Haiti Wood-Framed Housing Initiative

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ABSTRACT

The January 2010 earthquake near Port-au-Prince, Haiti was devastating to the nation. The scale of the disaster led many individuals and companies in the housing industry to lend aid in the recovery and rebuilding effort as well as to seek ways to improve the integrity of structures long-term. Forest products company Weyerhaeuser provided an immediate donation of building materials for temporary housing, and committed to introduce safer products for the long-term rebuilding of Haiti. This paper describes these efforts, the results accomplished, and the lessons learned.

THE TRAGEDY AND A COMMITMENT TO HELP

A 7.0 magnitude earthquake occurred about 15 miles west of Port-au-Prince, Haiti the afternoon of January 12, 2010. While estimates vary, most believe the disaster resulted in over 200,000 deaths, 300,000 homes destroyed, and over 1 million people living in tent cities. Poor construction quality and the lack of a building code resulted in widespread structural failures in and around Port-au-Prince. Inadequately reinforced masonry and concrete construction resulted in catastrophic structural collapse of a wide range of buildings.

On January 28, 2010, Weyerhaeuser made a $250,000 commitment to aid in the rebuilding of Haiti in the form of both donated building materials and technical expertise to help rebuild safer structures, properly designed for both wind and seismic loads appropriate for Haiti. While long-term rebuilding needed to take place, the more urgent need was to provide emergency and transitional shelters. Weyerhaeuser dedicated approximately half of the funds to providing building materials to be used by two organizations active in these phases of the recovery in the months after the earthquake.

TRANSITIONAL SHELTERS

Habitat for Humanity International used 161,000 board foot (BF) of framing lumber in the construction of 300 shelters in the Léogâne and Cabaret areas outside of Port-au-Prince. While not designed to resist the full wind and seismic forces that the area may experience, these structures (Figure 1) were intended to provide basic shelter as the 2010 hurricane season was approaching.

Figure 1. Habitat for Humanity transitional shelters.

The second organization with which Weyerhaeuser partnered was a Chilean-based Non-Government Organization (NGO) called Un Techno Para mi Pais (UTPMP). Weyerhaeuser provided plywood to support their construction of 150 transitional shelters (Figure 2) for over 600 people in the Canaán tent city about 5 miles north of Port-au-Prince in July 2010.

Figure 2. UTPMP transitional shelter.

PERMANENT HOUSING PHASE

Once the transitional shelter phase was complete, Weyerhaeuser began the second phase of its commitment. It is at this point that the authors took an active role in the project. It was also important to select an in-country partner to provide logistics support, a local connection and "owner" input into the design of the homes.

After exploring numerous options, we partnered with Nehemiah Vision Ministries (NVM) (www.nehemiahvisionministries.org). NVM works in the communities surrounding Chambrun, about 15 miles northeast of Port-au-Prince. They began in 1995, serving about 30,000 residents in small rural villages. After the earthquake, the population in this same geographic area grew to over 500,000 people as a result of the mass movement of people out of Port-au-Prince.

Our initial desire was to select a few Haitian families to receive the homes that we designed and supplied. In working with NVM, we soon realized that asking them to select the few families out of the thousands that they have contact with to receive these homes would be like asking them to select a lottery winner. This process would do more harm than good for NVM and the community. Instead, we chose to design and build five homes to be used by Haitian and international staff and volunteers to support NVM's work in the community. This approach ensured the homes met a real need, helped those who were helping others, and would still provide valuable experience and feedback to Weyerhaeuser and the wood industry.

ARCHITECTURAL DESIGN

Two home designs were prepared. The *Medical Staff House* (Figure 3 and 4) was intended to be used by expatriate staff or volunteers serving for extended duration in the hospital on the NVM campus. These 1,100 square foot (SF) homes would feature three bedrooms, 1½ baths, a kitchen, laundry room, living area and a small porch. Having plumbing, a full kitchen and bath, and air conditioning, these homes would be somewhat consistent with a low-end US style housing. Two of these homes are planned.

