Agua Prieta Building Plans

How to build a quality ladrillo shelter

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3 Introduction

3.1 Mission

Building a shelter for those less fortunate in Agua Prieta can be a very special experience. It can be very gratifying to be able to positively impact the lives of so many by volunteering a relatively small amount of your time and effort.

The building process in Agua Prieta can be very challenging. For those skilled in the art of homebuilding, the quality and availability of materials can be very frustrating. For those without experience, the process can be very confusing and difficult.

When you hear someone talking about building in Agua Prieta, you will often hear the word shelter used instead of house. We have found in describing our work to others the use of the word house is misleading. With the use of the word house, the assumption is we are building something similar to the work done by the group Habitat for Humanity.

The shelter consists of 4 adobe walls, 3 to 4 windows, 2 doors, and a roof. The floor is dirt, and there is no plumbing or electricity. The walls are not insulated. The home for a family of 4 to 10 people is 400 square feet in size. The shelters are constructed for approximately $6 per square foot, less than 1/10 the cost of construction in the United States.

There is no doubt what we build is a rudimentary shelter by our standards. There is also no doubt what we leave behind is a home for a family.

Because of what we are accustomed to in our everyday lives, the shelters resulting from your efforts will not be something you would necessarily want to live in. Despite this fact, in every instance the new shelter will be a significant upgrade in living conditions for the new occupants. While the shelter will be substandard by our standards, there are still several things to keep in mind to build the best possible shelter with the materials and labor available. Our goal is to build every shelter as well as possible.

We want to build and complete as many shelters in the shortest time possible. Our goal is to help as many families as we possibly can. We usually try to finish up as many partially built shelters as we can in the fall and build a complete shelter from start to finish in the spring. Many mistakes and things to avoid are listed in this document. We have either made or have seen every mistake we will refer to and we have experienced first hand the consequences of each of these mistakes. With this in mind, many tricks and techniques are included in this booklet to enable shelter building to go quickly and produce a high quality ladrillo shelter.

If you follow the guidelines in this document you should be able to build a better shelter in less time, which should make your Agua Prieta experience more enjoyable. If you come across additional tips and techniques, please let us know and we'll add them to this document for others to use. Send updates and new info to wilsons@us.ibm.com.

Our goal with this document is to share the knowledge and experience we have gained with a few years of shelter building in Agua Prieta to hopefully enable you to have an enjoyable and satisfying experience.

3.2 Acknowledgements

This ministry and outreach would not be possible without the help of several very dedicated individuals. The Emmanuel Lutheran Church in Douglas serves as a wonderful base camp and host to numerous groups from all over the United States.

Dorothy Millett is a wonderful hostess who has provided countless breakfasts, dinners, and food supplies to an endless stream of builders. She manages to make everyone feel at home.

Pastor John and Nina Lundering help keep the program running and fill in with a helping hand when needed.

Robert Spearman is a Douglas resident who accompanies us to Agua Prieta every time we go. Robert is our translator and general helper. He has made countless runs to local merchants for every supply imaginable. He's been a big help.

A special thanks goes to Kip Thompson, Frank Fountain, Tony and Pat Everett, Steve Wilson, Jr., Jim and Sandie Jacobson, and Bill Borland for their continuing dedication and hard work. Additional thanks go to the myriad of people who also performed exceptionally in the building process, too numerous to mention here.

Finally, the man who makes it all happen is Dan Schoenfelder. There are not enough pages in this booklet to adequately describe all of the things Dan does. To us he's just Dan "The Man". To the families in Agua Prieta, he is likely "An Angel".

4 General Building Notes

There are several stages to building a ladrillo shelter in Agua Prieta. In this section you are given an overview of these stages. Subsequent sections will add much more detail about each stage. Building a complete shelter will take four to ten days depending on the number and skill of the workers, the availability and quality of materials and weather conditions.

There are several processes that can be overlapped or done in parallel and several which cannot. We will try to highlight which can and cannot and any critical sequences that must be followed. Depending on how many days you are able to work and how many times you can return, you may or may not be able to experience every stage of construction. Being from Tucson, we have had the luxury of being able to build a number of shelters from start to finish, which has given us a unique perspective of how things fit together and which parameters can be critical.

We've had the opportunity to complete a number of shelters started by other mission groups. When we say avoiding certain mistakes will save hours of time later, it is from personal experience. What we have seen from others and done ourselves covers about every mistake we will refer to in the detailed instructions.

Some minor errors can be nothing more than an annoyance, others can cause several hours of delay or cause the waste of significant amounts of material. Given the construction time in Agua Prieta is so precious we would like to help you avoid both.

Every step and process in this document has a purpose. We will try to explain each as much as possible. Taking short cuts or leaving steps out could cause more work for you or others, or result in a shelter not as structurally sound or as aesthetically pleasing as it could be.

4.1 Building Summary

What follows is a summary of the six major elements of building a shelter. With good planning and a little luck, you can expect to accomplish the entire task in six working days.

4.1.1 The Foundation

The foundation, as its name implies, provides the structural base for the entire shelter. It consists of a steel reinforced concrete footing and a cinder block stem wall, which rises above the surrounding grade. The ladrillo used for the shelters (fired mud blocks), are only a weather-resistant building material, therefore they must not be set below grade level or in any placement where they can become wet for a prolonged period of time. They are extremely porous, and prolonged exposure to moisture will result in quick deterioration and structural failure of the ladrillo bricks.

The footing should not be above grade level more than an inch or two at any point because it is not formed. The goal is to provide a footing allowing the cinder block stem wall to extend at least 2 to 3 inches above the grade level. Because of this and the requirement to keep the ladrillo above grade level, you will have about 8 inches of grade

change you can tolerate from the lowest point of the shelter to the highest point before a step in the footing must be used.

It's nice to avoid having to build a step in the footing because the step requires more work and skill to set up and pour, and it will require more time and materials to lay additional block in the stem wall to bring it up to a uniform level. However, if the grade delta across the length of the shelter is over 8", a step usually cannot be avoided. Laying one course of cement block is challenging enough because of their nonstandard shape and irregular dimensions. Laying more than one course is not something to look forward to.

It is important to properly prepare the rebar used in the footing. The rebar is critical to providing strength to the footing. Without it, or if it is improperly installed, the foundation may move or settle over time resulting in cracks in the walls. Details on how to properly prepare and install the rebar will be provided under the construction details section.

The height of the footing is critical. If it is slightly low it generally is not a problem and is dealt with by using a little extra mortar when laying the cinder block stem wall. Too high a footing is a more significant problem. If the error in height is more than the nominal mortar joint for the cinder block, you will not be able to maintain a consistent elevation of the stem wall. If this occurs, it must be corrected by either chipping away at the cinder block to make it shorter or resetting the entire course at a higher elevation. Both of these adjustments will be big time wasters. Ultimately, the highest spot on the surface of the footing is the control point used to determine the height of the stem wall. Don't pour the footing too wet. Since time is critical the stem block are set soon after the footing is poured.

The outside dimensions of the shelter are 13'4" wide by 33'4" long. This allows for a stem wall of twenty four and one-half 16-inch cinder blocks along the length and nine and one-half 16-inch cinder blocks along the width. Unlike the ladrillo, cutting and working with partial cinder blocks, given the poor quality of the product, is a very difficult task to be avoided. The standard roofing material is 16 feet long. The 13'4" depth of the shelter allows for the proper overhang given this roofing material length. Any increase in the depth of the shelter must be avoided. Any change in the length of the shelter must be done in 16-inch increments. A change in length results in proportionally more material and labor required. There is no practical limit to the length a shelter can be.

It is very important for the shelter to be square. The galvanized corrugated roofing material does not adapt well to non-square shelters. Only a few inches out of square can result in significantly more time required at the roofing step and an odd looking shelter.

4.1.2 Walls

Once the stem wall is in place you can start to lay ladrillo on top of it. Again, since time is usually of the essence, this is done almost immediately.

The first thing required is to set the speed-leads on the outside corners of the stem wall. Speed-leads are metal posts made of angle iron set on the corners of the stem wall to provide an anchor for the lines used to guide the level of courses of ladrillo. Properly used, the speed-leads will greatly increase the speed you can lay the ladrillo and improve the accuracy of their placement. This statement we'll put in bold type **– the speed-leads must be set vertically and you <u>must</u> insure they stay vertical**. Check these often during the day. The walls will follow the speed-leads, whether vertical or slanted, period.

The speed-leads available have notches cut for each course level so no measurements or markings are required. Going from course to course simply requires moving the string up to the next notch.

The strings used to set the ladrillo to must be very tight. Use only string made to use for laying block. The length of the building, 33'4", is a long run for a string line. Sagging strings can cause many problems, including having to go back to remove and reset block, which is wasteful in time and materials.

Before the first ladrillo is laid you must decide where the 2 doors will go. These openings will be left starting with the very first course of ladrillo. More on the door openings will follow.

It's important to lay out the ladrillo before any are set in mortar. The ladrillo, even from the same supplier, may vary in dimensions by a half an inch or more. The mortar joints used with ladrillo are quite large in comparison and are nominally 1 full inch. Because of this you have considerable flexibility in laying out the first course to insure full blocks are used at each corner and half blocks are only used every other course at the door openings. This is important because it will make the resulting wall look better and will save considerable time where blocks do not each need to be cut to an odd size.

Take the time to set out the first course of block on the stem wall to make sure full blocks can be used all the way around the foundation. Make adjustments as necessary before setting the first block. If necessary, move the door openings slightly. While the first course is laid in mortar make sure you keep the spacing between the ladrillos correct. On subsequent courses, be sure to keep the ladrillo visually lined up with the alternate courses below (i.e. 3rd course to 1st course). This will insure an attractive looking wall when you are complete.

Assess the supply of ladrillo before starting. The length of ladrillo can vary from 13.5 inches to 14.5 inches. Some have been found to be as large as 18" to 20". If the supply of ladrillo is a mix of sizes, it will necessitate setting the first course with wider or narrower joints.

Laying ladrillo consumes a huge amount of mortar. The joint is an inch thick vertically and it is a solid joint. Enough mortar should be used so it squeezes out on all sides of the joint evenly. This is your assurance the joint is solid and does not have any voids inside. Also any gaps in the joints need to be filled by hand later. Insuring a good joint initially will save time and allow a consistent "strict" joint of each course.

The ladrillo are remarkably porous. To insure they do not pull too much moisture out of the mortar, each must be dipped in a bucket of water before they are set in place. If a course of ladrillo is going to be set on top of a course that has been allowed to dry, the dry course should be thoroughly doused with water before applying mortar to it.

Setting the ladrillo is generally a several person team. One group mixes the mortar and delivers it to the mortarboard and the person setting the ladrillo. Another person or 2 can deliver blocks and have them dipped in water. Following behind, after the ladrillos are set, the spaces can be filled by a helper (called grouting the joints) before the next course is laid.

Reinforcing steel (called Dur-o-Wal) is used in the mortar joints approximately every 4th course to give the walls additional strength. This must be remembered and set in place correctly to help strengthen the walls.

After the 11th course of ladrillo, the openings for the windows are established and marked. Similar to the door openings, a little planning can result in the maximum use of full blocks. It is very important to maintain verticality for the door and window openings. Frames have been built to assist in laying the ladrillos to the window openings. Any irregularities in door or window openings will result in significant additional work later. It's important to have the windows on the building site for size reference. More on windows in the construction detail section.

Depending on the grade level and your own personal height, scaffolding is used starting around the 13th course of block. Generally the scaffold is set in place and the wall is completed (set to 20 courses) for the particular section before moving on to the next section. Usually a section will begin and end at a door or window opening. Great care must be used working on the scaffolding. They don't quite meet OSHA requirements, but will do the job nicely if used properly.

To make the ladrillo more attractive on the outside, the joints are struck with a small tool consisting of a nail driven in to a small block of wood with the nail head protruding out approximately ¾ of an inch. The nail head is used to scratch out the mortar joints to a uniform depth. The striking can be done from about 15 minutes after the joints are set up until a few hours later depending on the weather. The use of this simple tool significantly improves the attractiveness of the walls from the outside. The inside walls will generally be plastered over "by others" at a later date so this tool is not used on the inside walls.

4.1.3 Windows

We have developed a scheme to create a slot in the ladrillos at the window opening to eliminate the need for the vertical mortar joint or buck-boards and provides a superior mechanical joint. The method for installing windows is to set the window opening slightly larger than the window frame (measuring from the frame, not the flange)

The windows used are common wood frame "nail on" style and come with a center flange on the top, bottom, and sides of the frame. (The window frames themselves are made of metal. The term "nail-on" refers to the fact they would be nailed to a wooden frame in normal applications.) Trim the flange from the top and leave the flanges on the sides and bottom. A 4-4½" grinder is used to cut a narrow vertical slot in the ladrillo at the window opening for the side flanges of the window to fit in to. This slot is cut 2½" from the outside face of the ladrillo and as deep as the grinder wheel will permit. The actual windows to be used in the shelter should be used to determine the width of the window opening.

