

Engineers Without Borders PSU Student Chapter Final Project Report – 2007 Nicaragua Project

I. Background and Purpose of Nicaragua Project and EWB Collaboration.

The Nicaragua project undertaken by PSU's Institute on Aging (IOA) and the Jesse F. Richardson Foundation (JFR Foundation) is focused on the improvement of health and living conditions for residents of the country's public elder care facilities (called *hogares*). These facilities are typically supported by donations and by government funding; however they are often overcrowded and/or underfunded. This can lead to basic health and safety problems such as inadequate supply of water and electricity or overload of septic systems. The combination of factors at the root of these problems includes budgetary constraints, a quickly aging population, high degrees of emigration of working age family members, and a general lack of public interest in aging issues.

Three years ago, the IOA and JFR Foundation began its collaboration with the Engineers Without Border PSU student chapter (EWB) on the Nicaragua project. The mission of EWB is to partner with developing communities in order to improve their quality of life through the implementation of sustainable engineering projects. EWB was brought into the Nicaragua project to create engineering solutions to some of the health and safety problems at the *hogares*. The collaboration has been successful because engineering skills are needed both to assess these problems and to create solutions, and because the Nicaragua project is very much in line with EWB's mission.

A. Background of 2007 EWB Project at Jinotepe Elder Care Facility.

1) 2006 Assessment at Jinotepe Facility.

In the spring of 2006, EWB traveled to the small city of Jinotepe to work on projects and perform further assessments at the elder care facility there called the *Hogar de Ancianos Dr. Agustin Sanchez Vigil*. Several problems were identified in the assessment that formed the basis of the engineering projects developed in 2007. These were: a) general overcrowding of the facility; b) inadequate/inefficient water reserve system; c) unsafe/unstable condition of the roof; and d) unsafe condition of the electrical system.

2) Planned Expansion of Facility.

Over the course of the past year, the JFR Foundation has taken action to remedy the overcrowding problem by coordinating a planned expansion of the *hogar*. New bedrooms, recreation and dining areas will be added to the facility, increasing its capacity by more than double. This will be accomplished with the collaboration of Nicaraguan and American architects, engineers and construction companies, as well as members of EWB. The 2007 EWB projects were developed while keeping in mind that the capacity would be increased and the layout of the building would change in the near future.

3) Team Description.

The engineering students of Engineers Without Borders PSU Student Chapter working on the project consisted of Ivan Perez, Tom Wharton, Helen Oppenhiemer, Michael Glickman, Corianne Hart, Seth Moody, Jenna Faulkner, and Norman Buccola. The students were accompanied by an interpreter/coordinator representing the JFR Foundation, Megan Harrington, and two professional mentors, Cole Presthus, P.E., S.E. with EWB-USA Professional Chapter, and David Leckey, associated with IOA.

B. Background and Purposes of 2007 EWB Projects.

1) Expansion of Water Reserve.

The necessity of establishing enough water capacity to meet the drinking, cooking, cleaning, bathing and sanitary requirements of the facility and its residents is evident. Water is supplied free of charge to the facility from the city's infrastructure; however, this supply is intermittent. Some reports say that water is only accessible two or three hours out of the day, others say that there are often stretches of three or four days when there is no water available. The solution is to have a large enough reserve water supply on site to meet the needs of the *hogar* during these periods until the city water is turned back on.

Upon completion of EWB's work in 2006, two 2,500 liter reserve water tanks were in operation. One tank was elevated on top of a three-meter tower and fed water to the facility using gravity to provide necessary water pressure. The other tank, installed by EWB that year, was located at ground level. An electric pump was used to drive water from the lower to the upper tank where it was then fed through the gravity system when the extra water was needed. Although the lower tank successfully increased water reserve capacity, it was still insufficient to meet the estimated 10,000 liter water reserve requirement of the expanded facility. Further, the cost of operating the electric pump was carried by the administration of the *hogar*, which already operated on a limited budget.

The purpose of the 2007 water reserve expansion project was then to increase the water reserve capacity to 10,000 liters and to have this reserve operate entirely from a gravity-fed system. Two new three-meter towers would be purchased, brought to the facility and installed with concrete foundations. The 2,500 liter tank at ground level would be raised on top of one tower, and a new 5,000 liter tank donated by an outside source would be brought to the facility and placed on the other tower. The tanks would then be plumbed to each other and to the facility with shutoff valves allowing them to fill when city water was turned on, and to supply the *hogar* when the water was shut off.