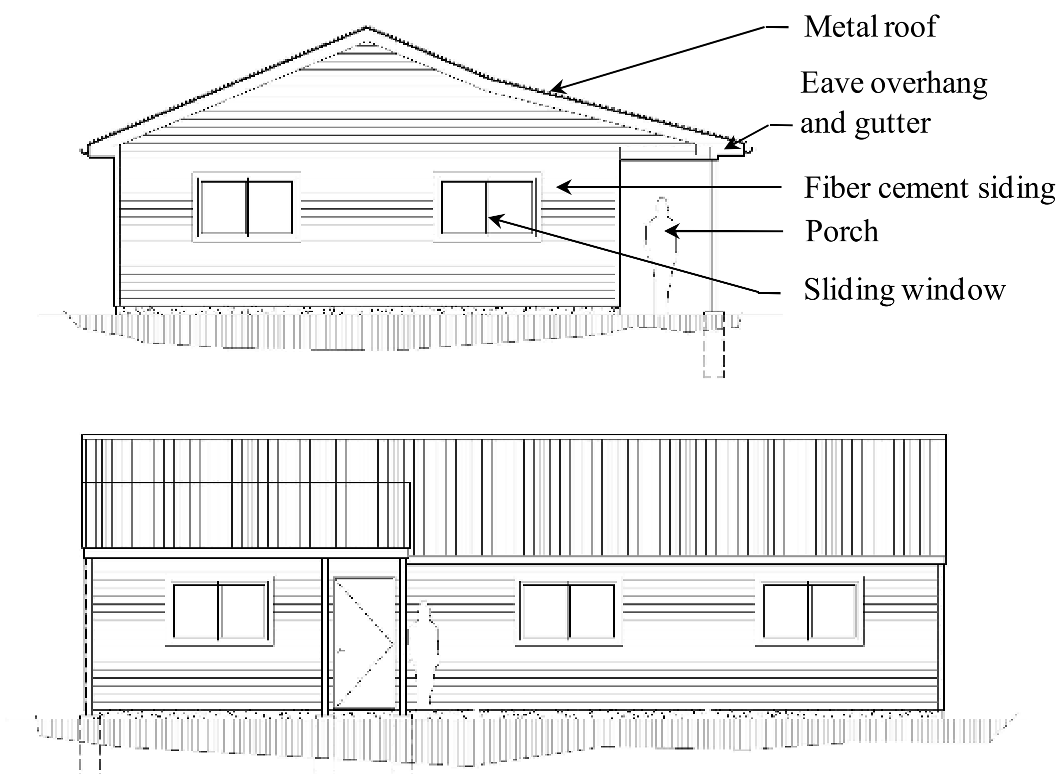


Figure 3. Medical Staff House elevations.