When the 11th course is in place, 90-degree angle frames to secure the finished window opening are screwed down, plumbed, and clamped together to provide a vertical reference to lay the remaining courses of ladrillo against. Having the frame in place greatly speeds the placing of ladrillo against the window opening. Once the remaining courses are complete, the frames are removed, and a level is used to mark the remaining ladrillo where the vertical groove is to be cut. The grinder is used to cut the slot for the flange along this mark. The reason the first one must be cut before it is laid is because the grinder cannot be used to cut the ladrillo at the bottom of the opening when it is in place.

Immediately after cutting the slot, the window should be installed in to the slot to be sure it fits. If needed, the slot can be adjusted. The grinder slot provides an excellent mechanical retention for the window. With a simple sill built beneath the window, and caulking all around, the window will be complete (after the dala [bond beam] is in place).

The windows must be in place before the bond beam forms are put up. Using our methods the windows cannot be installed after the dala has been formed or poured.

4.1.4 The Dala (Bond Beam)

The ladrillo make a reasonable building material but they are hardly strong enough to hold the shelter in a good wind. The purpose of the dala is to provide a rectangle of steel reinforced concrete to hold the shelter walls rigid, provide lintels for the doors and windows, and provide the support base for the roof.

The technique for building the dala is crude but effective. Basically a 1" x 8" wooden form is built on top of the 20th course of ladrillo. Reinforcing steel (called castillo) is added. (This lumber will later be ripped in to 1x4 inch strips for use as the stringers fastened to the top of the rafters, fascia boards and frieze boards.) To support the forms, a conventional 8" stem-wall "clip" typically used in the modern world to hold/space 1" thick plywood panels to the top of a footing are used. After the forms are set, 5000 lbs. of concrete is hand lifted and dumped in the form. A sketch showing what a clip looks like and how the form is set in the clip is provided in the Construction Details for reference.

While the concrete is still wet J-bolts (for the low side of the shelter) and L-bolts (for the high side of the shelter) are inserted into the concrete to provide a secure anchor for the front and rear plates later on. The plates serve as the anchor for the rafters. The shelters are designed to be 16 inches higher (or 4 courses of ladrillo) on the front to allow for proper drainage off of the roof. The high side should be on the side of the shelter allowing another unit of the same size to built adjacent to it at a later date to double the size of the unit.

The L-bolts on the high side will be 24 inches long and extend above the dala. On this high side 4 more courses of ladrillo will be set in mortar on top of the dala. This short wall is called the pony wall. The L-bolts are laid out so they fit in to the mortar joints on the 1st and 3rd courses of the pony wall. On the other 2 courses the ladrillo must be drilled to allow the L-bolt to pass through them. The ladrillo are soft enough to be drilled easily with a ¾ or 1 inch spade bit or masonry bit and a standard drill.

A short sloping wall is built on top of the dala at each end of the shelter to follow the rafter line down from front to back of the shelter.

4.1.5 Roof

The roof has many key features to provide a strong and sufficiently well insulated cover for the shelter. The main supports for the roof are 2x4 inch rafters set on 24-inch centers. Before you conclude this is too weak, keep in mind a 2x4 in Mexico is usually a full 2 by 4 inches, approximately the same strength as a 2x6 in the US. We've seen the dimensions range from 1¾" -2 1/8" by 3¾"-5".

With the dala complete and the pony wall in place, the roof is ready to be installed. There are six major components to the roof: plates, rafters, stringers, fascia, frieze boards, foam insulation and corrugated galvanized steel.

The plates are 2"x6" lumber cut to length and bolted in place on top of the pony wall in front and on top of the dala in back. Usually there are 2 long pieces at each end and a shorter piece in the middle. The J-bolts and L-bolts should have been set in the dala in such a way to insure at least 2 bolts are available for use in bolting down the middle piece

of the plate. The plates are drilled to match the bolt locations and held in place with ¾ inch nuts. They are aligned with the outside edge of the dala. The plates extend 2 inches beyond the end of the dala to allow the end rafter to be set on the outside of the sloped ladrillo side-wall.

The rafters start as 16-foot sections of 2x4 lumber. They are checked for adequate strength and straightness (a relative term) and marked for crown direction and sorted by size. When set on edge, they may vary in height by over an inch. The crown is the direction of vertical arch when viewed with the board on edge. The rafters must be set in place with the crown up so the weight of the roof will tend to straighten them out, not cause them to sag farther downward. They should be sorted by size so you don't end up with a high rafter in the middle of the roof, which is very difficult to hide because of the resulting gap above the fascia board. Something to keep in mind is sorting the rafters by the dimensions on one end may yield a different result than sorting them by the dimensions on the other end. Put the most visually appealing ends to the side of the shelter seen the most.

The rafters are cut to 15' 8" to allow for 2 inches of fascia (1 inch each, front and back) and 2 inches of overlap from the roofing metal (1 inch each, front and back). The metal roofing material is a uniform 16 feet in length. The ends of the rafters are pre-cut to make them plumb in the front and square in the back to minimize exposure to weather and rain runoff.

The rafters are carefully positioned and toenailed in place and then secured with H-3 rafter ties. Frieze boards are use as blocking to straighten the ends of the rafters. The stringers form a lattice pattern perpendicular to the rafters. There are 8 rows of stringers from front to back of the shelter, 5 of which must be precisely located. At this point the dala forms are cleaned and ripped in to 1x4 material to serve as stringers. There should be enough form material for all of the stringers and fascia board. The fascia should be cut from the better-looking stock (another relative term).

The fascia board is put on the ends for the rafters in the front and back of the shelter. The first stringer (front and back) is laid over the end of the rafters and flush with the outside edge of the fascia and nailed to the fascia and rafters.

The next stringer in (front and back) is set in place to extend forward of the plate by the width of the frieze boards so the frieze boards can be pushed up to the stringer and nailed in place from the top through the stringers for a better weather seal. Essentially, the stringer will be flush with the outside face of the frieze boards, which also looks nice.

The center of the middle stringer must be 8 feet from the outside edge of the stringer on the front of the shelter. Because the roofing foam comes in 8-foot sheets, this will guarantee the seam between sheets will be over a stringer, which looks nicer from the inside and provides it strength. The remaining 3 stringers (2 on the wide side of the middle one, and 1 on the narrow side) should be evenly spaced between the middle stringer and the stringers over the frieze board.

After the stringers you're ready for foam and steel. Basically the foam is laid down, then steel is placed on top of it and secured in place with screws with gasket washers to provide a water seal. Screws are placed on every other ridge of the roofing material along the length of all 8 stringers. The side lengths of the steel are wrapped over the ends of the side wall to cover the end rafter and the ends of the plates. About 500 to 800 screws are used to secure the roof, depending on the type of corrugated metal used. It is good to have a lot of batteries for your cordless drills.

4.1.6 Doors

Door installation can be the most challenging part of the shelter construction. If the door opening is not built plumb and the correct width by the team building the walls, the door installation process can be very time consuming.

This is a major challenge. It is not practical to use a frame to build against, because it can't be properly braced and held in place without impeding the movement of people and wheelbarrows through the door opening. Generally we make the opening 41 inches wide. If the door opening is not vertical a significant amount of shimming may be required.

The doorframe is kept vertical as you are laying courses of ladrillo by using a 4-ft level against the ladrillo and checking it at each course. The door opening should be checked every few courses to insure it is remaining 41" in width. Care must be used when grouting the joints for ladrillos against the door opening so the grout does not push the ladrillo farther in to the door opening after it has been set in place. Four 12" J-bolts are set in the mortar joints on each side of the door opening at prescribed levels to be used to bolt the doorframe against the ladrillo. Don't forget to put these in. The nuts holding the buckboards are counter sunk in to the doorframe and any additional bolt length is cut off. The length of protrusion of the J-bolts is very important. Too shallow and they may not be long enough to accommodate shimming, too long and the threads may end too soon.

We use solid core 36" x 80" wood doors, 4-inch metal interior frames with snap-on trim, and smooth metal thresholds with bottom door sweeps. We have found this combination works best in terms of cost, speed of installation, and durability. This type of door and frame will likely be waiting for you thanks to the many contributions and donations made by the Tucson building industry.

Standard door locks and striker plates that come with the frames are used to hold the door closed. Several tubes of caulk are usually required to seal where each doorframe abuts ladrillo. Insulation can be stuffed in to the wider openings to reduce the amount of caulk required.

4.2 The Agua Prieta Environment

Building in Agua Prieta is a unique experience. With proper planning and anticipation, the work can usually proceed quite well. At times, the lack of the most simple items can be very inconvenient, or possibly stop the work altogether. We've included some notes here to help you with what to expect and to aid you with the planning process.

4.2.1 How to mix mortar and concrete

Your greatest "friend" in Agua Prieta will be the 8 HP mixers used to mix the concrete and mortar. At times a crew of 2 can barely make the mud fast enough to keep up with the masons. It's hard to imagine having to build the shelter without the mixers available. If you had to mix by hand, half the crew would do nothing but mix all day and wouldn't be able to move their arms at sundown.

What we're trying to say is **"Take care of your mixer**". It's a harsh, dusty environment to operate small engines in. Regularly check the oil and don't run the mixer above the minimum RPM to keep the drum turning smoothly under load. Running low on oil or running the mixer for long periods at high RPM will likely render it unavailable for another group (or your next trip), causing them delays or forcing them to rent another mixer to

continue, wasting precious funds and time. It can take several hours to locate one having two wheels and worth renting.

In the course of building the shelter you'll go through about 5 yards each of mortar sand and gravel, and countless bags of cement and mortar mix. You'll be making basic mixes of concrete and mortar. The quality of the mortar sand in Mexico is notoriously poor. Sometimes you can't tell which pile is mortar sand, and which pile is gravel for the concrete. If the mortar sand has any significant content of pebbles or rocks, it must be sifted before use, otherwise the resulting mortar will be very difficult to work with. There are a number of sifting screens in the neighborhood. Find one, borrow it, use it, and plan on having someone spend most of the day sifting sand.

Concrete is used for the footing, filling the cinder blocks on the stem wall, and for the dala. Extra or leftovers can be used to make a simple outside pad by the door (throw a few scraps of rebar in).

Mortar is used to set the cinder block on the footing, to set all ladrillo, and to make the windowsills.

The mix for concrete is two 5-gallon buckets of water, 1/2 bag of cement (50 kilo bag, 110 lbs.), and 54 large shovels of gravel. The mix for mortar is 1 bucket of water, 1/2 bag of mortar mix (25 kilo bag, 55 lbs.), and 21 large shovels of mortar sand. Always wet the wheelbarrow before dumping in the first load of mortar. The same is true for the mortarboards. This is more important the warmer and drier the weather.

Always start with some water, then at least 10 shovels of gravel or sand, then half a bag of cement or mortar mix, and repeat until everything is in. Keep the mix wet until you get the right consistency with the final shovels of dry material. This insures a very thorough mix.

It's hard to describe the proper consistency with words. For concrete, if it's too wet it will flow nicely but it will lose strength because of excessive displacement of the extra water, if it's too dry it won't flow around the reinforcing steel, resulting in voids. It needs to be "just right". Similarly for mortar, if it's too wet it won't hold it's shape and will slump under the weight of the cement block and ladrillo. If it's too dry it won't "set" or be sticky enough and it will be difficult to set blocks correctly with it.

4.2.2 Availability of Water and Power

Through the years water and power are becoming less and less a problem. Power and water is often available either from the lot you are working or at an adjacent lot. Community spigots are available throughout the neighborhood as well. The water can also be used for cleanup, but of course should not be consumed. Always bring a few hundred feet of hose and extension cords and lots of 5-gallon water buckets. A generator can be used for power but can be difficult to get across the border and is annoying to listen to all day. Cordless drills and saws can help too, but when it comes time to grind block or rip the form material, 120 volts is necessary.

4.2.3 Food, Water and Sanitation

Food and water should be brought with you from Douglas each day. Protection from the sun in the form of hats and sunscreen should be considered. Pretty much every shelter has an outhouse, which can be used by the workers. If you're on the edge of town the desert can be a nice alternative, but this isn't very feasible if you're 5 blocks in. The

outhouses are aromatic, but do the job, at least for #1. For #2 you might want to consider waiting or heading for the 3 Caminos Restaurant on Hwy 2 (adjacent to Schneiderville).

4.2.4 How They Make the Ladrillos

The production of ladrillo is interesting to watch. Depending on what part of the neighborhood you are in, there may be several ladrillo yards next door or nearby. The workers start with clay and mix in sand and sawdust and pile an impossibly heavy load into their wheelbarrows. They use a simple wooden form to make 2 to 3 ladrillos at a time on the ground. They leave them to dry for a day. The next day they come back and stand them on their sides, and later stack them up on their sides loosely, about three high.

When they're fully dry, the ladrillos are stacked in to a kiln containing about 1,000 to 7,000 ladrillos. The outside is covered with a mix of mud and manure to seal it and 2 to 3 channels are left open at the bottom. The ladrillo are carefully stacked inside to allow airflow between them.

