Long Way Home
San Juan Comalapa, Guatemala
This manual is intended to help LWH staff, volunteers and supporters better understand the alternative construction practices utilized at the Escuela Técnico Maya. It strives to synthesize the major construction and design decisions for all to understand, and to help us improve our work as we move forward. It is a thorough description of our process but it is not meant to be used a sole resource for others to build from.

Long Way Home
www.longwayhomeinc.org

“Sustainable development is a dynamic process which enables all people to realize their potential, and to improve their quality of life, in ways which simultaneously protect and enhance Earth’s life support systems.”
- Forum for the Future, Annual Report 2000

“If we do not change our direction, we are likely to end up where we are headed.”
- Chinese Proverb

“The good building is not one the hurts the landscape, but one which makes the landscape more beautiful than it was before the building was built.”
- Architect Frank Lloyd Wright

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Updated December 2010
EXECUTIVE SUMMARY

Long Way Home Inc. (LWH) began community development work in central Guatemala in 2004 to respond to educational and community building needs of the youth in the municipality of San Juan Comalapa, Chimaltenango. After successfully constructing a recreational park and prototype tire structure LWH decided to build an educational complex to provide an environmental education for Comalapan youth and adults and exemplify alternative construction techniques on a larger scale.

In June 2008 LWH purchased 1.75 acres of land in the aldea of Paxán and gained permission from the Municipality to construct an educational complex. Paxán is a rural settlement of 100 families just outside the center of San Juan Comalapa, Chimaltenango. The Department of Chimaltenango is situated in the west-central region of Guatemala, twenty kilometers northwest of Guatemala City. San Juan Comalapa is a municipality of approximately 39,000 inhabitants. The population is principally dedicated to agriculture with the main sources of income being the sale of corn and beans and the small-scale production of artisan goods. The ethnic composition of the municipality is approximately ninety five percent indigenous Maya-Kaqchikel and five percent people of mixed ancestry (Ladino).
LWH has formed an alliance with an existing school in Comalapa and has agreed to build the school complex with the goal of creating a future stream of local experts, environmentalists and entrepreneurs, uniquely skilled and motivated to lead their communities with innovative solutions for the future. Long Way Home’s role will be to fundraise for the project, construct the school, and oversee the new curriculum’s implementation.

Our partner in this effort, the local Técnico Maya School, is currently experiencing difficulty maintaining financial stability and the dedicated faculty has sacrificed time and money to provide an adequate low-cost education for its primary and secondary school students. The teachers have often worked months without salary at the substandard school facilities located in Comalapa’s urban center. The Long Way Home school project plans to absorb the Técnico Maya student body (30) and faculty (3) into the new facility and additionally provide vocational training to a different student demographic once construction is completed.

The new Técnico Maya school will empower young Comalapans between the ages of 6-16 by teaching them an array of relevant technical skills. In addition to the standard educational curriculum, the vocational school will offer coursework in carpentry, masonry, mechanics, electrical, welding, and horticulture, as well as business and technical training in alternative energy production. Environmental education will be a main focus of the school’s new curriculum. From organic gardening to green building, responsible land stewardship will be central to the coursework for these students.

The workshop classrooms will be used for formal training as well as applied apprenticeships where students will work with professionals in each applicable field on income-generating products. Revenues generated by the workshops will supplement staff salaries, helping the school reach its goal of financial sustainability.

The structure of the school itself will have a positive environmental impact on the community of Comalapa through the use of green building techniques. The four main building elements are rammed earth, used car tires, polypropylene grain sacks and plastic bottles filled with compacted inorganic trash called trash bottles. The school will be a practical demonstration of how to transform waste into a structurally sound, eco-friendly, low-cost structure. Local residents have been encouraged to participate in the school’s construction and those involved are getting hands-on experience with the innovative building techniques which we hope they will use when planning their own construction projects.