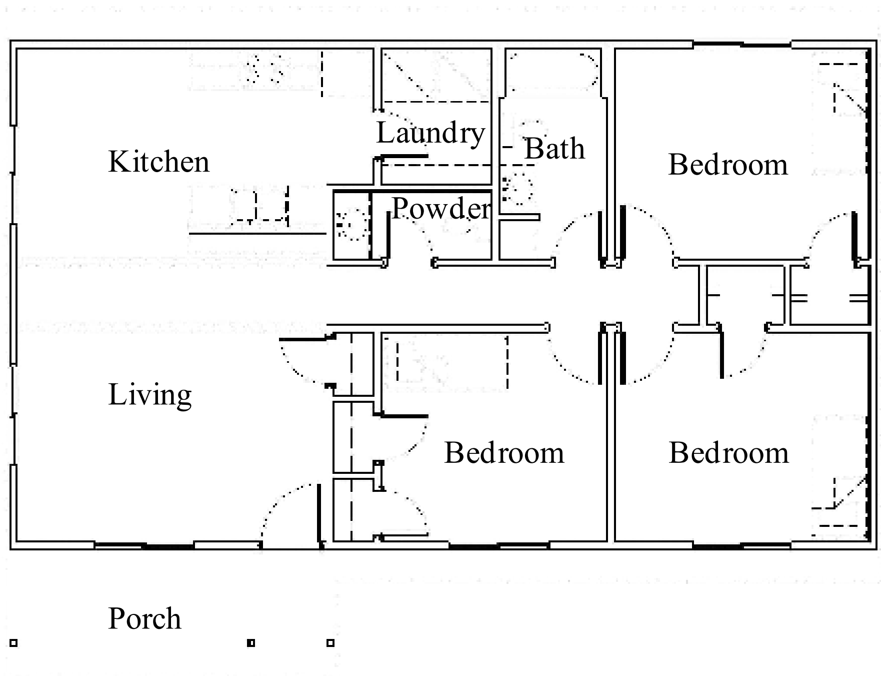


Figure 4. Medical Staff House floor plan.

The *Intern House* (Figures 5 and 6), of which there are 3 planned, was designed more in line with the needs of a typical Haitian family. At less than 500 SF in size, these homes would have two small bedrooms and a central living area. There would be no kitchen or plumbing. Instead, a full length porch (180 SF) would provide a shaded outdoor living area where cooking would also take place. Community lavatory facilities would be used rather than individual bathrooms. These homes were also designed with large windows centered across from each other on either side of the building to allow natural cross ventilation. While most homes would not have electricity or air conditioning, these particular homes were upgraded to include electricity, insulation, moisture control, and air conditioning.

Another consideration of the design was the depth of the roof overhangs. In climates subject to both heavy rainfall and sun, overhangs can perform the dual purpose of providing shade to the building and shielding the walls from wind driven water. Large overhangs, however, can complicate structural considerations in designing for uplift forces. Therefore, moderate eave overhangs were provided to direct water away from the walls while shading the majority of the windows. Overhangs were minimized on the gables which had fewer openings and less exposure to roof run-off.

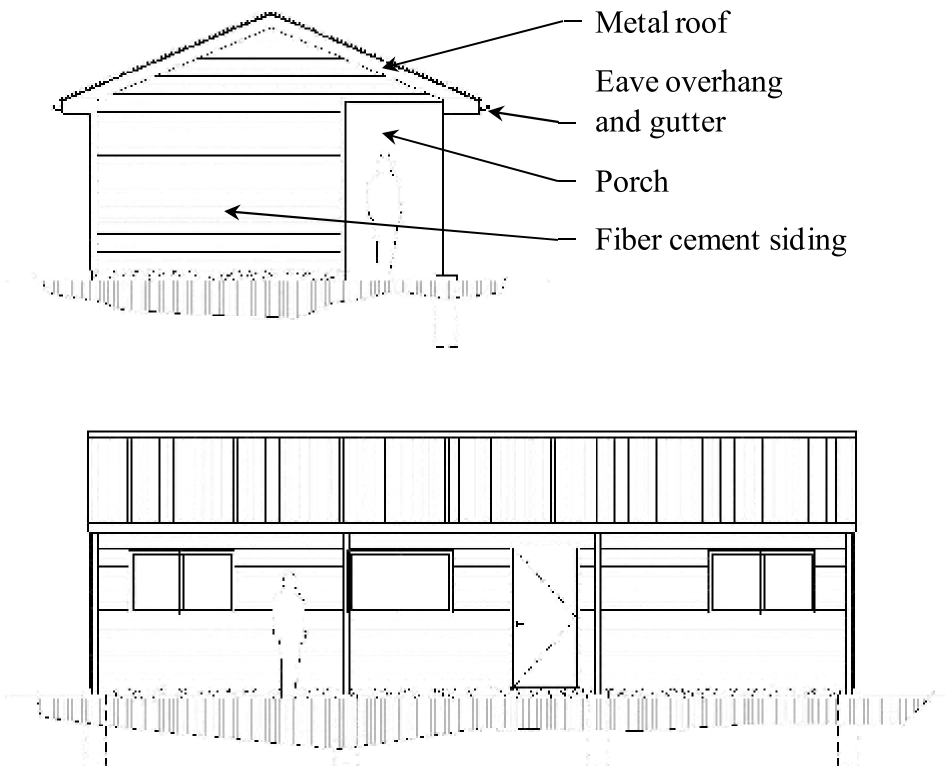


Figure 5. Intern House elevations.