2) Stabilization of Roof Structure.

The structure of the *hogar* was originally built by Grupo Sofonias in an experimental project in low-cost building; the current design is three wings which form a "U" shape. The roofs of each wing are constructed of cement-fiber tiles laying on top of a system of wood rafters and stringers attached to a central tube steel ridge beam. In the 2006 assessment, it was found that the roof tiles seemed to shift easily and several gaps had opened between them, causing water leakage into the

facility during rainstorms. Further, the wood rafters appeared to be simply resting on top of the concrete walls of the facility with no method of attachment.

Nicaragua is located in a zone of both high seismic and high hurricane risk. For this reason the ease of tile movement and lack of attachment of the roof to the walls of the facility represented a safety concern. Although it was later determined that the rafters were indeed attached to the walls by a single steel spike in each rafter, the system was still determined to be unsafe. An event of high lateral loading such as an earthquake or hurricane could have disastrous consequences should the roof or tiles move enough to create a falling hazard on the residents and staff occupying the rooms and corridors below.

The purpose of the 2007 roof stabilization project was to create a system of uniting the roof to the concrete walls of the structure so that they function as one unit during events of high lateral loading. Over 700 feet of CS16 galvanized steel tension strapping donated by Simpson Strong-Tie would be attached in a cross-brace formation using concrete anchor bolts, metal and wood screws to anchor the strap to the walls, ridge beam and rafters. This cross-bracing roof stabilization system should help not only to prevent catastrophic falling of the roof or tiles during a large event, but also to resist small tile movements during minor events so that leaks between the tiles are minimized.

3) Upgrade of Electrical System.

The electrical system at the *hogar* prior to the 2007 project had been described as insufficient and in a risk situation. The system had crashed three times in the previous two years, causing two small fire incidents. Circuit breakers were often tripped, indicating system overload, and there had been frequent brownouts at the facility. The 2006 assessment team found that junction boxes were mostly without covers and improperly placed, many wires were exposed and/or tangled, and connections were isolated only with electric tape rather than wire nuts. Wires were run through PVC conduit rather than metal, which is considered safer and more effective. Finally, problems were indicated with insufficient or improper placement of light switches and many of the individual rooms utilized energy-inefficient incandescent bulbs.

The planned expansion to the facility also presented issues regarding the electrical system. Preparation for adding circuits and a new junction box to the system was necessary to accommodate the expansion. New lighting was also required in the upgraded outdoor common area.

Early in project planning it was established that the broad scope of electrical work identified, time constraints in accomplishing all of the group's planned projects at the facility, and general inexperience of EWB members in electrical work prevented the group from feasible accomplishment of all of the desired electrical upgrades. However, areas were identified where EWB could facilitate the work to be performed later by in-country electricians and contractors; these areas became the purpose of the electrical component of the 2007 Nicaragua project.

The team would work with local electrical contractor Freddy Garcia to install new metal conduit, fluorescent light fixtures and switches through the entire length of corridor in the three wings of the existing facility. Wiring would then be ran through conduit and attached to the installed fixtures and switches; this effectively prepared the facility for further installation of circuitry in the individual rooms and in the planned expansion. Finally, new energy-efficient fluorescent light bulbs would be brought and installed, replacing inefficient incandescents.

C. Work in Portland.

1) PHE 410/510.

In total, four PHE 410 classes were held once every month starting roughly 4 months prior to the groups' trip departure. During these classes, the engineering students and health students were lectured by Margaret Neal, Keren Brown Wilson, Alan DeLaTorre and Megan Harrington on current events, health and economic issues, and cultural background surrounding the country of Nicaragua. This class was designed to prepare students for living and working in Nicaragua.

2) Group Work.

Planning the projects involved about 6 months of biweekly meetings and discussions for the engineering students. In general, all engineering students were equally informed of all projects and encouraged to discuss the planning and design. Coordinating these meetings with the JFR Foundation to keep fully informed about the details of the *hogar* was needed to keep all information current and relevant to any changes that needed to be made. Questions were sent down via Keren Brown Wilson to be answered by the architect for the proposed expansion of the *hogar*, Carlos Beteta, and the electrical engineer. The answers to these questions enabled the students to have a better understanding and layout of the proposed projects.