Long Way Home’s recently completed construction of a prototype house built solely with the above mentioned materials was performed to test the feasibility of this building method for our planned school complex. Used car tires are transported to the work site from regional auto body shops while trash bottles are collected at Parque Chimiyá by visitors who are given the option of contributing one bottle filled to capacity with inorganic trash as an alternative to paying the admission fee of five Quetzales. We are enthusiastic about this green building discovery as it addresses the ubiquitous problem of waste disposal, uses free building materials and produces an earthquake-resistant structure due to its rubber frame and sturdy, rounded design. It has been determined to be cost-effective and highly appropriate.

Once completed, the school will impact Comalapa’s economy by restoring salaries to its Técnico Maya teachers and creating new jobs for teachers in the vocational school department. Other beneficiaries include annual students, the administrative staff, and the local ecology. The long-term economic effects of the vocational school will be felt when a group of skilled young Comalapans trained as environmental entrepreneurs enter the Guatemalan job market.
Aerial view of site, in Aldea of Paxán
The Técnico Maya school is an educational complex comprised of primary school classrooms, vocational workshops, library, internet cafe, dining area, offices, recreation area, meeting spaces, gardens and volunteer area. The site slopes to the south dropping 50' from top to bottom, requiring cutting into the hillside to create flat terraces suitable for building. Rammed-earth tire retaining walls play an important role in stabilizing this cut land and separating the different areas of the site. The complex is organized around the middle retaining wall with the primary school and public spaces occupying the upper level, and the vocational workshops, gardens and recreation occupying the lower level. The eastern most part of the site houses the dedicated volunteer housing and gardens, accessed by the path along the Northern edge of the property. The entrance for the upper terrace is a large stairway off the existing road in the northwest corner of the site, while the entrance for the vocational workshops and services is the driveway located in the southwest corner of the site.

Rammed-Earth tires, Earth Bags and Trash Bottles (see Terminology) are the main construction methods for the school’s buildings. The majority of the buildings face due South to take advantage of the sweeping views of the valley but also have shade structures to provide refuge from the strong southern sun. During the day the Rammed-Earth walls keep the classrooms and workshops cool while storing the heat from the sun to be released during the brisk nights. The increased thickness (mass) of the walls creates thermal mass that requires no additional heating and cooling. Other integrated sustainable systems include solar electricity, rain water harvesting and waterless composting toilets. A large portion of the fruits and vegetables served at the school are grown in the gardens, and the nursery grows a variety of regional trees and plants for local reforestation. Additionally the complex offers open spaces where students are free to experiment with small building projects and investigations.
Planning Stage

Before beginning construction it is important to build community support, hire a local crew, enlist the help of engineers and investigate the availability of materials. It is preferable to build during the dry months (Nov.-Apr. in San Juan Comalapa) of the year, but building during the wet months is possible if appropriate measures are taken. Having a set of schematic drawings and important details to guide the construction is highly advisable. A projected construction/materials/budget schedule is also useful, and in Guatemala is highly subject to change based on funding, availability of materials, volunteers, weather and a general slower pace of work than found in other places.

Materials

The materials are the backbone of our construction work and heavily influence the school's design and our building techniques. Every effort is made to use as few industrially manufactured materials as possible and we estimate 85% of the building materials are second-use or natural. The second-use materials include worn out car and truck tires, plastic bottles, glass bottles and inorganic trash. Natural materials include on-site dirt, lime, pine needles and sand. Manufactured materials include gravel, cement, rebar, paper-crete board, PVC tubing, lumber, hardware and polypropylene bags. (See Data for a full summary of quantities and costs).

Tires are collected from regional auto-body shops in a pick up truck and because they no longer are usable for driving are given to us free of charge. Trash bottles are collected at Parque Chimlya in exchange for students' park entrance fee. Empty plastic bottles also come from the local community and glass bottles are found at bars and restaurants in the neighboring tourist cities. The majority of the natural materials are found within the state of Chimaltenango, and manufactured materials are purchased in San Juan Comalapa, Chimaltenango, Guatemala City or brought from the United States.