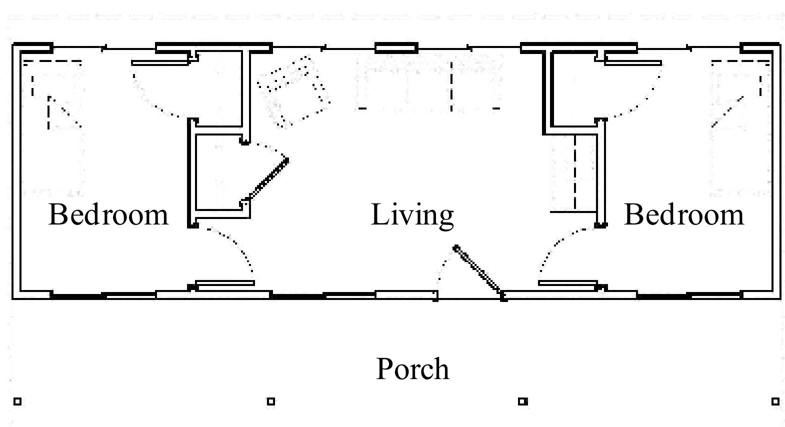


Figure 6. Intern House floor plan.

ENVIRONMENTAL PROTECTION

In addition to structural forces, the design of a permanent wood-framed structure in Haiti must provide for protection from termites. It is inappropriate to assume active protection via inspection and pest control measures, so passive protection of wood products to at least 6 feet above grade was implemented. Sill plates and wall studs were pressure-treated with 0.14 pcf of dispersed Copper Azole, Type C. The TJ®-Shear Brace was made with zinc borate additive in the TimberStrand® LSL. FrameGuard® treatment was applied to the plywood & T1-11 paneling.

Because the structures would be insulated and air conditioned, there existed the chance that a dew point would be present in the wall between the conditioned interior space and the warm moist exterior air. To prevent condensation in the wall envelope, an exterior vapor barrier was achieved by the use of taped Styrofoam SIS™ Brand Structural Insulated Sheathing (SIS) panels on walls and ceiling. For non-insulated and non-conditioned buildings where the potential for a dew point is minimized, this vapor barrier will be less critical. Emphasis on protection from liquid water will remain important. HardiePlank® cement board siding and trim was used to provide increased UV resistance, and higher strength and durability. It also will provide inherent moisture and insect resistance.

STRUCTURAL DESIGN

Space does not allow a presentation of the full design steps associated with these structures. However, some portions of this analysis are presented here to highlight the key structural approaches and construction details. The primary design consideration was wind design based on a 150 mph wind speed (3 second gust). The zone D2 seismic loading did not control the design given the lightweight wood framing of these single-story structures. With an importance factor of 1.00, exposure C, 8′ eave height, and 5/12 roof pitch, the resulting design pressures are summarized in Tables 1 and 2.

Table 1. Main Wind Force Resisting System (MWFRS) Wind Pressures. (psf)

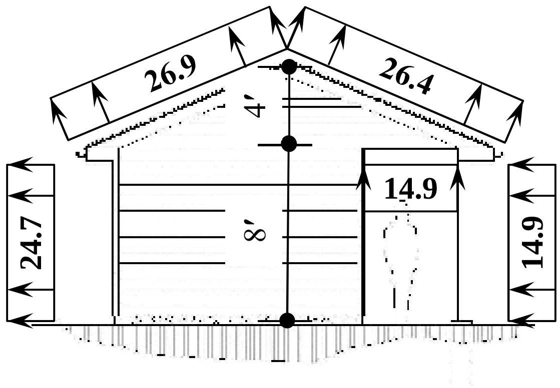
Location		Zone	
		Interior	End/Edge
1	Windward wall	14.9	24.6
2	Windward roof	-26.4	-37.4
3	Leeward roof	-26.9	-34.5
4	Leeward wall	-24.7	-32.4
5 & 6	Endwalls	-26.2	N.A.