Pallets or other scrap wood is used to make a fire in the channels at the bottom of the kiln. The fire is kept hot for 30 hours, generally consuming around 150 wooden pallets. The kiln is left to cool for a few days and when it is disassembled the resulting burnt adobe bricks, or ladrillo, are ready to sell for about 3½ pesos, or 40 cents, apiece.

They start out the color of brown mud and become a pinkish orange after firing.

Unfired adobes are cheaper and can be used for construction also, but they must be sealed against the elements. They will eventually wash away to nothing if left exposed to the rain over a short period of time. Several examples of this can be seen in the neighborhood.

The ladrillo are risky to make in the coldest part of the winter. If they are allowed to freeze before they dry initially it will destroy the structural integrity of the ladrillo and they will crumble after firing. A light frost may only slightly damage them. If it's particularly cold, the supply of quality ladrillo can be limited. It's common for the temperature to drop to the low 20's during January because of the high elevation (4000') and extremely low humidity. Dew points in the single digits are not uncommon. A 35-degree temperature range from low to high is typical.

When buying ladrillos for a job, check the stock. Holding the ladrillo in both hands, break the ladrillo in half over the sharp corner of a wall or fence. Hold on to both halves after it breaks. The break should be clean and even and the ladrillo should not crumble in your hands. The inside should be light brown to tan, and the rectangular center should be a darker brown.

Watch out for the size of the ladrillo. The width should be 7". A length of 13 ½" to 14" will work best. Sample a few for uniformity of dimensions.

4.2.5 What to Bring with You

There are a number of things you may want to bring with you depending on the time of year, the group you're with, and the length of your stay. The church provides floors for sleeping, tables, chairs, kitchen items for preparing meals, dishes/flatware, and 2 showers and bathrooms.

Air mattresses, cots or sleeping pads are handy for a comfortable night's sleep. Basic toiletry items and towels are essential. There's plenty of room for parking motor homes adjacent to the church, but no hook-ups are available.

Many groups bring clothes, food, toys, school supplies, and other items to take across the border to distribute to residents of the neighborhoods in Agua Prieta. One note here: Mexican border police may stop you from bringing items across if you try to bring too much in one vehicle. A good suggestion is to take a little at a time and split the load up over a number of trips. We've never had a problem when using this technique.

The church provides many of the tools required for building the shelter. Other groups have purchased these tools and then donated them to the "camp". In general, the more tools you can bring with you the better. In the construction details we list the tools required for each stage of construction of the shelter. If you know which stages of construction you will be involved in, review the lists of tools required and bring as many of the tools as you can.

Marking your personal tools with a unique marking can make it handy to sort out the tools at the end of the workday. It's surprising how all the shovels, hammers, and trowels will start to look alike.

We have had a few isolated instances of tools disappearing from the work sites. While this has not been a major problem, it's a good idea to keep an eye on the tools. Don't leave any tools at the site at the end of the workday. If any valuable materials or tools must be left behind, they should be secured inside an occupied dwelling.

Many times the process can go quicker if more tools are available. For instance, when the metal roofing material is being attached to the stringers, it's handy to have 5 cordless drills to use as screwdrivers at once. The job can be done with less, but having more will make the work go more quickly.

5 Construction Details

5.1 Building the Foundation

Tools required:

- transit (builder's level)
- 100 and 30ft. tape measures
- square and round end shovels
- pickaxes
- string
- 12 concrete stakes or other large stakes
- concrete mixer
- trowels
- mortar boards
- rebar bender/cutter or hacksaw or chop saw
- small sledge hammer
- rebar tie tool and ties or wire and wire cutter/pliers
- float
- wheelbarrows
- general tool kit including spark plug wrench for the mixer

Materials required:

- eight 50 kg bags of concrete mix
- three 25 kg bags of mortar mix
- 75 8"x8"x16" cinder blocks plus extra 8"x4" or 8"x8" blocks if a step is required
- gravel/sand for concrete
- mortar sand
- gasoline/oil for concrete mixer
- seven 40 ft pieces of #4 (½ inch) rebar
- 50 plastic chairs to elevate the rebar in the trench

5.1.1 Site layout

Deciding where to build the shelter is the first decision to be made. Generally there will be some discussion with the future owners as to the exact location and any special features required. Often, when a shelter is proposed for a lot, a shack or similar structure is on the lot and generally blocks the best location to place the new shelter. The options existing at this point include:

- Place the shelter in a less desirable location
- Reorient the existing or new shelter
- Relocate the family for the duration of construction and have the shack removed

Choose as flat an area on the lot as possible. The maximum drop in elevation from corner to corner of the footing is 8" without adding a step to the footing. If the elevation change is greater than 6", a step will be required (see "footing step" detail).

Set the initial position for the 4 corners of the shelter using the 100-ft tape measure and the concrete stakes. Look around to see if any access problems will exist. It will be nice if you can get a wheelbarrow around the entire shelter or across the footings with a plank. The speed-leads will require about 4 feet of clearance in both directions from each corner to be anchored in the ground properly.

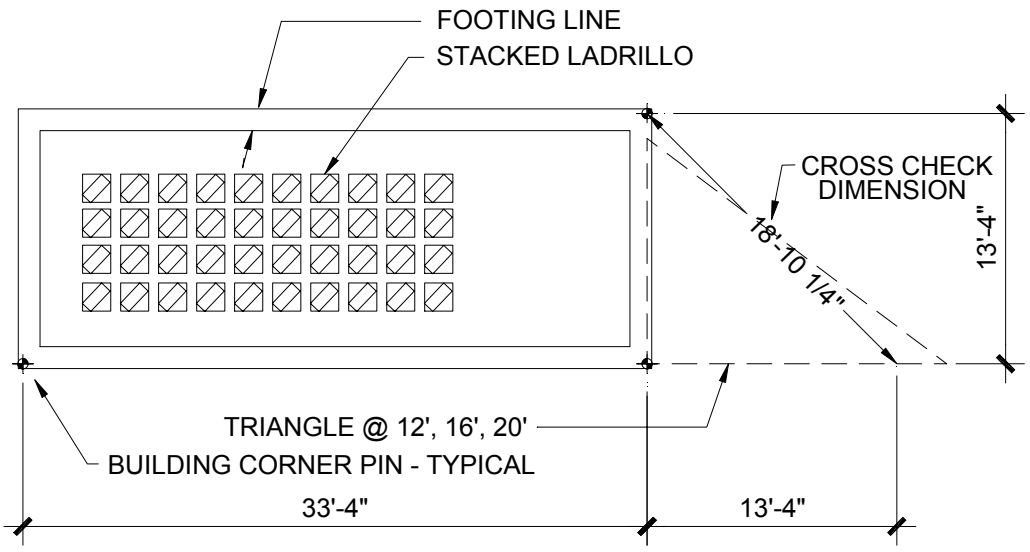
Set the shelter position as a rectangle 13'4" by 33'4". You can get the corners reasonably square using the 3/4/5 right triangle method. In this case 12' by 16' sides with a 20' diagonal can be used effectively. When you think you're reasonably close, you can verify how square the shelter is by checking the length of the 2 diagonals measured from opposite corners. If the distance is the same the rectangle is square. The diagonal distances should be 35'10¾" and no more than 1 inch different from each other. Take care in making these measurements, as your errors will accumulate as the shelter progresses. A few minutes invested here will be rewarded with a better shelter and less work later. Set a concrete stake firmly at each corner.

In some instances, you may be able to pre-stake a shelter footing and have it dug by the future owner or a local laborer. Builders are encouraged to take advantage of this opportunity whenever possible, as it can save a considerable amount of time and manual labor. However, a few things need to be considered before handing over the pick and shovel and leaving the new site.

First, it is recommended that the corner stakes used be a minimum 24" long and driven into the ground so only 4" or so is left sticking above the ground. The reason for driving them so deep is to keep them from coming out, being bent over or tilted out of alignment while the footing corners are being dug. It helps to ask the digger not to remove them, too.

Second, to assist the digger, place another stake (outside the building wall area) about 4 ¼" diagonally from the corner stake. These do not have to be hammered in very deep but enough to remain stable while digging the footing. Set an additional one in the same place for each corner. When you finish, there will be four stakes in addition to the corner stakes and they will aligned 3 – 4 inches outside of and parallel to the future building wall. Each of the second stakes will coincide with the outside edge of the footing. Next, wrap a string around the outside set of stakes to identify the outside edge of the footing to be dug. Provide the digger with a tape measure or mark a stick at 14" that he can use to measure the width of the footing, and another marked at 8" to measure the depth of the footing.

If the corner stakes are missing when you return you can re-determine their location by using an "outside squaring" technique. See Figure 1 - Outside Squaring Technique. First, locate two corners inside the long footing 33' 4" apart and set a stake for each of the two corners. Measure an additional 13' 4" beyond a corner stake. Then measure 13' 4" from the stake at a right angle in the bottom of the shorter footing. Using the same method as the 12', 16', 20' triangle shown in Figure 1, close the 13' 4" triangle with a diagonal measurement of 18' 10 ¼" and set a stake for the third corner. Do the same thing on the other end of the shelter footing. Double check the distance between all corner stakes and then set the 8 stakes shown in Figure 2 - Site Layout.

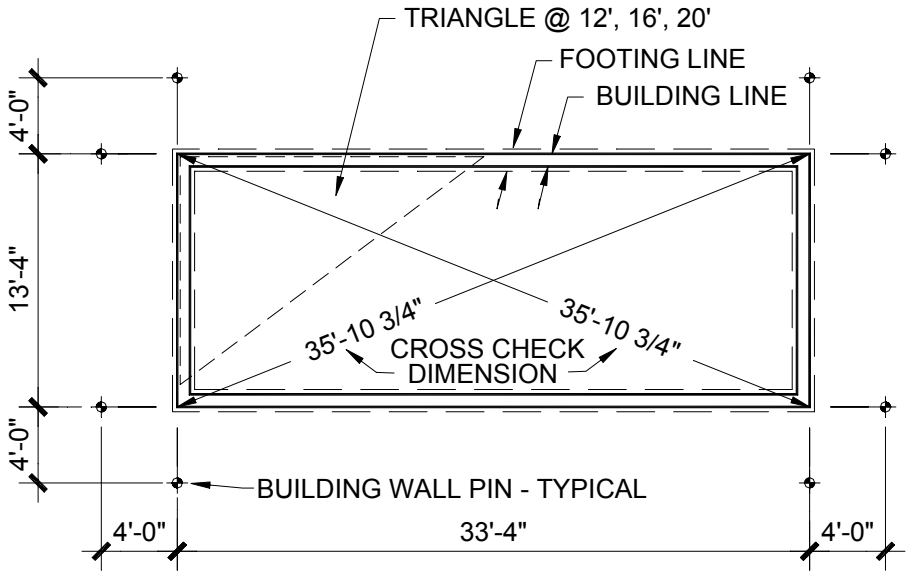


• Figure 1 - Outside Squaring Technique

In some cases, there may be an obstruction in the way that does not permit squaring both ends of the footings in this manner. If this is the case, there isn't much else to do in the field but just do the best you can to locate the missing corners as accurately as possible.

5.1.2 Determining the footing elevation and marking for excavation

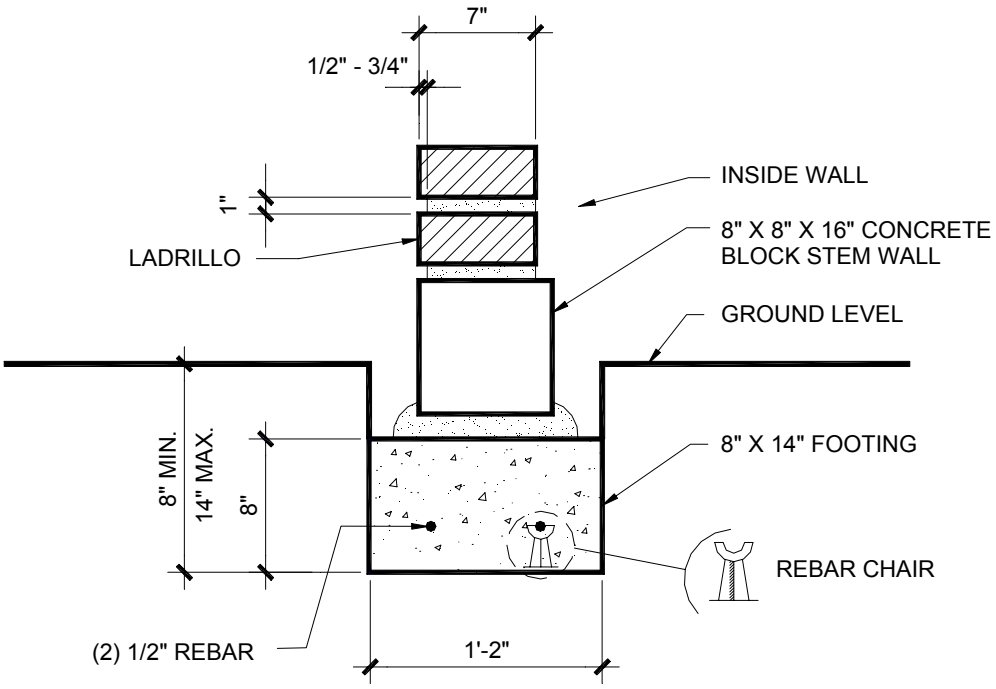
Using 8 concrete stakes, extend each of the 4 sides of the shelter approximately 4 feet past the stakes marking the corners of the shelter. See Figure 2 - Site Layout. This is done because the original 4 shelter wall corner stakes will have to be removed to do the excavation for the footing. Wrapping a string tightly around the outside of the new stakes will mark the outside walls of the shelter. This string, set to the correct height later, will provide the guide to align and lay the cinder blocks for a level and straight stem wall.