The building blocks of a school.
The foundation is a 2'x2' trench, filled with tamped down gravel. At the doors a wider trench is dug to allow for the door frame footing to be poured. Additionally these locations adjacent to the doors have one gravel-packed tire. At the top of the gravel 1/2" rebar is laid along the center to tie the bottom course of the wall to the foundation. The gravel keeps the lowest course of the walls dry and allows any moisture below the wall to drain down into the ground. If digging the trench during the wet season it is important to prevent the trenches from filling with water. It is recommended to have a large crew on hand so that the trenches can be dug and filled with gravel in 1-2 days.

Foundation detail @ door - section

Foundation detail @ door - plan
Rammed-Earth Tires

The dirt used to fill the tires is produced during the excavation, and consists of 2/3 poor clay and 1/3 sand with veins of straight sand, originating from volcanic ash. No modifications are made to the soil except to add moisture in the dry season and protect from rain in the wet season. The tire is placed in location with a small piece of garbage or plastic laid flat in the bottom of the tire to prevent any dirt from falling out. This lining is secured with a couple of scoops of dirt and then tire is ready to be hand packed. (A lining is not necessary when packing a tire on firm ground). Once no more dirt can be pushed in to the sidewalls by hand, packing with the sledgehammer begins. While no special skills are required to pack tires it should be noted that it is important to learn correctly from the outset, since there is a method that results in consistently well packed tires. Although there are some techniques that crew members will do slightly different based on personal preference, the basic tire packing procedure should be done the same way, every time. Exceptions to the rule will surely arise, and should be evaluated on a case-by-case basis and on previous experience.
How to pack a building wall tire.

*No space between tires
*Packed tires should sit flat and not rock
*Keep packed tires covered from excessive water
*Each tire grows approximately 2 inch
*All tires vary
*Car tires use approximately 3 wheelbarrows or 9 buckets
*Fill soil can be any material that compacts well (ideally 70% sand & 30% clay)
How to pack a retaining wall tire.

Excavate location  
Place and Fill tire  
Setback each course 6”

*Fill, sledge and tamp the same as building wall tires  
*If sitting on solid ground liner is not necessary  
*Margin of error is greater, can be less precise than building wall tires, within 1”  
*Truck tires use approximately 5 wheelbarrows or 15 buckets of dirt

How to pack a tire block.

Space  
Place  
Line & Fill  
Tamp

*Block should be placed and packed after adjacent tires are complete to make a tight connection  
*Filled with mix of 10:1:1 / dirt, cement, lime  
*Blocks are used where a full tire will not fit, or the running bond can not be maintained.  
*They should be placed and packed after adjacent tires are complete to make a tight connection.  
*Fill with a mix of 10:1:1 (dirt, cement, lime)  
*Add the mix
The Wall

The tires are stacked in a running-bond pattern - like concrete blocks - to maximize strength. At corners and door openings it is permissible to stack the tires directly on top of each other, making sure to use tires of the same size or taper up to smaller tires. Before beginning to pack lay out a section of tires to ensure correct spacing, leaving a gap where the running-bond pattern cannot be maintained. The block that fills this gap is a tire with the sidewall cut off that is coiled around itself to fit in the residual space between the already packed tires. It is then filled with cement-stabilized dirt (10 parts dirt:1 part cement) and packed straight down with the sledgehammer and sprinkled with water on the top. It is best to have an ample supply of already cut blocks of varying sizes on hand while building the wall. To help support against shear movement while constructing the tire wall, horizontal rebar can be laid between two courses about half way up in the wall.

A concrete bond beam is poured on top of the last course of tires, tying the whole structure together. This beam is tied into the walls and roof with rebar and provides an extra layer of support to the walls. Rebar pins to guide the interior and exterior finishes as well as for the exterior awning are also cast into the bond beam.
Framing Doors and Windows

Concrete doors provide a hold for the tire walls and tie the roof into the foundation (see Foundation). A 2'x3' window is framed using Earthbags layed over a wood arch form. The opening above the bond beam and under the roof arch is filled in with a Glass-Brick wall supporting a metal framed window. The Glass Bricks are created by attaching two glass bottles that have been cut to the desired length. These glass bricks are an opportunity to create a decorative element utilizing reused materials.