Table 2. Components and Cladding (C&C) Wind Pressures. (psf)

Component	Zone/Direction		
	Interior/Pressure	Interior/Suction	End & Corner/Suction
Studs	47	51	62
Rafters	24	43	82
Overhangs	N.A.	92	141
Wall fasteners	N.A.	66	66
Roof fasteners	N.A.	45	95

Lateral Resisting System. The MWFRS forces shown in Table 1 produce lateral and overturning loads that must be resisted. These forces on the Intern House are shown in Figure 7, with the resulting horizontal diaphragm and shearwall forces shown in Figure 8.

Interior Zone



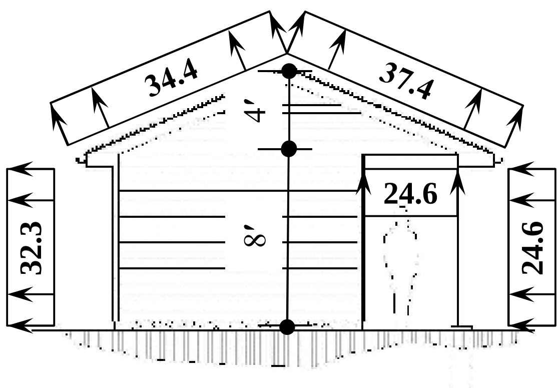
Diaphragm Reaction

(4′)(14.9 + 24.7) = 160 plf
+ (4′)(26.9 – 26.4) = 2 plf
162 plf

Foundation Reaction

(4′)(14.9 + 24.7) = **160 plf**

End Zone



Diaphragm Reaction

(4′)(24.6 + 32.3) = 228 plf
+ ignore offsetting roof = 0 plf
228 plf

Foundation Reaction

(4′)(24.6 + 32.3) = **228 plf**

Figure 7. Intern House MWFRS loads.

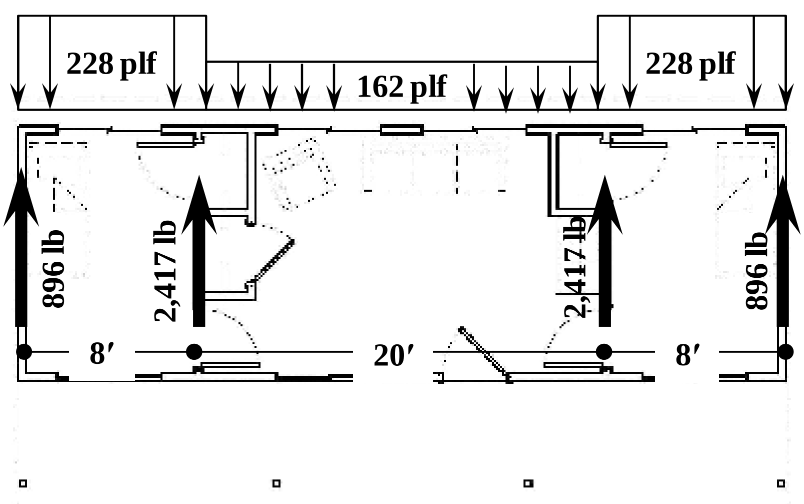


Figure 8. Intern House diaphragm and shearwall forces.