- Figure 2 - Site Layout

The transit is used to determine the relative elevation of the corners and determine the optimal elevation of the footing and whether a step will be required in the footing. Generally the high and low spots will be at opposite corners, but check to make sure this is the case. If it is not, use the actual high and low spots instead of the corners. If the delta between the high and low spots is more than 6 inches, a step will be required. (If a step is not required, high-5's at this point are appropriate.)

The goal is to have a footing 8" thick and 14" wide. If possible, choose an elevation having the top of the footing approximately at grade level at the low corner. This will minimize the digging required. The total trench is 93' long, every inch matters.



• Figure 3 - Footing Detail

Before removing the original 4 stakes marking the actual corners of the shelter, use the strings as a guide and mark (with paint or otherwise) a line 3" outside the string and 11" inside the string all the way around the shelter. This should provide a minimum 14" wide footing which when completed will extend at least 3" beyond each side of the stem wall. After marking the trench outline, remove the string.

Now you're ready to start digging. Be careful to keep the edges of the trench as vertical as possible. Sloppy work here such as a caved-in side will result in wasted concrete in the trench. Check the depth frequently using the transit. If the perimeter string is leveled, it can be used as an easy reference for depth of the trench. It is important not to dig too deep. If dirt is filled back in to obtain the proper depth it must be compacted, or it will result in weakness later on. Clean the trench of any loose debris and square the bottom of the footing the best you can. See Figure 3 - Footing Detail for a picture of what the trench should look like.

Remember, the whole idea behind the stem wall is to keep the ladrillo at least 2 inches above the ground and located where standing or running water or wet dirt can not come in contact with them. To accomplish this, the concrete stem wall has to extend above the ground a minimum 2 inches.

5.1.3 Continuous Footing

If the lot has a grade differential of over 6 inches measured from the corners of the foundation, two options are available. The first option is to continue to dig the footing bottom level under the four wall alignments. This results in a footing starting out 8 inches deep and may end up being over 14 inches deep. An 8-inch thick footing is still poured for the entire foundation but because of the deeper foundation several courses of block are required in order to rise above ground level. Since building funds are generally tight, the

cost of the additional block and mortar can be significant. Also, digging the footing an additional 8 inches deep around half of the foundation takes critical time and energy. In addition, until you have picked up an 8 x 8 x 16 block made in Mexico and lean down and into the footing with it for the first course, can you say, “now this is certainly an experience waiting to be forgotten”.

Being fair, though, some believe a footing and stem built this way provides the best continuity and stability for above ground wall construction.

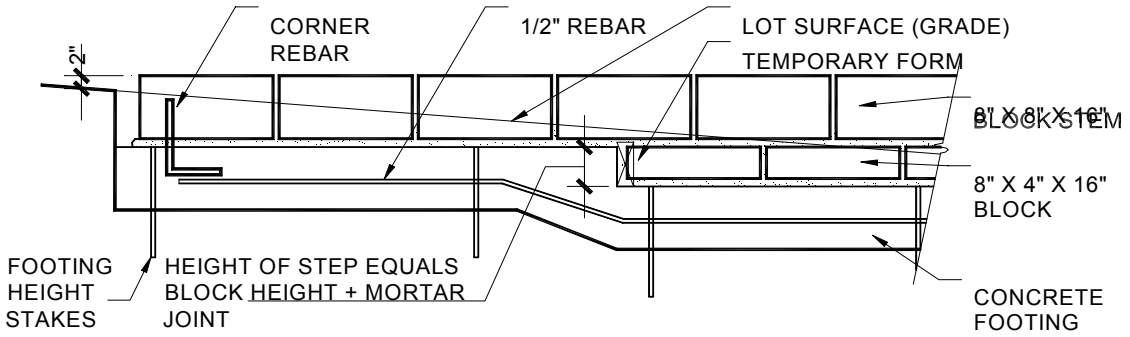
Another option is to “step” the footing. Stepping provides a way to minimize the dig and keep the number of block needed to stay above the ground within budget.

5.1.4 Stepped Footing

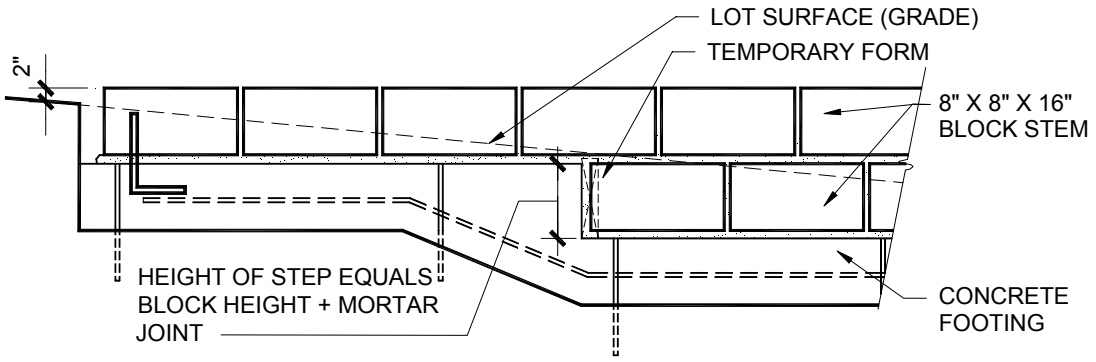
This is not the ideal situation to be in but if the ground level between corners of the foundation is greater than 6 inches, a step in the footing should be considered. If possible, try re-orienting the structure on the site to avoid having to step the footing, which then requires more than one level of block for the stem.

The step will be either 4 inches high or 8 inches high (or two 4 inch steps spaced out) depending on the grade difference of the lot. In either case the process to make the step is the same except for the height of the first course of ladrillo being laid.

Let’s assume the change in grade across the foundation is 6 inches. We know a step is not required, (8” block height minus 6” grade leaves 2” of block above the surface). Once a difference of 7 inches to 10 inches occurs, a 4-inch step is necessary in order to keep the ladrillo out of the dirt by at least 2 inches. See Figure 4 - 4" Step Diagram for the layout required for a 4-inch step. Greater than 10 inches requires two 4 inch steps or an 8-inch and so on. See Figure 5 - 8" Step Diagram for the layout required for an 8-inch step.



• Figure 4 - 4" Step Diagram



• Figure 5 - 8" Step Diagram

Location of the step is determined by digging 8 inches deep at the lowest point of the lot/footing. (Another way is to set up a builder's level/transit and "shoot" grades and mark the points ahead of time.) Keep the bottom of the footing level as you continue to dig along the footing line. With the bottom level, the trench will eventually get deeper the further you dig along the line and away from the lowest point. When you get to a point where the footing depth is 12 inches, this is approximately where the step (up) will be placed. Roughly mark this location and dig at least two feet past. Now go back to the spot where digging the footing started and go the other direction until the bottom of the footing is also 12 inches below ground level, roughly mark the location and continue at least 2 feet past.

As well as 12 inches deep, the footing should about 14 inches wide at the step area. Two pieces of lumber 2" x 4½" x 14 inches should be cut. To determine the actual location of the step, determine the future building wall corners in the footing just dug. Since Mexican made cinder block is generally 15 ¾ to 16 inches long, we calculate the distance assuming a 16¼ -inch module.

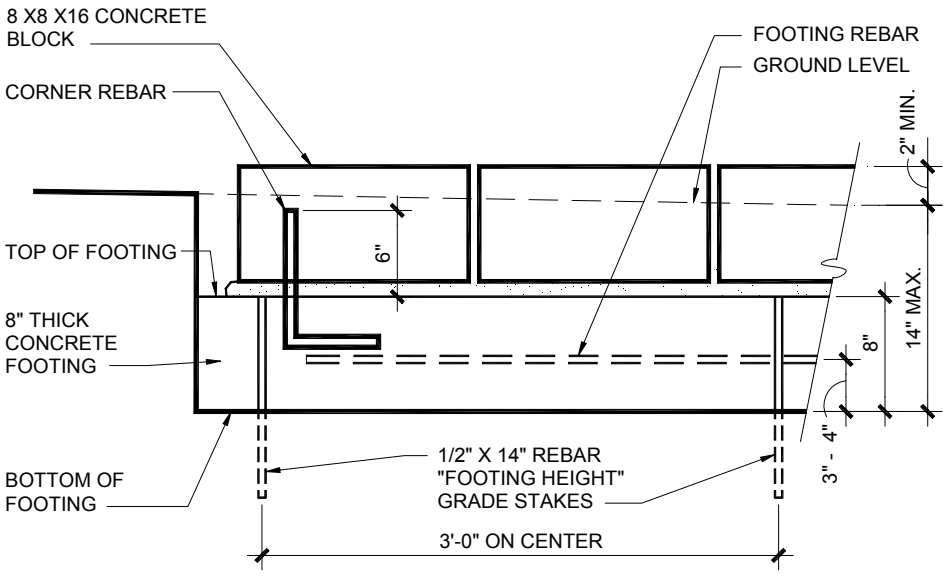
From the building wall corner to the BACK of the 2 x step material, determine the distance needed to accommodate 16-inch long stem wall block and add two inches. Drive two pieces of rebar into the footing about 4 inches from the each side and tie-wire the 2 x board to the rebar with the top of the board 12 ½ inches from the bottom of the footing. Essentially, the bottom of the 2 x board should be level with the ground of the lowest point of the footing which should be where you first started digging.

When the footing is poured, be careful not to move the board much. The weight of the footing behind the board will put some pressure on the form, so make sure it is braced well. For best results, remove the board after the concrete has set-up but is still wet. Once again, identify the building corner, re-measure for block layout and adjust the step if there is not enough room to place the row of block by using a trowel or shovel to shave the face of the stepped-up footing. More than enough distance to lay block is fine. The spacing will be made up on the second course.

5.1.5 Setting stakes for the footing height

In order to insure the correct height for the footing, rebar stakes are set approximately every 4' in the trench. Make the stakes by cutting twenty-five 14" pieces of rebar. The transit is used to set the correct elevation for each corner stake about 8" above the bottom of the footing. After the corner rebar are set in the footings, a string can then be run between the top of the corner stakes and be used as a guide for the elevation of the stakes set in between. This process goes relatively quickly. Care should be taken to

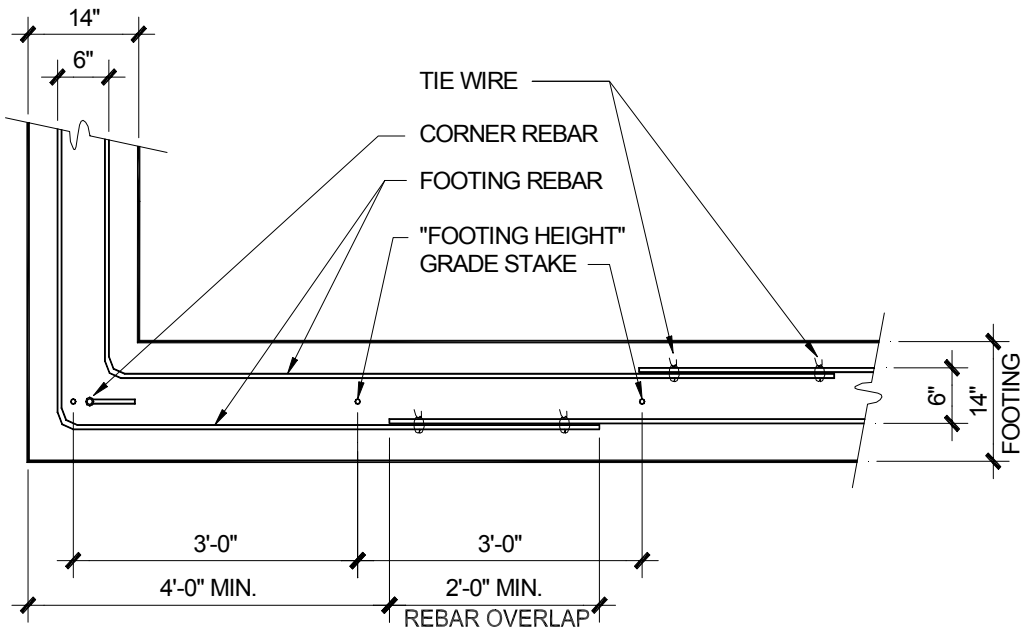
insure the footing is at or slightly below the desired elevation. If the footing ends up being too high it can end up causing significant additional work. Once the stakes are set, another pass around the trench is required to insure the depth of the concrete will be a uniform 8". See Figure 6 - Footing Stakes in Trench. This may require some additional digging or filling in to achieve the desired depth.