Facade window - elevation

Glass brick detail

Exterior door

Interior door

Earthbag window

Floor

A concrete floor is poured to withstand the weight and usage of a workshop with heavy machinery. This floor extends out beyond the workshops to create the patio, or exterior classroom area. The patio is reinforced with a metal mesh to withstand the weight of vehicles that drive on top. Floors utilizing more natural and recycled materials are suitable for different applications, such as classroom or house.

Workshop floor

Patio floor

Exterior classroom area
Roof
The thin-shell concrete roof is tied into the bond beam with rebar. The 5° barrel vault is achieved through a form work consisting of 6" metal mesh (Welded Wire Fabric) and large sheets of plywood (or plastic sacks dipped in neat cement). This form work is supported by wood bracing on the inside of the workshop. Once the form work is up another layer of metal mesh is put in place on the exterior, which is cast into the roof for reinforcement. Glass bottles cut in half are tied into this layer of mesh to become colorful skylights. Sculpted gutters between the roofs drain water toward the awnings and into the water cistern.

Patio Roof
The patio roof allows for the space to be used as an extension of the workshop space in harsh sun and heavy rain. The corrugated panels are supported by metal rafters and purlins which rest on the bond beam and columns. A galvanized canal collects rain water that is stored in the water cistern.
Wall finish - interior

Once the tire wall is complete the finish is applied in three layers. The first layer is cob which fills in the voids between the tires and creates a flat surface for applying the subsequent layers. Small shelves or nooks can be created where the tires either bulge or recede from the face of wall.

3" nails and finger holes (keys) help the next layer of plaster adhere to this cob. The lime-based interior plaster is then applied in two layers, coarse stuff first, then fine stuff. To help the rough and fine stuff layers adhere to each other a thin coat of cement and sand (lechada) is applied in between see drawing. (Plaster work will always vary depending on plasterer’s preferences).

Wall finish - exterior

The exterior wall finish can be applied as soon as the walls are completed or they can be finished at a later date. The finish is applied in multiple layers like the interior finish, beginning with cob. Decorative designs can be incorporated into the cob layer.

Cobbing is a great opportunity to incorporate volunteers and community members. It is easy for non-experienced builders to learn the correct cob technique and helps to lots of people on hand for mixing and throwing.

* This drawing to be updated
Ceiling Finish

Once the thin shell concrete ceiling has cured for four weeks a chisel is used to create small divots to help the finishes adhere. The interior ceiling plaster is the same used on the walls; a layer of rough stuff and fine stuff, with thin coats between. The exterior ceiling plaster consists of cement-based render, coarse stuff and sealant paint (see drawing in Roof).

Interior

Thin shell concrete after forms are removed.

Rough stuff coat, ready for fine stuff.

Finnish with bottle skylights.
Drawings

Workshop plan

Workshop section
Workshop elevation

Workshop rendering
Classroom rendering

Dry Composting Toilet

A low-cost, low maintenance system that requires no water and produces zero waste.

- Rainwater collected (in roof storage) in tank feeds sink
- Cross ventilation natural light and plant life
- Ventilation pipe and incoming air ducts make the operation odorless
- Human waste can be mixed with organic kitchen waste and this mixture will slowly turn into organic fertilizer
- Helps vegetable, flower, and herb gardens flourish
- Trash (bottle wall construction)
- Urine diverted from basin and diluted for fertilizer
- Basin has a 30 degree sluice to help waste turn and compost

Composting toilet rendering
Data

* This section is still under construction
Design / Build Process

In contrast to conventional construction work much of our project is designed as we build. The overall building shape, dimensions and strategies are in place at the outset, and we refine and edit this design based on field observations, professional advice and financial considerations. Working in this manner allows LWH to learn valuable information as we progress, as well as enables volunteers, interns and our local crew to learn the work as they build. While we always maintain a professional, safe and productive job site, our fluid construction process also creates an atmosphere of collaborative, experimental and hands-on learning.