Horizontal diaphragm resistance was provided by a combination of the metal roofing, SIS ceiling sheathing (top of the ceiling joists) and wood panel ceiling (bottom of the ceiling joists). Blocking and fastening of the horizontal diaphragms was specified to ensure adequate transfer of the horizontal shear forces from the diaphragms to the resisting shear walls. The TJ®-Shear Brace was used at the interior shear walls (Figure 9) while the SIS and wood sheathing provided lateral resistance at the outside shear walls.

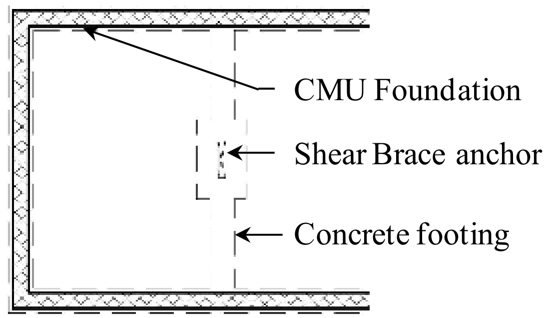


Figure 9. TJ-Shear Brace at interior braced wall location.

Uplift and Overturning. Various Simpson® connectors were used to transfer uplift forces from the roof and wall down through the wall framing to the foundation (Figure 10). Uplift anchors were specified at corners and openings to resist overturning forces, and wind uplift forces on the roof were resisted by screw fastening of the purlins to the rafter framing. Furthermore, decreased purlin spacing at the ends and corner zones (Figure 11) allowed for a concentration of framing and sheathing fasteners to resist the higher loads in these zones.

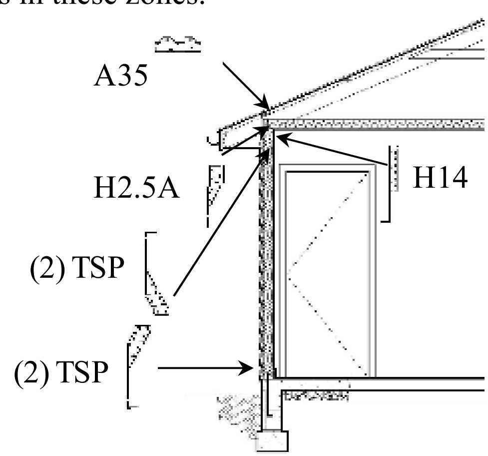


Figure 10. Typical uplift connections.

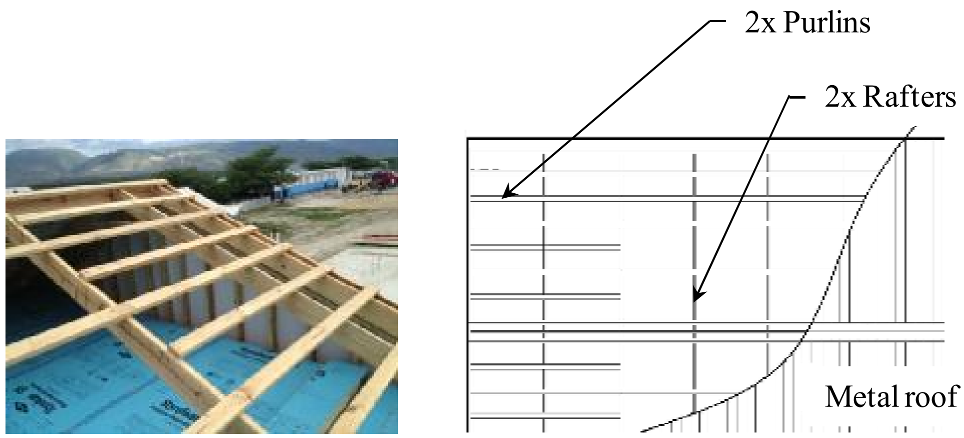


Figure 11. Increased end/corner zone framing.

CONSTRUCTION LESSONS

In October 2012, thirty volunteers spent from one to two weeks in Chambrun, Haiti, to begin construction of these five homes. The project was extremely humbling and rewarding. It was a chance to experience and better understand the Haitian culture, and to help those involved in recovery and development efforts.