• Figure 6 - Footing Stakes in Trench

5.1.6 Installing rebar in the trench

The #4 rebar is critical to giving the footing strength. 2 pieces of rebar are laid in the trench approximately 6" to 8" apart. 90 degree bends are used for the corners. If you have a rebar bending and cutting tool this process goes much easier. Without it, the 90 degree bends can be challenging. At each overlapping joint of rebar the bar should overlap at least 2' and be tied together firmly with wire. A rebar wrapping tool and rebar ties are very handy for this. The joints should be at least 4' from each corner and offset so the two runs don't have joints at the same point. If a step is used, additional bends will be required to go down the step. The rebar should be held 3" off of the ground to insure the concrete surrounds it completely. See Figure 7 - Rebar Layout. Elevating can be done with rebar chairs that snap on to the bar. Small rocks or chunks of block placed under the bar also work, however voids can occur using this method. Now you're ready for concrete.



• Figure 7 - Rebar Layout

5.1.7 Pouring the concrete

After checking the gas and oil, fire up the mixer. Using the mixing directions earlier in this document, mix a full batch of concrete. Wet the wheelbarrow thoroughly and dump a load of concrete in the wheelbarrow. With some experience and strength you can handle ½ of the batch at a time in the wheelbarrow. If in doubt, start small. The concrete is very heavy and spilling it makes a real mess. If you do spill some, recover what you can, but try not to scoop up any extra dirt with it.

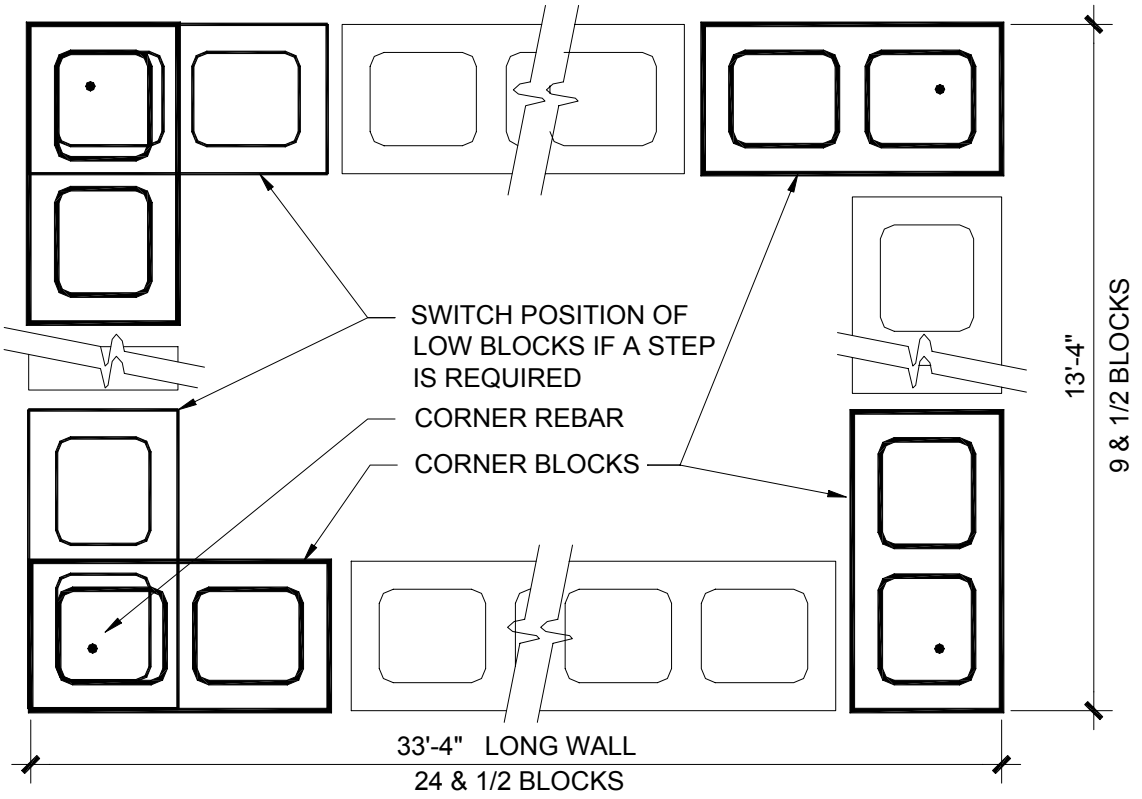
The concrete is dumped directly in to the trench from the wheelbarrow. Use a concrete float to work the concrete down to the top of the stakes. Don't overwork the concrete, as this will reduce its strength by forcing the gravel down leaving only cement at the top. It is preferable to under-fill the trench slightly and to add concrete to the proper level. Take great care to insure the level of the footing is not too high. This may require some shoveling of concrete to achieve the correct height.

After the concrete is in place and floated to the correct level, reset the building stem wall string using the 8 concrete stakes from the previous steps. Take four 15" pieces of rebar and put a L bend in the middle of each. Sink the L bend into the corner of the footing so it extends vertically 5" to 6". The corner stem wall blocks will be set over these pieces of rebar, locking the stem wall to the footing, so be sure the placement of the rebar L is about 4" inside both string lines. This will insure the rebar L will be in the corner cell of the concrete stem block.

5.1.8 Setting the corner blocks

The 33'4" dimension of the front and back walls allows for 24½ 16" 8x8 blocks to be set in a row. After mixing up your first batch of mortar, set 1 block in each corner and level it in both directions. Because the Mexican block measures very close to 16 inches (unlike US block at 15 5/8"), we will use ½ block less on each edge of the house to insure an

adequate mortar joint. At this point make sure your outer dimensions are still 13'4" by 33'4" and your diagonals are still close to each other in length. If not reset the corner blocks to make the dimensions correct before proceeding. Use the transit to set the elevation of the 4 blocks to be with ¼" of each other. This may require some trial and error. When finished, at the lowest corner of the lot, the stem wall will be about 12 inches above the ground. At the highest point of the lot, the stem wall is probably around 4 inches above the ground. See Figure 8 - Setting Corner Blocks.



• Figure 8 - Setting Corner Blocks

5.1.9 Setting the remaining cinder blocks

Attach a block line to the top of the outside edge of two corner blocks. Twenty-three 16-inch blocks will fit between the corner blocks on the front and back of the shelter and 9 will fit on the sides. A good idea is to set out the ladrillo along the footing to verify the spacing is uniform. If the joints are too wide and the final block will not fit, it's a major inconvenience to go back and reposition the ladrillos you have already set.

The quality control of cinder block manufactured in Mexico is basically non-existent. No two blocks are alike and frequently they are not square. Measure the cinder blocks before setting them in mortar to be sure they will fit with uniform spacing. If in doubt, set the cinder blocks on the dry footing to be sure they will fit. If the gap between the cinder blocks is less than ½" you will have difficulty setting them in the correct place with mortar in between the cinder blocks. If this is case set the cinder blocks in mortar with a dry joint between the cinder blocks and come back later and fill the joint with mortar.

5.1.10 Filling the cinder blocks with concrete

Once the sixty-six 8x8x16 cinder blocks are set in place they need to be grouted, or filled with concrete. Before filling the cinder blocks with concrete, make sure the vertical joints between the cinder blocks are filled completely before discarding the remaining mortar. When you're getting close to having all of the cinder blocks set in place, monitor the mortar production to minimize waste. Do not fill the cinder blocks with leftover mortar. Some can be put in to each cell, but the majority of the fill needs to be concrete to have sufficient strength.

The concrete mix must be wet enough to flow down in to the holes of the cinder block, but not excessively wet, as this will weaken it when it dries. Use a trowel to force the concrete all the way down in to the holes uniformly.

When you're done, clean up any excess mortar and concrete away from the footing and stem wall. Now is a good time for a morning break or lunch, depending on when you got started in the morning. After the break, you're ready for ladrillos.

5.2 Building the Ladrillo Walls

Tools required:

- 30ft. tape measures
- square or round shovels
- 2 ft and 4 ft levels
- string
- 4 speed-leads
- 8 ¾" concrete form stakes
- 4 concrete stakes for bracing the speed-lead bases
- concrete mixer
- trowels
- mortar boards
- bolt cutter
- small sledge hammer
- wrench to tighten bolts on speed-lead adjusters
- wheelbarrows
- line blocks
- hand grinder with 4" masonry wheel
- general tool kit including spark plug wrench for the mixer
- 2 sets of scaffolding
- scaffold boards
- 8 buckets
- cinder blocks to set mortar boards on
- pencils or other marker
- 6 to 8 large C-clamps
- joint striking tools

Materials required:

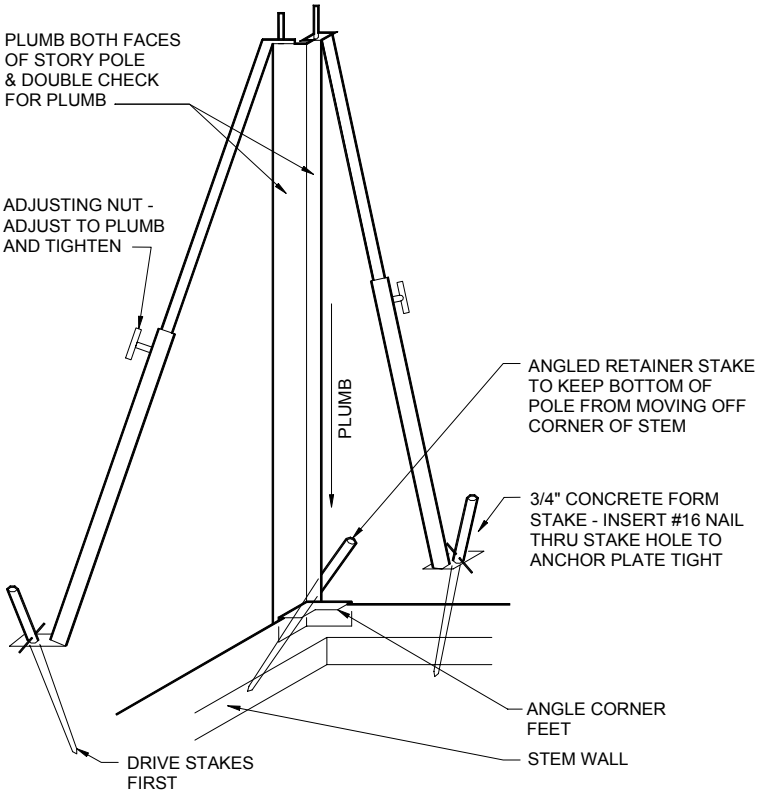
- 30 25 kg bags of mortar mix
- 1,500 ladrillo
- 5 cubic yards mortar sand
- gasoline/oil for concrete mixer
- 1 bundle of 3½" Dur-o-Wal
- 3 to 4 windows
- 16 12" J-bolts
- 2" drywall screws

5.2.1 Setting the speed-leads

This step is very important. The walls will follow the speed-leads. The leads must be plumb and remain plumb through the full 20 courses of ladrillo. The speed-leads have angled corner feet that sit on the corners of the stem wall. Make sure the base is snug against the outside cinder block of the stem wall. Use a concrete stake driven in to the ground at an angle to hold the shoe of the speed-lead base against the stem wall corner block.

The adjusting arms on speed-leads are anchored before the poles are adjusted to be plumb. Get the adjusting arms close to where they need to be and drive a speed-lead stake in to the ground to hold it in place. Do not use a rebar stake. It is not the proper diameter and it will allow the speed-lead to move. Use a #16 nail inserted in one of the

stake holes near the top end of the stake to anchor the pole brace plate. Depending on the height of the corner of the stem wall with respect to the grade level there may be some limitation on how far out you can brace the pole. See Figure 9 - Speed-lead Setup. Once the adjusting arms are anchored in place, loosen the adjusting nut and use a 4-ft level to plumb the pole. Firmly tighten the adjusting bolts of the arms and check the poles to be sure they are still plumb.



• Figure 9 - Speed-lead Setup

Repeat the process as necessary to get all 4 poles set vertical. Recheck the poles before beginning and in the morning before starting and anytime you think the poles may have been disturbed. Check the stakes to make sure they remain firmly in the ground and they are not loose. The stretched block line will put force on the poles and will move them if they aren't anchored securely.

5.2.2 Laying Out the 1st course of ladrillo

Before setting any ladrillo in mortar it's necessary to determine where the door openings will be (usually 2) and to insure even spacing of the ladrillo around the shelter. The only ladrillo needing to be cut will be those against the door openings and they should only have to be done every other course. A little forethought and care in spacing the ladrillo can make the walls attractive; conversely, half blocks in the middle of the wall can detract from the finished product.