A set of construction drawings are present at the site for all to reference and are periodically updated to reflect the latest changes. Often times we work out details in the field - sketching in our notebooks or on the ground - and record the change at a later time. We also keep a log to record important ratios and quantities that we want to remember. We have learned that an accurate account of what was actually built, versus what was planned, is vital to consistent construction.

Employing and teaching local laborers is the cornerstone of our work. Although there are often challenges related to language, culture or different construction practices, we believe strongly in taking the time to work as closely with Comalapans as possible. Additionally, we create volunteer appropriate jobs at that site and generally speaking think its best when volunteers are doing work that they like and pushes their limits just beyond their comfort zone. The volunteers that have been the most successful with us are those that understand when it is important to stop and ask questions and when it is better to try their best at the task, and ask questions later.

Lessons learned + Implications
*This section still under construction

Technology is appropriate to community, resources available, and needs
Positive response - people are convinced by visiting and repetition
Community outreach, but mostly putting words into actions.
Caution in getting involved in politics
Indigenous, mountainous, low-resource, poverty, agricultural, community-oriented . . .
need connections first, prototype structure, workshops

Replicability in Comalapa, Guatemala, Latin America, and beyond
Impact on local environmental degradation; Impact on teaching community about alternative construction and looking at second-use materials in a more positive way.
Importance of good design in improving the lives of the under served.
Terminology

Green Building
Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building’s life-cycle including siting, design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high performance building.

The common objective is that green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by
- Efficiently using energy, water, and other resources
- Protecting occupant health
- Reducing waste, pollution and environmental degradation

Alternative Construction
Alternative Construction is the practice of using non-mainstream materials and processes to achieve the same results as conventional materials. Rather than using the most typical or mass-produced material the practice seeks the best solution by weighing multiple factors, including what is locally available, climate, cost, construction time and cultural context.

The objective is to question the standards and norms of conventional construction and select the most appropriate solution. Alternative Construction methods include: Adobe, Cob, Rammed-Earth, Earth-Bag, Light Clay, Straw Bale, Bamboo, Earthen Plasters, Earthen Floors

Rammed-Earth Tires
Rammed-Earth tires consist of used car or truck tires filled with dirt that is usually available on site—any dirt can be used, as long as it compacts well. The dirt is first packed by hand and then compacted using hand tools to ensure the tire is tightly and uniformly packed. Walls are gradually built up by laying the tires in courses with a staggered pattern, like brickwork, and packing them in place. A concrete bond beam is typically poured on top of the wall for structural integrity and to support a roof system. The walls are finished with cob and stucco to isolate the tires from air and water and prevent any degradation from solar radiation. Uncovered tires are also used for retaining walls to stabilize the natural terrain.

Earthbags
Earthbags consist of sturdy polypropylene bags, sacks, also know as “costales”, filled with inorganic material usually available on site and it is important the dirt be roughly 2/3 clay and 1/3 sand. Walls are gradually built up by laying the bags in courses and are almost always curved to provide improved lateral stability, forming round or U-shaped rooms. To improve friction between each row of bags barbed wire is often placed between the courses. The structure is typically finished with plaster, stucco or adobe both to shed water and to prevent any degradation from solar radiation.

Trash Bottles
Trash bottles, also know as “Eco-ladrillos”, are created by stuffing plastic inorganic trash into the neck of an empty plastic bottle, using a thin rod. The plastic garbage is stuffed until the bottle is packed tight, resembling a brick. The bottles are used as wall fill between conventional framing, held in place by chicken wire on two sides, and covered with typical stucco or plaster.
Project Milestones

- Property signing
- Ground braking ceremony
- First tire
- Design meeting with Técnico Maya staff
- Técnico Maya students and families visit site

Construction Process

- 5%
- 10%
- 20%
- 20%
- 80%
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YouTube channel - http://www.youtube.com/user/longwayhome100


Long Way Home website - www.longwayhomeinc.org
All activism is volunteering in that it’s done above and beyond earning a living and deals with what people really care passionately about. Remember, no one gets paid to rebel. All revolutions start with volunteers.

