ 70,000.00**
Misc. concrete work and repairs	LS	1	$ 15,000.00	**$ 15,000.00**
Construction Finishes	LS	1	$ 50,000.00	**$ 50,000.00**
Engineering				
Structural and Civil	LS	1	$ 12,000.00	**$ 12,000.00**
Drafting	LS	1	$ 2,000.00	**$ 2,000.00**
Supervision and Project Management				
Construction Supervision	LS	1	$ 35,000.00	**$ 35,000.00**
Project Management	LS	1	$ 15,000.00	**$ 15,000.00**
Haitian Consruction Foreman	LS	1	$ 3,500.00	**$ 3,500.00**
Heavy Equipment and Tools				
Heavy Equipment Rental	LS	1	$ 5,000.00	**$ 5,000.00**
Power and hand tools	LS	1	$ 2,000.00	**$ 2,000.00**
Shipping				
Shipping	LS	1	$ 6,000.00	**$ 6,000.00**
Customs clearing and transport to site	LS	1	$ 2,400.00	**$ 2,400.00**
Flights and Logisitcs				
Flights and reimbursables	LS	1	$ 5,500.00	**$ 5,500.00**
Vehicle rental	LS	1	$ 3,100.00	**$ 3,100.00**
Housing and Food				
Housing	LS	1	$ 6,000.00	**$ 6,000.00**
Food	LS	1	$ 3,000.00	**$ 3,000.00**
BHI OH (15% on Construction)				**$ 29,475.00**
Total BHI Cost				**$347,475.00**

Table 2