The rough door openings should be 41 inches wide. Discussions should be held with the owners to determine where they want them to be. Don't assume you know where they

should go. We've seen several combinations. However, because the ladrillo is rather unstable during construction and the walls are subject to falling due to winds, the doorway opening should be no closer than 4' from a building corner.

Mark the door openings with pencil or other marker on the stem wall block. Take ladrillo and set them out along the stem wall all the way around and up to the door openings. You should be able to set them out in such a way as to not require any partial ladrillo in the first course. A little trial and error may be necessary to get the spacing right. Try to get the spacing of the ladrillo as uniform as possible. A spacing of 1" will be consistent with the joint between the courses and be most attractive.

Find out where the windows are to be placed also. Nothing needs to be done with the window information until after the 11th course of ladrillo but it is a good time to get the resident thinking about it. The only structural consideration is the window and door openings can't be too close together. Probably a separation of 6' minimum would be good. The wall will be weaker at the window opening and the door puts a reasonable amount of stress on the wall.

5.2.3 Setting the block line

Using 2 line blocks (for each side of the shelter) and good block line, set the line around the perimeter (or halfway around, depending on your preference) of the shelter using the 1st slot in the speed-leads. The string should be very tight. The run along the length of the shelter, at 33'4", is a long run for the string and if it is not very tight it will sag in the middle, causing the ladrillo to be set to the incorrect height.

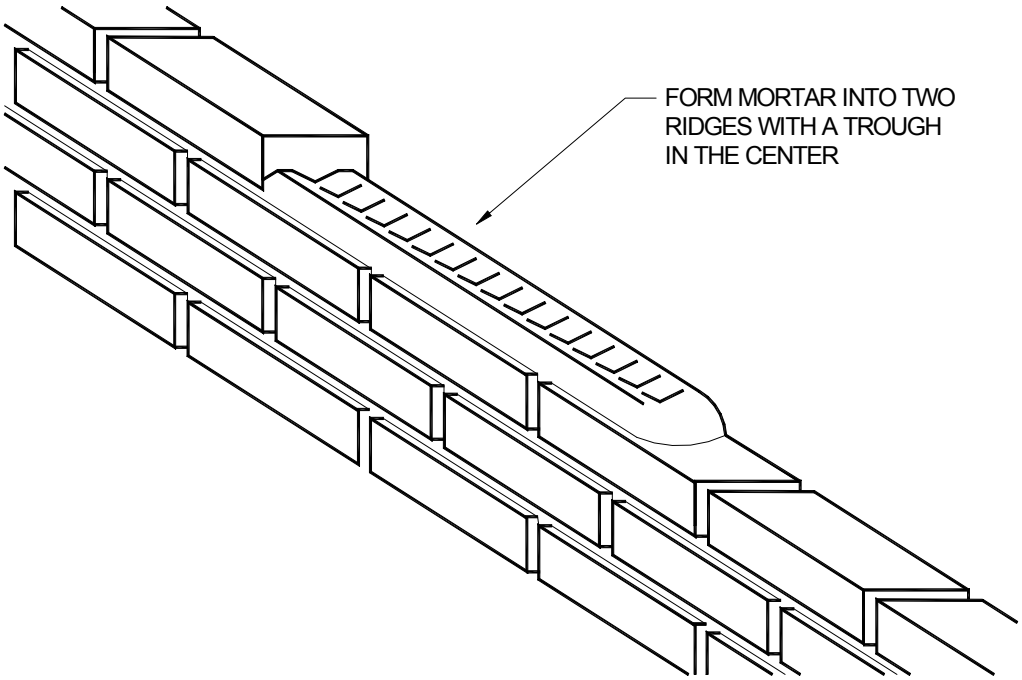
5.2.4 Setting the ladrillo in mortar

It's time to check the gas and oil on the mixer and fire it up again. Mix a full batch of mortar per the mixing instructions in this document. When it's ready, wet down the first wheelbarrow and dump half of the load in. For the first courses you can work directly out of the wheelbarrow or set up a mortarboard on cinder blocks, depending on your preference.

If you have 2 people setting ladrillo, with a good support crew you will probably be able to use mortar as fast as the crew can make it. Keep an eye on supplies; if anything starts to run low, send someone for more before the operation grinds to a halt.

Set the ladrillo off to the side of the stem wall, keeping them in the same location. Make sure the top of the stem wall is clean of debris. If it is not, get a broom or rag to clean away any debris.

The ladrillo requires a 1" thick solid mortar joint. Use the trowel to put a generous amount of mortar on the stem wall block. Use the trowel to fashion a furrow down the middle of the mortar. See Figure 10 - Ladrillo Mortar for a picture of what the mortar should look like before the ladrillo is set in place.



• Figure 10 - Ladrillo Mortar

Dip the ladrillo in a bucket of water momentarily to wet it. Set the first ladrillo in place on the mortar. Use the string as a guide for the outside elevation of the ladrillo. Gently move the ladrillo with your hands to set the correct elevation. Make sure the ladrillo is not touching the string after it is set in place. If it is, it will cause subsequent ladrillo to be set too far out. Don't waste time trying to get the placement perfect. The irregularities of the ladrillo make this unnecessary. If there is adequate mortar in the joint it will squeeze out evenly all around the joint. Use the trowel to scrape away any excess and use it to fill the joints in between the ladrillo if the mortar is still fresh. Because ladrillo is only 7" wide and the concrete stem wall is 8" wide, the 1" inset will occur on the inside of the wall.

If you have a good crew delivering mortar and dipping the ladrillo in water you can set ladrillo in mortar quite quickly at this point. Keep checking the line frequently to make sure nothing is touching it. Make sure the ladrillo set at the door openings are set in place at the correct locations and the resulting width is 41", consistent, and plumb.

A helper can follow along behind the person setting the ladrillo to grout the joints.

5.2.5 Raising the line

Once the first course is complete, you're ready to raise the line for the next course. Start with 1 line block and raise the string around the shelter 1 pole at a time. Each time you raise the line, take as much slack out as possible. As the string warms and is used it will tend to stretch some, resulting in line sag if not properly tightened. When you get to the point on the speed-leads where the braces connect you'll have to completely remove the string to get it above the braces. This only has to be done once.

5.2.6 Setting subsequent courses

Getting a nice uniform pattern in the ladrillo wall can really be quite easy. Beginning with the 2nd course, always look at the ladrillo below for a guide of where to place the ladrillo you have in your hands. For the 2nd course, put the middle of each whole ladrillo directly over the joint in the course below it. For the 3rd course you can do the same thing, but also line up with the 1st course below.

5.2.7 Cutting ladrillo to fit

The end of the course of ladrillo at the door opening will require a partial block every other course. The same will be true at the window openings, and depending on the placement of the windows a partial block may be required on every course.

The ladrillo are remarkably soft and can actually be drilled with a spade bit. In the course of moving them around and handling them a number of them will get broken. Keep the extra pieces; some of them will actually be the correct size or can be cut for what you'll need later.

If the correct size is not available, you'll need to cut one to fit. This is usually done by gently striking the side of the ladrillo with the edge of your trowel to make a shallow groove. After doing this on the top, bottom and sides, strike the ladrillo increasingly harder until it breaks in to 2 pieces. Another way to cut ladrillo is to use a grinder and groove all four sides to the depth of the grinder wheel. Then gently strike the ladrillo in the groove with a trowel. This can be messy but quicker. A little experimentation and practice will quickly make you proficient.

Don't worry about making half-bricks the exact size. The joint of mortar next to the partial ladrillo can be varied to make up for a slightly narrow or wide partial ladrillo. A good job for a helper is to pre-cut all of the partial blocks for a given door or window opening. If the person setting the ladrillo stays on course, each subsequent alternating course will require the same size partial ladrillo.

Always make sure the end of the ladrillo against the door or window opening is one of the original ends of the ladrillo. Don't set the broken end of the partial ladrillo against the opening. Also, don't use a piece that has been cut out of the middle of a ladrillo as it will expose the interior of the ladrillo which will not be as weather resistant and will not have a consistent appearance with the rest of the end pieces.

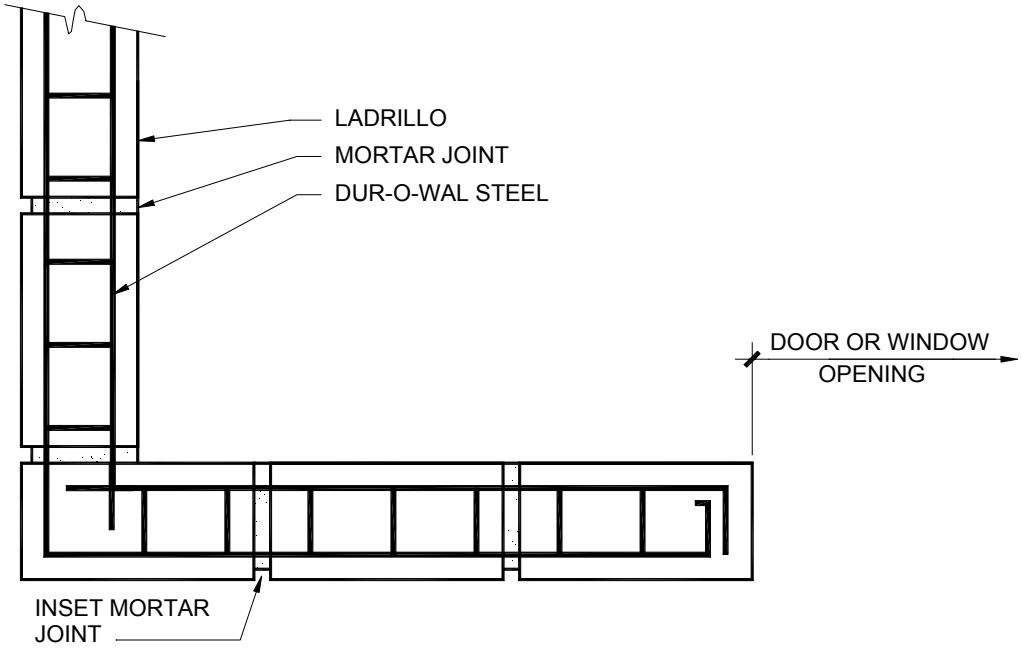
5.2.8 Putting Dur-o-Wal in the wall

The Dur-o-Wal is reinforcing steel that looks like a 3½" wide ladder. The ladrillo walls can be strong but brittle. Therefore, the Dur-o-Wal adds significant strength by bonding the wall making it unified.

The Dur-o-Wal is put on top of the ladrillo after 4th, 8th, 11th and 16th courses before mortar is applied. It's a good idea to have someone with a good memory counting the courses because it's very easy to forget, especially once the scaffolding is up and you're working around the window openings. The exact courses the Dur-o-Wal goes on are not critical. If you forget one, put it on top of the next course and continue.

At door or window openings the ends of the Dur-o-Wal should be bent to make them perpendicular to the course being set. At the corners, cut the inside leg of the Dur-o-Wal

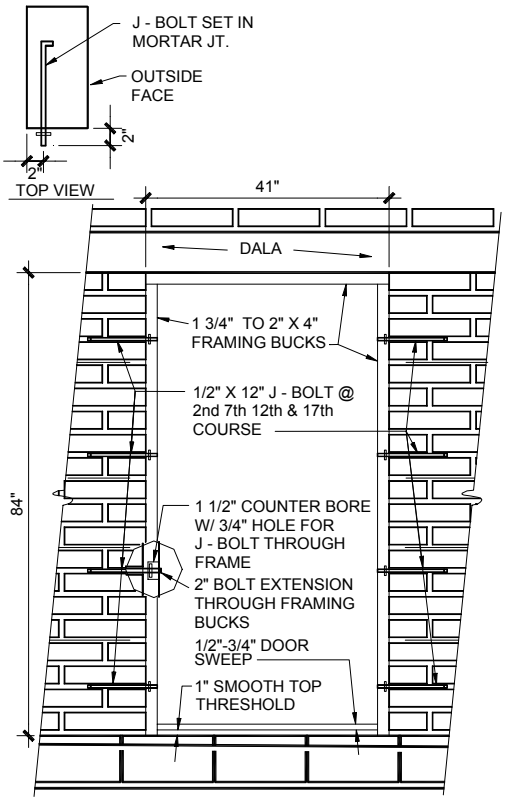
and bend the outside piece around the corner. This is very important. If 2 pieces of Dur-o-Wal meet at the corner the pieces can slide over one another, and the corner will have almost no strength. Where pieces join along a course, overlap the 2 pieces of Dur-o-Wal approximately 18". See Figure 11 - Dur-o-Wal Installation



• Figure 11 - Dur-o-Wal Installation

5.2.9 Placing the J-bolts for the door frame

The doorframe is attached to the shelter with 12" J-bolts set in the mortar and protruding in to the door opening. It is critical to put these in place and set them in the correct position. Forgetting to put these in place will cause significant grief for the crew hanging the doors later on. If these are forgotten and your crew has to install the doors, chances are you will never forget them again. The J-bolts should be put in place on top of the 2nd, 7th, 12th, and 17th courses. They should be set in from the inside wall 2" and should protrude 2" in to the door opening. If they protrude too far there may not be enough threads close to the wall opening to bolt the frame. If they don't protrude far enough they may not allow for shimming required when hanging the door. See Figure 12 - Door Frame J-Bolt Installation



• Figure 12 - Door Frame J-Bolt Installation

5.2.10 Keeping the door opening plumb

Like setting the J-bolts correctly, careful work here will be appreciated by the door hanging crew later (and this crew might just be you). The speed-leads will insure the door opening remains plumb with respect to leaning in or out. We are working on a practical way to build a frame for the door opening to set the ladrillo against, but until that time, the person setting the ladrillo needs to insure the door opening remains plumb. This is best accomplished using a 4' level and checking each time a ladrillo or partial ladrillo is set at the opening. Because of the irregular shape of the ladrillo, check for any abnormal shapes on the end of the ladrillo before using the level. Checking at different places may yield different results.