3) EWB Support.

From the Portland, OR EWB professional chapter, Cole Presthus regularly attended project meetings to guide and develop a legitimate and appropriate design scheme for the roof stabilization of the *hogar*. Presentations given by Cole, Tom, and Seth helped to inform and raise any concerns on the details of the design and practical application of the various projects.

II. Description of Work Accomplished in Jinotepe.

A. Overview of Materials.

When possible, materials were purchased in Jinotepe or Managua. Efforts were made to use construction techniques typically practiced in Jinotepe. Supplies either not guaranteed to be available in Nicaragua or donated by US companies were transported via the EWB group's luggage.

The following is a list of the materials brought from Portland aside from three (3) 50lb boxes of tools:

- 1200' of 1¼" CS16 steel strapping (donated by Simpson Strong-Tie)
- (150) 1/4" Self Tapping Metal Screws (1/2" length)
- (200) 1/4" Concrete Screws/Anchors (2" length)
- (12) 1/4" or 5/16" masonry bits
- (4) PVC elbows (1" diameter)
- (4) PVC tees (1" diameter)
- (4) PVC elbows (1" diameter)
- (4) PVC Valves (1" diameter)

- Compact Fluorescent Light Bulbs

Among the supplies purchased in Nicaragua were:

For the Water Towers:

- 2.25 cubic yards of concrete
- (2) pre-fab steel tube, welded water towers (~12 ft. tall)
- (1) 5000L Water tank
- (1) 2500L Water tank
- 150 LF of #4 steel reinforcing bars
- (6) shovels

For the Electrical Project:

- Electrical conduit
- Junction boxes
- Copper wire
- Switches
- Light Fixtures

B. Water Storage Installation.

The expansion of the water storage system consisted of erecting two towers on site, placing the storage tanks atop the towers, and connecting the newly elevated tanks to the existing storage system. The two new towers were ten foot tall, seven foot square at the base and six foot square at the platform. The tanks were of poor construction and had to be augmented with steel base plates and platform bracing in order to support the weight of the water filled tanks. The 2500L tank installed by last years EWB team was similar in size and shape to the existing elevated tank, but the 5000L tank was approximately one foot in diameter larger and two feet taller than the other tanks. In order to maximize the storage capacity of the system, the tops of all three tanks were required to be at equal elevations. As a result, the platform of the tower holding the 5000L tank needed to be two feet lower than the other two platforms.

After the site for the new towers was cleared of debris and vegetation, the footings for each tower were laid out, taking advantage of the slope of the terrain to minimize the digging required to lower the tower holding the 5000L tank. Seismic analysis indicated that 2' x 2' x 2' concrete footings were required to mitigate the overturning potential of the elevated tanks. Holes were dug of the dimensions indicated above, and the towers were erected and leveled such that each leg of the towers was embedded ten inches into its respective footing. Reinforcing steel was tied and placed so as to prevent uplift failure of the footings. Concrete was mixed by hand on the ground using the local customs and mix proportions and each footing was filled.

When the concrete had set, the tanks were installed on top of their respective towers. The 2500L tank required dunnage to prevent shifting as the tower platform was one foot wider than the diameter of the tank. After placement of the tanks, one inch diameter PVC pipe was used to connect the bottom of all three tanks together, with valves and cleanouts provided for isolation and

emptying of individual tanks without interrupting the water supply. The nature of the connection allowed the water level in all three tanks to raise and lower in unison, preventing stagnation of the water in any one tank. The three tanks total 10,000 liters of storage capacity for the *hogar*.

C. Roof Stabilization Project Installation.

The first step of this project consisted of installing steel tension strapping to stabilize the weakest points in the *hogar*. Work started in the women's wing and proceeded into the main entrance, kitchen area, and men's wing. First, two people (one with drill, one holding ladder) inside the *hogar* bolted the end of one strap to the main roof beam with self-tapping metal screws. This proved to be a job for those with adequate upper body strength. The other end of the strap was fed diagonally to an appropriate spot and bent to attach to the existing concrete walls of the *hogar* with concrete screw anchors and bolts. Attachment points were systematically located at the intersection of existing concrete shear walls of the building wings. As one person pulled the end of the strap taught, the other pounded the strap over the screw anchor with a hammer and secured the strap with a bolt. Finally, wood screws were used to anchor the straps at points where they crossed the wooden rafters. This procedure continued around the *hogar*.