-Susan J. Ellis

Construction of the Escuela Tecnico Maya started over a year ago and more than 140 volunteers have helped turn an empty Comalapan hillside into the beginnings of a school. So far we’ve brought 1,430 tires to the site and packed them with 4,510 wheelbarrows of dirt—and that’s just the beginning! It is sometimes easy to forget that much of the work that goes into building a school cannot always be seen in the final product. While your contribution might feel small it is actually an important part of making the school a reality. After you leave you can continue to follow the progress of the school and see the fruits of your labor:

Daily updates from the field - become a fan of LWH on Facebook
Design + Construction news - http://catorcekt.wordpress.com/
LWH in general - www.longwayhomeinc.org

Thank you for all your hard work!
Long Way Home promotes and uses recycled, discarded and basic materials. The result is a construction method that is economical, low-tech and directly affects the environment of Guatemala. The school that we are building will be an example of these methods and also teach this alternative construction to the youth of Comalapa so that they can continue to improve their community.
Vocab
Useful vocabulary to study and know

- El azadón
- La barreta / la coxa
- La navaja
- La pala
- La piocha
- El rastrillo
- El alambre
- El alicate
- La malla
- La tenaza
- El clavo
- El martillo
- El tornillo
- La sierra
- La pita
- El desarmador
- El destornillador
- La manguera
- La cubeta
- La regadera
- La zaranda / el cernidor
- El tonel
- La madera
- La carretilla
- El nivel
- La madera
- Metro
- Escuadra
- La horca
- Horquilla
Las Herramientas = Tools
La Pala = Shovel
La Bodega = Storage shed
El azadón = Traditional hoe
El albañil = Mason/Bricklayer
La Piocha = Pick axe
El carpintero = Carpenter
El rastrillo = Rake
El ayudante = Helper
La manguera = Hose
La ferretería = Hardware Store
La cubeta = Bucket
El aserradero = Lumber store
El plomo = Plumb-bob
La regla = Screed/Leveling board
El martillo = Hammer
El hacha = Axe
El desarmador = Screwdriver
El destornillador
La prensa = Clamp
Las tijeras = Scissors
El cernidor = Sifter
La plancha = Finish screed
La cuchara = Mason’s trowel
El tenaza = Wire cutters
El corta lámina = Metal shears
La careta = Wheelbarrow
El trepano = Brace & Bit
El formón = Chisel
El machete = Machette
El metro = Tape measure
La regla = Ruler/board
El nivel = Level
El papel de lija = sandpaper
Los alicates = Pliers
El serrucho = Wood hand saw
La sierra = Hacksaw (for metal)
Colocar = to put in place
Cortar = to cut
Lijar = to sand/sharpen
Apretar = to tighten
Cererno = to sift
Medir = to measure
Soldar = to weld
Afilar = to sharpen
Excavar = to dig/excavate
Desapretar = to loosen
Construir = to build
Oxidar = to rust
Aserrar = to saw
Zanjar = to trench
Zanja = trench
Puente = batter board
Barilla = bar (of rebar)
Armadura = form work
(rebar inside concrete)
Formaleta = wood form work
(to give concrete its shape)
Grava/piadrín = gravel
Arena = sand
Cartón = cardboard
Escalimetro = scale (for drawings)
Ampliar = to increase
Fachade = facade
Nilón = plastic tarp
Quebrar = to break
Lograr = attain, achieve
Alcanzar = to reach
Echar = to throw, fling, toss
Lodo = mud
Manzo/Pashoun = pounder
Hule = rubber
Cuello = leather
Bareno = drill
Corona = bond beam
Cadena = chain
Agarrar = to hold
Sueldo = salary
Translado = to move from one place
to another
Mover/se = to move
Estable = firm, stable
Arcilla = clay
Caliza = limestone
Drenaje = drainage
Terremoto = earthquake
Roca = rock
Avanzar = to advance
Respiradero = vent, air valve
Tubo = drain pipe
Desaguar = to drain
Cuena = basin, catchment area
Grueso = thickness
Delgado = Thin
Ancho = Wide
Sacar = to take out, pull out
Quitar = remove