In most every case, when the last ladrillo of the course is laid at the opening and the joint is grouted, the ladrillo will shift further into the opening. What we found to be helpful is to set the last ladrillo but do not grout the joint at this time. Wait to grout this ladrillo until the next course is laid. This gives the ladrillo a chance to set up on the mortar bed and if grouted just before the next ladrillo is laid on top of it (by the time you get around to the opening again) it will not move into the opening.

A sawsall can be used later to trim any protruding ladrillo, but try to avoid slippage, as any protruding ladrillo will make it difficult to check the level over the next 4 feet. Remember, when setting a ladrillo at the door opening, wait to grout the joint on that ladrillo until the next course is being set in place. Grouting the joint, especially on the partial ladrillo, will cause it to move slightly in to the door opening.

5.2.11 Making the window openings

The window openings begin on the top of the 11th course of ladrillo. If the owners haven't already indicated their preference, now is the time to determine the exact location of the windows. Generally 3-4 windows will be installed. Using the actual windows as a guide, mark the window opening on top of the 11th course with pencil or other marker. You want a snug fit horizontally for the window, but be careful not to make the opening too narrow. If you do, the ladrillo may need to be cut later with a sawsall or other cutting tool.

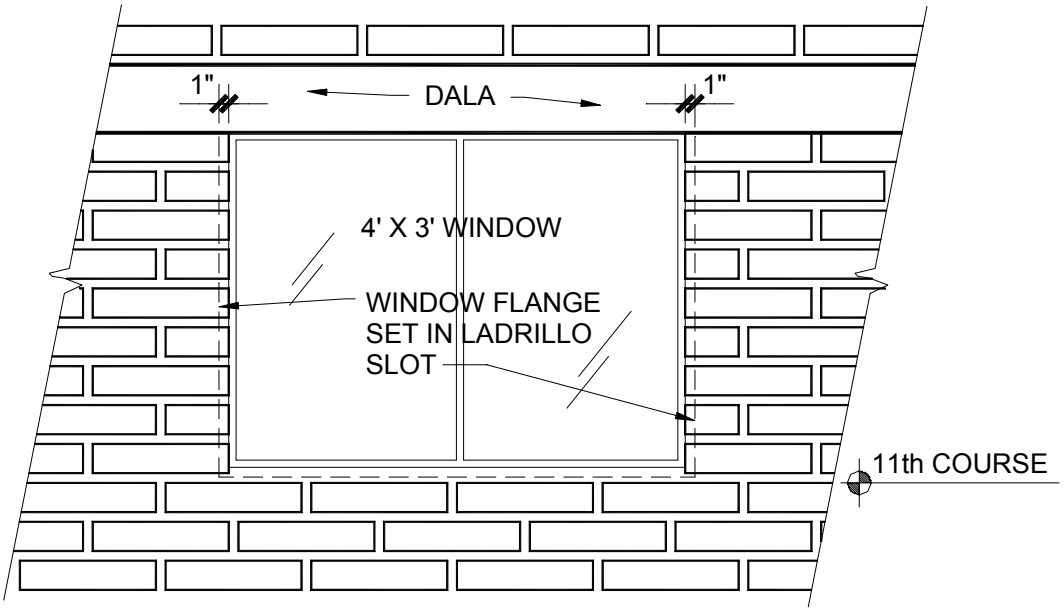
With a 4' wide window, if you choose the opening location carefully, you will be able to lay a full block against the window every other course. This will save time cutting ladrillo and will result in a more attractive window opening. The first course with the full ladrillo the window opening may require some adjustment to set the full ladrillo properly. Carefully look at the courses below to see what adjustments will be required. If the adjustment is done over several ladrillo placements it will not be perceptible in the finished product.

A 3'x5' wide window does not set with as clean a finish but can be used. Care should be taken, however, because a partial ladrillo will be required on both sides of the window. The trick is to consider the result of both courses above the sill. You want all partial ladrillo in every course to be at least 4" in length. The two lower courses provide a nice pattern to follow for placement of the opening.

It is important to have the actual windows to be used in the shelter on site before setting the window openings. If the windows turn out to be different than what you have planned for and you are up to dala height, you're in for some potentially painful rework.

The windows used must have a frame with a 1" or less flange extending from the center of the outside surface of the frame. This type of window is commonly known as a "nail-on" frame.

The basic technique is to make a vertical slot in the ladrillo at the window opening for the flange to fit in. The slot is cut using a 4" masonry blade on a hand grinder and should be biased towards the outside of the opening to allow for a slightly larger windowsill inside. For a 7" wide ladrillo, cut the slot 2½" from the outside of the ladrillo. See Figure 13 - Window Frame Slot.



• Figure 13 - Window Frame Slot

After the 1st ladrillo are set in place on either side of the window opening, take the actual window and verify that it will fit in to the slots in the ladrillo. If not, re-set the ladrillo so the window will fit.

90-degree frames have been constructed to enable the 12th through the 20th courses of ladrillo to be set quickly. The frames provide a stable, vertical surface to set the ladrillo against. The frames are set in place on both sides of the window opening and held together with c-clamps or other clamping tool. Make sure the frames are set far enough in so the block string will not be touching them. The frames are also screwed down to the base of the window opening by driving 2" drywall screws in to the 11th course of ladrillo.

After clamping them in place and securing them with screws, use a level to verify the frames are plumb. You are now ready to set ladrillo against the frame. A further note: set them against the frame gently so as not to knock the frames out of plumb.

5.2.12 Slotting the final window opening

When the 20th course is in place and set for 30 min or so you can cut the slot in the ladrillo from courses 12 through 20. Use a 4ft level to mark a plumb line from the existing slots in the ladrillo on the 11th course through the 20th course. Take the hand grinder and carefully cut the vertical slot from the 12th to the 20th courses. The slot should be cut to the depth of the grinding wheel. After all slots are cut, replace the wheel with a new one and cut them again to ensure they are at full depth. If the window does not fit easily in the slot, trim a bit off the flange.

5.2.13 Striking the joints

Using the striking tools referred to in the general building notes, the mortar joints on the outside of the shelter should all be struck. The tool consists of a small block of wood, around 4"x4"x2" with 1 or 2 nails driven partially in so the head(s) protrudes approximately ¾". By dragging the exposed nail head through the mortar joint, the joint will be reduced

to a uniform depth. This can be done after the mortar is set 20 min or so up until a few hours later, depending on the weather. This is a good job for a helper who might not have the strength or endurance for other jobs. To get to the upper courses, an upside down bucket makes a very good step stool.

It's hard to overstate how much nicer this makes the shelter look. At the end of each ladrillo setting day be sure to make a final pass around to make sure all the joints have been properly struck. After setting for the night they will be difficult, if not impossible, to do.

5.2.14 Using the scaffolding

Generally around the 12th or 13th courses the scaffolding is used to provide an elevated work surface. The scaffold consists of 2 end pieces (called jacks), an X-brace to hold them together, and 2 to 3 planks to provide the working surface.

When assembling the scaffold, make sure the X-brace is held in place with some type of retention device to the bolt holds with either the built in clips or a piece of wire. If the scaffold collapses, serious injury may result.

Usually you will set the scaffold in place and build the wall up to the 20th course before moving on. Sometimes getting mortar to the scaffold can be a challenge when doorways are blocked so you may have to pass a full shovel full of mortar to someone on the inside. You can use 3 leftover cinder blocks as a stand for the mortarboards on the scaffold.

Resident children are attracted to job sites. Be careful to make sure none of them are playing under the scaffold or on top of it. Dropping a ladrillo or mortar, or moving on the planks can be a problem.

5.2.15 General cleanup

When the 20th course is complete, the speed-leads can be disassembled and removed. Sometimes the stakes can be a challenge to get out of the ground. Use a square shovel to remove the excess mortar from the base of the wall inside and out of the shelter and pile it up with the construction debris. Do a final check of the joints for proper striking. A shower and an ice cold Corona with a slice a lime would definitely be in order at this point.

5.3 Installing the Windows

Tools required:

- hammer
- small chisel

Materials required:

- window units

The work to install the windows takes places over several stages covering several days. The windows must be in place before the bond beam is formed and poured. The remaining items required to complete the process are described here.

5.3.1 Trimming the top flange

When installed in its final position, and the top flange is removed, the window frame should fit snugly up against the bottom of the bond beam, which serves as a lintel for the window opening. Sheet metal shears should be used to trim off the top flange from the window frame before installation. Also, the top and bottom of the side flanges should be trimmed at a 45-degree angle, and the screens and sliding panels should be removed.

5.3.2 Putting the window in the slot

Visually inspect the slot on both sides of the window opening. If it is not clean, use the hammer and small chisel to clear all debris. Attempt to slide the window down in to its slot. If it will not go, determine the cause and attempt corrections. If the opening is too narrow, a sawsall can be use to trim the ladrillo as necessary. If the slot is not aligned properly, the hand grinder can be used to open it up as required. Make sure the window can slide freely up and down in the slot. There must be enough room in the opening above the window for a 1" board to support the bond beam during pouring.

5.3.3 Cleanup after the Dala is built

After the dala has been formed and poured and allowed to set, carefully remove the form board above the window. Use the hammer and small chisel to clear away any concrete blocking the slot. Verify that the window can be raised in the slot to fit firmly against the dala. Brace the window frame up as far as it will go against the dala by placing small rocks underneath it. You should not be able to see light coming through between the top of window frame and the bottom of the dala.

Note: For completing the process, see section entitled "Finishing the Window Installation" on page 60.

5.4 Building the Dala (Bond Beam)

Tools required:

- circular saw
- bolt cutter
- hammers
- cordless drills
- mixer
- 2 wheelbarrows
- 8 buckets
- 3 shovels
- rebar wrapping tool (or pliers)
- scaffolding
- tape measure
- chalk line

Materials required:

- 6 bags of cement
- 34 stemwall clips (20 can be recovered and used on another shelter)
- gravel
- five 20' long castillo
- thirteen 1"x8"x16' lumber
- twelve 14" rebar pieces
- several 2" drywall screws
- ten 8" J-Bolts
- ten 24" L-Bolts
- 16 penny nails

5.4.1 Installing the Windows

If they aren't already in place, install the windows now. Remove the screens and sliding panes (if not already removed) and store them someplace safe. The new shelter owners usually can assist with this storage. These tend to be high theft items.

5.4.2 Preparing the reinforcing steel

Because the ladrillo is unstable, the dala essentially "bonds" and stabilizes the walls of the shelter. A key element of the dala is the reinforcing steel (castillo). Without this steel the dala has almost no lasting strength. The castillo is a 4" square cage made of heavy gauge steel and comes in 20' lengths. The castillo has to be bent around the 4 corners of the shelter and overlapped where the pieces come together to form a continuous piece around the top of the walls.

Pre-cut and pre-fit the castillo on top of the wall.

The corners and over the door and window lintels are the most important point to add strength to the dala. Joints in the castillo cannot occur in either one of these locations around the top of the wall. Where a joint will be made, the perpendicular wires on one end of each castillo are cut out to allow the ends to be pushed together to form a minimum 12" of overlap. Rebar tie wire or other wire is used to secure the ends together, if necessary. If they fit together nicely and aren't sticking up, no wire tying is necessary.

Try to keep the castillo centered over the ladrillo all the way around. This may be difficult because the castillo is often bent and twisted slightly and it is difficult to re-form by hand. If the castillo ends up against the form it will possibly be exposed at the edge of the dala and rust later on when exposed to rain or other moisture. But it is easy to physically adjust its location during the "pour".

Making the corner bend is sometimes difficult. To do it, use the bolt cutter or other heavy-duty wire cutter to cut out the 2 inside wires of the Castillo at the point where the bend is needed. With the castillo on the ground, use your foot to hold the wire and make as tight a 90-degree bend as possible. It may take a few tries to get it right.