Upon completion of the essential roof straps, a second round of steel strapping supports were installed to minimize the lateral movement of the exterior glass walls facing the courtyard. These walls surround a corridor-living area with many windows and would be a safety hazard in the event of an earthquake or hurricane. The strap installation continued until roughly 700' of steel strapping was installed throughout the *hogar*. This project consisted of 5-6 people working about 30 hours each.

After the completion of the roof strapping supports, a local crew from Grupo Sofonias in Jinotepe came to repair any damaged tiles and fix any apparent leaks in the roof. The coordination of this timely repair seemed ideal in that this both limited the amount of damage from the strapping installation and made the roof water tight for the future.

D. Electrical System Upgrade Installation.

The installation of a completely separate and new circuit was completed throughout the main halls of the *hogar*. When completed, the circuit housed new overhead fluorescent ballasts and bulbs, wall switches, and access for future wall outlets. The new circuit will be coordinated with the expansion of the *hogar* and installation of a new breaker box at the entrance of the building.

In consultation with the electrical plans and under the supervision of an electrician from Managua named Freddy Garcia, the students began by laying out electrical conduit and setting junction boxes in place. Each piece of 10' conduit was set in place and bent accordingly to fit the specific area where it was to be installed. As each length was installed, the appropriate colors of wire were pulled through to each junction box and later connected to the corresponding switch or ballast. Students learned to fit conduit, wire 2 and 3-way switches, and wire light fixtures. This job used about 4 or 5 people working about 20 hours each.

E. Community Partners.

Without the help of the local civil engineering students from Universidad Paulo Freire in Diriamba, these projects would probably not have come to full completion. Namely, Edieberto, Maria, Juan Carlos, Gabriel, Jacinto, and Julio were in attendance every day of work that the EWB students were. Since all of the Nicaraguan students also work full time with school on weekends, they faced even more hurdles in volunteering their time than did EWB students. Many students arranged time off work to come help with the projects. Not only did the Nicaraguan students provide people-power, but they also gave the English-speaking students an opportunity to practice Spanish and share cultural nuances. The personal friendships made between the PSU-EWB and local university students will hopefully be extended to both future visits and EWB projects.

Upon the invitation to city hall in Jinotepe, the EWB group met with the Mayor of Jinotepe, Alvaro Portocarrero Silva, and city council member Juan Navarrete Vindell. The mayor expressed his thanks for the work that was taking place, offered his assistance in the current projects and expressed a strong interest in EWB providing assistance with future municipal public works type projects. Particularly, he offered travel and planning coordinations in the case of future projects in the Jinotepe region. Following his offer, the group expressed the need for wheelbarrows and taller ladders. Without hesitation, the mayor began calling local sources and eventually provided these tools within hours of the meeting.

III. Sustainability and Public Health.

A. *How sustainable were the projects?*

Time will only tell how the systems installed in 2006-7 will hold up to natural disasters and human abuse. However, numerous steps were taken by EWB toward achieving a lasting effect at the *hogar* for years to come.

- *Partnership and friendship building with staff and residents of the hogar:* The respect given to each person is hoped to be transferred down to the “nuts and bolts” that were installed around the *hogar*.
- *Communication with the staff of the hogar:* Many decisions small and large were addressed to the clinical director, Don Carlos. Ideally, these decisions give the staff a sense of ownership in the projects.
- *Partnership and friendship with the engineering school in Diriamba:* Many of the students in Diriamba will stay in the region to work after they graduate from college. This provides the *hogar* with a local source of engineers to be called upon for troubleshooting or problem-solving concerning the projects that were installed.
- *Sustainable design considerations:* The water storage system upgrade was designed to be operative during power outages. As these power outages occur sometimes nightly, the *hogar* will now have a gravity-fed potable water storage supply whenever either power outages or public water system shutdowns occur.

- *Installation with the use of quality parts and local materials:* When at all possible, the objective of the installation was to create a product that would last as long as possible. Using local materials promotes local businesses and provides a convenient source for any replacement parts that may be needed by the *hogar* in the future.

