ENGINEERS WITHOUT BORDERS

Go to Guatemala

By Dan Mazzei, P.E.

In mid November of 2009, I joined an Engineers Without Borders (EWB) team from The University of Oklahoma (OU) to help build a small school in the mountains of Guatemala. The structure consisted of a metal roof fastened to wood framed trusses, supported by concrete masonry unit (CMU) walls bearing on a continuous strip footing. All construction materials were to be locally supplied, including the local species of wood used for framing members. Once finished, it would serve as a school for the children of a rubber harvesting community in La Pradera. The project site was southwest of Guatemala City.

DESIGN AND CONSTRUCTION ISSUES

OU students had performed all site recons, initial materials research, and preliminary design prior to my joining the team. However, we differed in opinion on a few items and they adjusted their design to accommodate my recommendations. Once we agreed on a design philosophy, they worked to finalize rudimentary design drawings that would be used to build the structure. The structure was designed for moderate wind loads and the extreme seismic events possible in Guatemala.

Figure 2: Reinforced Concrete Footings With CMU Dowels.

Figure 1: Local Method for Mixing Concrete and Water Distribution.

During the preparatory phase, we had three significant challenges to overcome. First was a general lack of information on exactly what types of fasteners, wood, steel, CMU, and concrete would be available. During the final design stage, we were able to get some of this information, but for the most part had to use extremely large safety factors to account for this very significant unknown. Once in country, we would attempt to determine the validity of our design assumptions.

The second challenge was the three week construction schedule. The plan was to procure building materials as fast as possible and engage villagers to increase manpower.

The third and most significant challenge was our general lack of construction experience. Mike Schmidt, the other professional mentor, and I both had some framing, concrete, and finishing experience, but neither of us had significant masonry experience. The students had no construction experience. To compensate for this, we had a weekend training session during which we learned the basic elements of how to mix mortar and lay CMU. A master-mason conducted all the masonry training. Mike also used this time to train the students on some basic carpentry techniques, and I gave a short structural design lesson to cover basic design principals. Lastly, the OU EWB chapter hired a Guatemalan contractor skilled in masonry and local framing techniques to help with the actual construction. His presence was invaluable and he became an integral part of the team.

Now that we had a team of 'well trained craftsmen,' we were ready to embark on our mission to build a 2100 square foot masonry building, utilizing special seismic detailing, with unknown materials, without consistent electricity, in the jungle of Guatemala, using locally available tools, in record time.

ON-SITE CONSTRUCTION

A few days prior to team departure, the US State Department issued a travel advisory for all US Citizens in Guatemala. Apparently the risk of kidnapping had increased, but after a little research we decided it was still very safe for careful travelers. We did notice that many stores of significance had an armed guard and banks had three or four.

The advance party arrived on site the 27th of December 2009 and I arrived on January 1, 2010. They set up the base-camp, started buying tools and construction materials, and began excavating for the footings. Upon arrival, I was pleased to find that we had 36 ksi reinforcing steel, bagged concrete, good sand, lots of clean graded gravel and other building materials similar to what we had assumed in our design. We did not have running water and only intermittent

Figure 3: Placing High Slump Concrete for Grout in CMU Cells Near Door Opening.

Figure 4: Working Off a Corner, Placing Block and Pointing Joints.

electricity. We solved the running water problem by repairing and rerouting a water line fed by a spring box about a half mile from the project site. The line was gravity fed, with minimal head and very slow flow, but still much faster than relaying buckets full of water to the site from the nearby river. Once repaired, the line was fed to an onsite and 'empty' septic tank for storage. We were now ready to mix and place concrete (*Figures 1* and *2*).

Once the footings were placed and cured, we began the laborious process of laying CMU blocks. Like many engineers, I have substantial CMU design experience but very little actual placement experience, so this was a challenge to say the least. Our local master mason, Hugo, kept us inline and the CMU walls went up surprisingly fast and gratifyingly straight. The greatest challenge, beyond simply laying the blocks, mixing the mortar, mixing and installing high slump concrete grout, keeping reinforcing steel aligned, and keeping CMU lines straight and plumb (*Figures 3* and *4*), was making bond beam blocks out of lintel blocks. This was done with rebar chisels, hammers, and lots of elbow grease.

We made a valiant effort to maintain the pace required for timely completion, but multiple late material deliveries, the language barrier,

The Team from Left to Right: Ivan Calderoni, Dan Mazzei, Mike Schmidt, Nicole Rowlette, Chris Breazile, Hugo Yax, Katy McNeil, Diana Lucero and Yonathan Reches (The Team Leader).

lack of skilled laborers, insufficient funds to cover the 'cultural' inflation factor, and the general difficulty of building in such a rural environment resulted in the team finishing about half the project. We were obviously disappointed, but not terribly surprised, and made initial arrangements for a follow-up visit to complete the project. However, I was gratified that we had helped get the project started, made some great relationships with the villagers, made some great relationships with future engineers, had an ideal setting for teaching practical design lessons to engineering students, and learned quite a bit about CMU construction. Additionally, since I love the outdoors, I enjoyed the return to rugged living.

RUGGED LIVING

Speaking of rugged living, we essentially camped in an abandoned house, bathed and washed clothes in the river, cooked over a fire, and purified our own drinking water. A typical work day consisted of waking up at around 5:00 AM with the roosters – unless of course a truck drove by with its lights on, temporarily convincing the sprightly foul that morning was coming earlier that day. We would walk down the trail to the project site around 7:00 AM, work until noon, break for lunch and then work until about 4:00 PM, when the locals had to shift their energies to rubber harvesting (rubber is harvested at night when the rubber tree sap flows the best). Our schedule gave us just enough time in the evening to bathe in the river, wash our clothes, prepare dinner and eat. Typical evening entertainment consisted of getting ready for the next day, discussing favorite books and movies, a few outings on the 'town,' and lots of story swapping. There was no television, radio, refrigerators, or other modern conveniences but, as most folks find out in such situations, we didn't really miss them after a few days.

CONCLUSION

I think it is safe to speak for the group and say that we had a great time. I was extremely impressed that a group of OU engineering students would donate their Christmas vacation to a long distance community service project, and was glad to be able to use my engineering skills to improve a rural community unfamiliar with the conveniences of life to which we are so accustomed. As far as project status goes, the follow-up team is currently raising the necessary funds to permit a speedy return to finish the project.

The School Building with Walls Erected Up to Midspan.

I recommend teaming up with your local EWB student chapter to help with a similar project. Being involved in such endeavors helps pass on the real-world engineering expertise we look for in engineering graduates. If you do get involved, I recommend keeping the following four points in mind during the set up and planning phase of the project:

1) A registered engineer with at least ten years field experience should accompany student chapters on site assessments to positively identify local construction materials and methods.
2) A registered engineer experienced in the design of structures with the identified construction materials should be involved in all phases of the design process.
3) A registered engineer and/or licensed architect should be involved in the creation of construction documents and bill of materials.
4) A registered engineer and/or licensed contractor should be involved in the development of a construction work schedule to included identification of all critical path items.▪

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