The team experienced several construction challenges including a delay in the release of our materials from customs, the heat and intensity of the Caribbean sun, and the wind, rain and resulting mud brought by the nearby passing of Hurricane Sandy. Despite these challenges, we were able to get two homes (one Intern House and one Medical Staff House) weathered in and partially sided. The remaining siding, electrical, plumbing and interior finish work was completed by Haitian workers and other NVM volunteers. Construction of the final three homes is scheduled for February, 2013.

The availability of construction lumber remains very limited in Haiti—especially higher grades, wider dimensions and treated material. Other structural components required for wood-frame construction, including shear brace systems or components, rated structural sheathing, connection hardware and fasteners, are also not available. Furthermore, supplementary materials to support wood-frame construction are also not readily available. This includes concrete hardware such as threaded anchor bolts and electrical components like junction boxes and nail plates designed to fasten to wood studs. Products to provide for conditioned spaces and weatherproofing such as building wraps, insulation, sealants, tapes and flexible flashings are also difficult to obtain.

A lack of knowledge and experience with wood-framed building techniques among Haitian construction workers is significant. However, during our work on these homes we were able to train several Haitians in wood framing and installation of metal roofing, lap siding, and windows. They had a curiosity and enthusiasm about learning these new methods and began to refer to these homes as "bèl kay" – meaning "beautiful house" in Creole.

Based on our design and construction experience, we recommend several changes if similar homes were to be built. These include:

- Utilize oriented strand board (OSB) for the exterior sheathing rather than SIS panels. This approach would be less costly, would be easier to install without pneumatic nailers, and provide more reliable lateral resistance. Other methods of providing a vapor barrier could be used for a conditioned home.
- While the Copper Azole-treated studs provided termite protection, this treatment was more costly than required, and necessitated increased corrosion resistance of the fasteners and hardware. FrameGuard® brand, or similar treatment of the framing, would provide adequate protection.
- Treated wood column embedment (for uplift resistance) directly into the column footing rather setting column anchors would be less expensive and easier to accomplish in this construction environment.
- Consider options to reduce the amount of connection hardware in the structure. Multiple connectors were required at many locations to properly transfer the loads. This created a construction challenge of getting all of this hardware installed when there is limited space to work with.
- Consider the application of a stucco exterior finish over the wood structural panel wall sheathing. The application of stucco is a skill readily available in Haiti and would provide a finished appearance similar to the masonry & concrete walls more typical of the region. However, this approach would require additional investigation and detailing to ensure adequate moisture control given the heavy driving rains during certain times of the year.
- Metal wall sheathing would provide another exterior finish option, but may not be as readily accepted.

While these homes were designed and constructed as entirely wood-framed structures, it is realized that a more incremental approach to improving wood construction in Haiti may be appropriate. Properly reinforced masonry, "confined masonry", or reinforced concrete walls with wood framed floors and/or roofs may increase the use of wood while also improving the structural integrity of the homes.

NEXT STEPS

This Weyerhaeuser-led initiative is scheduled for completion in early February and there are no specific plans for further work beyond the five homes. We have been able to provide support for immediate relief efforts in the aftermath of the 2010 earthquake as well as make a long-term impact on the redevelopment efforts in Haiti by providing permanent structures that will help those who are helping others. We have been able to provide limited training of a few Haitians associated with this effort. We have demonstrated, within Haiti as well as to the US wood industry, the feasibility and challenges of the design and construction of wood-framed homes in Haiti.

This effort will not change the way homes are built in Haiti nor will it lead to the sale of vast amounts of lumber from US mills. We know the task of implementing new construction practices and/or products even in the US is a costly and time-consuming challenge. In sharing the details of this project, the authors hope to encourage other individuals and the wood industry to learn from this experience and to continue efforts to address supply-chain issues and provide design and construction training to improve the reliability of construction practices in Haiti as well as other Caribbean and developing nations.

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