B. *How does the work done by the engineering students relate to public health?*

The installation and repair work done at the *hogar* in Jinotepe will have direct effects on the health of the residents and workers who spend many hours each day there. With an increased water storage capacity, the health of those at the *hogar* will not be hindered by a lack of potable water during temporary municipal shutoffs. As public health is directly related to water quality and availability, this will be an improvement to their previous water storage capacity. Prior to the water storage upgrade, there may have been a subtle hesitancy by those at the *hogar* to conserve water by not using it to bathe or drink as frequently as they have wished. An increased storage capacity may give a larger freedom to use water more liberally, thus improving health through increased cleanliness and hydration.

Installation of the roof strapping supports and tile repairs will stop current leaks and help to prevent further leaks through the roof in the future. Leaks in the roof were a big complaint by many in the *hogar*. As some residents noted that leaks were over their beds, the preventing leaks may increase the amount of steady sleep the residents have each night. Without as many leaks in the roof, there may also be a reduced number of slips or falls that occur.

The installation of the light circuit throughout the main corridor of the *hogar* is the first step at increasing the safety of the electrical system. As this old network of exposed wires and faulty switches is replaced, the residents and workers will be able to see more of what is around them. This can be very important to the safety of the elders as their eyesight becomes deteriorated.

One can only hope that the newly installed materials at the *hogar* will remind the residents and staff of the excellent time that was had together during the students' time there. This in itself may not heal any physical wounds, but may provide a little emotional encouragement.

IV. Other Work.

A. Assessment of Boaco Hogar.

On Thursday, June 28th, David Leckey and Margaret Neal accompanied EWB students Corianne Hart, Michael Glickman, and Norman Buccola to an elderly care home in Boaco, Nicaragua to inspect and assess their water supply needs. After speaking with staff at the *hogar*, the students were told that in the past, water trucks had filled cisterns at the *hogar* regularly. Currently, water was being transported by hand, multiple times per day from a source many meters away. At the same time, a private contractor had just dug a well, installed a pump, and was in the process of wiring and piping the new system. The students performed a site survey of the existing water storage facilities and well location. The survey was documented with maps, notes, and photos.

Shortly before the assessment crew's departure from the *hogar* in Boaco, the well construction crew returned to finish work that was incomplete. The construction crew explained that they were simply connecting the electrical pump only. A new cistern and connecting pipes

were also in the process of being installed by another entity. Overall, it was confusing for the assessment crew to know what was needed, and what questions to ask before exploring the situation any further than an initial site assessment.

B. Assessment of Jinotepe's Municipal Projects.

The Mayor of Jinotepe, Alvaro Portocarrero Silva, requested time with both the student and the professional chapters of EWB to talk about possible municipal projects that the mayor and the EWB could partner on. Professional mentors David Leckey and Cole Presthus and engineering students Corianne Hart and Seth Moody accompanied the mayor and a city council member, Juan Navarrete Vindell, on a day-long assessment of projects across the state of Carazo of which Jinotepe is located.

Project # 1: Drainage problem at local elementary school .

Located at the southeast edge of the city of Jinotepe, the school is adjacent to a natural overland drainage route where new public street construction has recently taken place. The installation of the new street curbs has forced storm water to collect on the school property and flood several classroom buildings. The mayor is hoping a new solution will solve the neighborhood wide drainage problem without necessitating the reconfiguration of the recent construction work.

Project # 2: Water wells on the Pacific Coast.

There are several small communities on the coast that depend on well water for their main source of drinking water. The wells would service many of the surrounding villages and their people. They had previously drilled two wells, both that have had salt-water intrusion after a couple years use. They are planning on drilling a third well and would like advice about where and how to manage it to prevent salt-water intrusion.

Project # 3: School House.

Also located on the Pacific Coast, the state owns property on which a small wood structure with dirt floor serves as a schoolhouse for 30 students. It is entirely open on all four sides and is located on sloping property with little vegetation. The students are subjected to the weather both during the hot and rainy seasons. The mayor asked EWB to build a school with multiple rooms that will also serve as a community center.

V. Conclusions.

The successful completion of the three main construction/installation projects at the *Hogar de Ancianos Dr. Agustin Sanchez Vigil* in Jinotepe, Nicaragua was a fortunate outcome for a short 10 days of work. Again, the work would probably not have been completed had it not been for the added efforts of the local civil engineering students from Diriamba. These students helped to give an additional light-hearted cultural element to the daily work and helped carve friendships that may last many years to come. It is the hope of many students that further work can be pursued in the Jinotepe region while strengthening these friendships and serving those that are less fortunate.