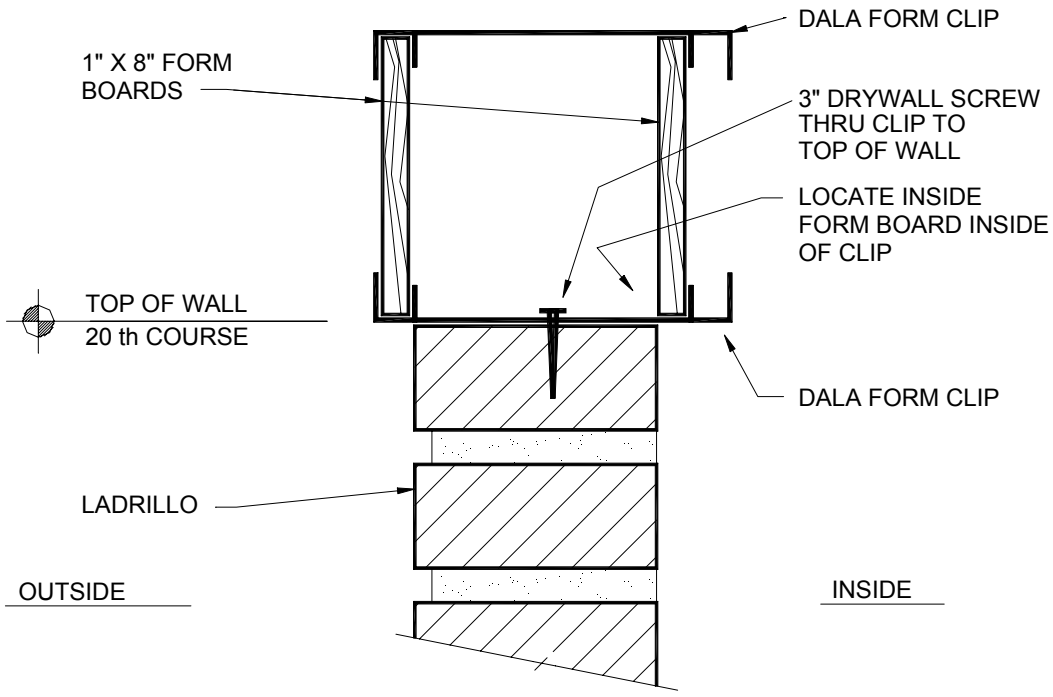
Once they are fit, leave the castillo sections linked together on top of the wall. The dala forms can be built around the castillo.

5.4.3 Installing the Dala Forms

The forms are 16-foot long 1 x 8's. These forms are held elevated on the inside and outside of the shelter wall by using "stem wall clips" typically used in the modern world to hold/space 1" thick plywood panels to the top of a footing. These clips are screwed in place on top of the last course of ladrillo.

A figure showing what a clip looks like is provided for reference. See Figure 14 - Dala Clip Installation. Essentially, up to fourteen clips can be used. No more than five are placed on top of each long wall and three on top of each short wall. The ladrillo are only 7" wide and the clips are 8" long. So, proper placement and attachment, perpendicular to the ladrillo, is necessary. In some cases, the clips could be sawn off after construction is complete but usually they are left alone. The residents have used the protruding parts of the clips to hang pictures or laundry cords on the inside or outside of the shelter.

While the figure fairly well speaks for itself, their spacing along the top of the wall is a judgment call. The clips serve two purposes. First, they support the forms evenly. Second, and more important, is to keep the form from spreading due to the pressure from the wet concrete. Generally, one should be set on each wall about 2 feet from each corner. One goes near the center of each short wall. Two or three are spaced out on the long walls. If a window or doorway opening is in the location where a clip would be placed, move the clip at least 1½ feet from either side of the opening. There is a hole in the center of the clip. Setting the clip perpendicular as shown, screw the clip to the ladrillo using a 3-inch drywall screw.



• Figure 14 - Dala Clip Installation

Once the clips and forms are in place, a 2nd clip is used upside down on the top of the forms to hold them together at the correct width. In addition, one is placed on top of the forms over each of the window and door openings. The lintels over the windows and doors will hold the forms at the proper width from below. If you used 14 clips on top of the walls, and you have 4 windows and 2 doors, you'll need 14 + 14 + 6 (or 34) clips total. The 20 clips from the top of the wall can be recovered after the dala has dried, and used on another shelter in the future. Refer to Figure 14 - Dala Clip Installation.

Next, sort the forms. The quality of the form material will be questionable so look each one over. They will be cupped, twisted, crowned and/or split and in a variety of thickness and widths. The cup should be convex to the wall, the crown turned up, and if possible, sparingly square-cut split ends off. The twists will be somewhat straighten as you go along.

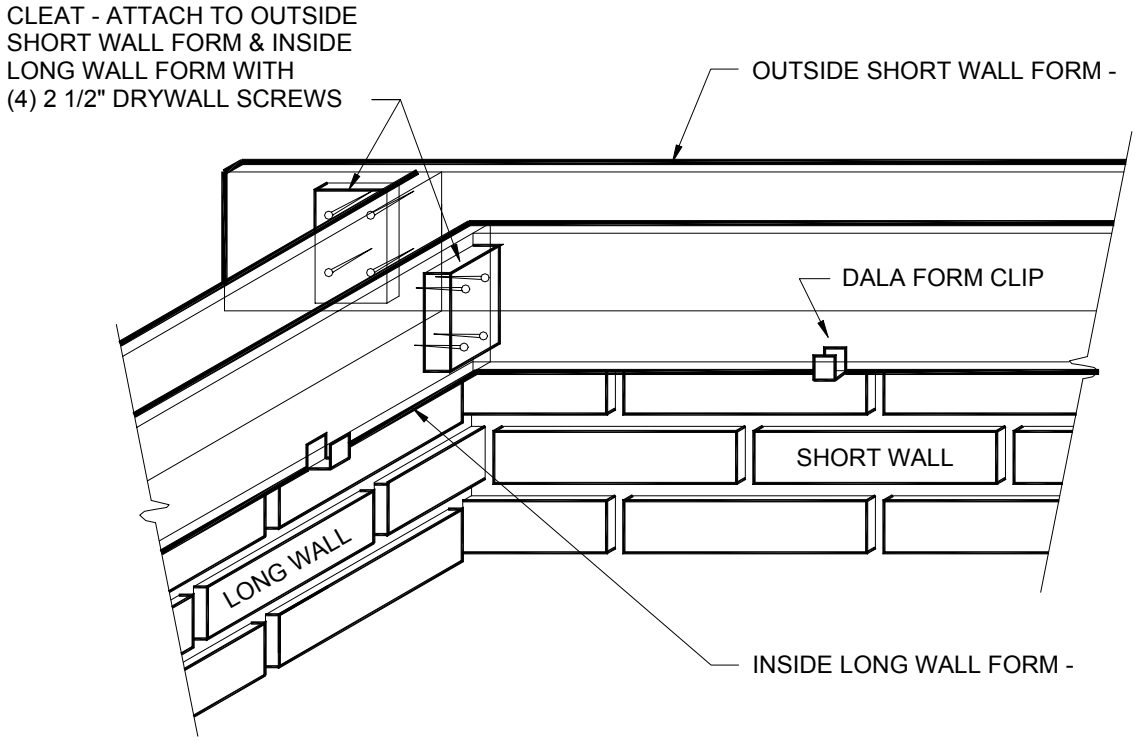
Once they are sorted, each end of all forms is square cut. Since the forms will later be used for stringers on the roof, when squaring the form ends, do not take off any more than absolutely necessary. After squaring, they can be set in the clips. First, set either one of the outside *short wall* forms and let both ends extend past the corner about six inches or more. Outside forms are placed between the outside tab and the second tab of the clip. Next, either of the contiguous outside long wall forms is set and butted against the short wall form. This butting-up plumbs the short wall form and after plumbing the long wall form, use four 2 1/2" drywall screws to fasten them together. (The wood is rather soft and pre-drilling is not necessary.) Screw through the short wall form and into the end of the long wall form. Squaring and plumbing along as you go, fasten all outside corners the same way. About a two foot gap will occur between the two outside forms on the long wall that we will fill a little later.

All outside forms should be set. Before an inside form is set, place the sections of castillo back on top the wall. Tie each joint and make sure they are secure.

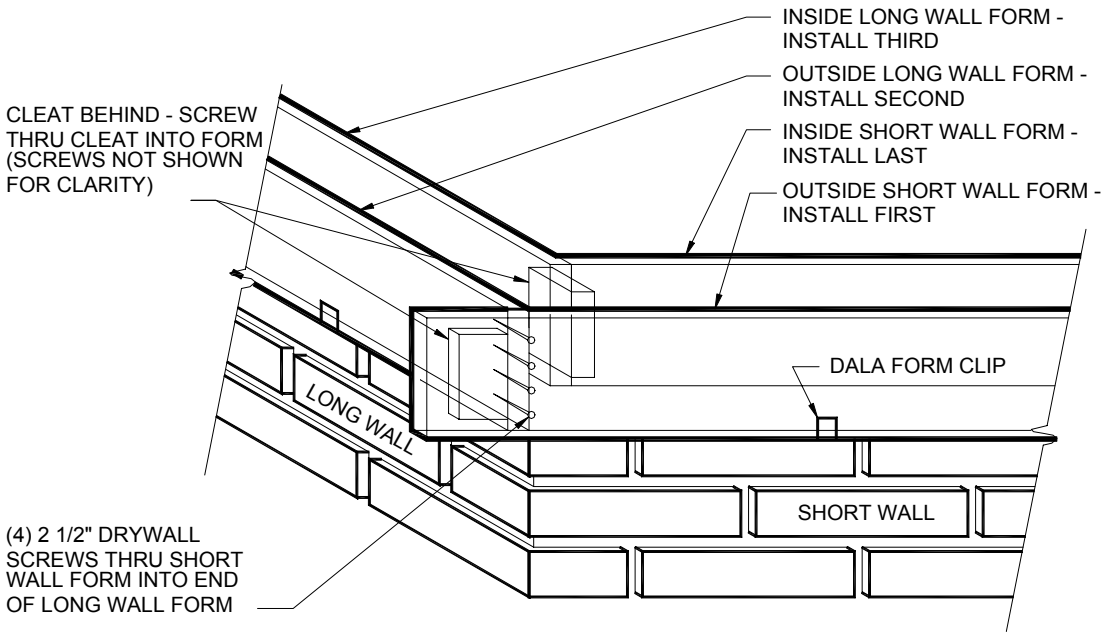
Next, set an inside long wall form. Notice the figure places the inside forms inside the second tab rather than sandwiching it between the other two tabs of the clip. The form is set on the clip and the end is pushed against the ladrillo of the short wall. Set the other inside long wall form extending from the same short wall. The next two long wall forms can be cut in length to fit and be installed. The last to be installed are the inside short wall forms. Square the ends of the inside long wall forms at the corners and measure the distance between them less 1/4 inch. Cut to length and set the short wall form in place.

Since the outside forms have been screwed to the short wall forms, they should be rather rigid. Double check all the outside forms to be sure the insides faces are flush with the outside face of the ladrillo wall. Measure the length of the gap between the outside forms and cut a piece to fit. Usually, the scrap cut from each of the inside short wall forms can be used. If the scrap is not usable, cut a piece extending from the outside short wall form. Similar to the cleats, the sketch below shows how "plates" made of the scrap lumber are used to fasten the long wall form joints together.

Securing the forms for "the dala pour" is the next step. Cleats cut about 2" wide from 1-inch scrap form lumber are screwed to the forms and used in every corner and long wall form joint with at least four 2 ½ " drywall screws. If at all possible, do use screws in locations that can be easily removed after the dala concrete has set-up.



• Figure 15 - Dala Form Inside



• Figure 16 - Dala Form Outside

The figure should be helpful but, essentially, the objective is to keep the form from moving outward from the force of the concrete. Cleats can be easily attached to the wrong form so take care to identify the correct location. On the outside form corners, the cleat is attached to the short wall form. On the inside corners, the cleat is attached to the long wall forms. After the cleats are installed and the forms screwed tight, the dala clips are placed on the top of the forms to keep them from expanding when filled with concrete. One clip is placed over each of the clips under the forms, and over the middle of each of the window and door openings. Make sure they are securely set in place.

See sections 5.4.7 and 5.4.8 for locations of the L-Bolts and J-Bolts to be placed in the dala. These locations should be marked before the dala is poured since they need to be set in the wet concrete fairly quickly after it is poured.

At this point, you are almost ready to pour the dala, so it's time to get the scaffold up and someone mixing the concrete.

5.4.4 Adding lintels for the doors and windows

The last step is to cut the width and length of boards needed to fill between the forms over the window and door openings. Slip the board over the windows and when the top of the board surface is even with top of the ladrillo wall, using one 2 ½ " drywall screw per foot, screw them through the forms and into the boards. For the openings, basically flush the top of the board with the ladrillo wall and screw in place the same way.

Now we double-check everything. If all is well, let's pour.

5.4.5 Filling the form with concrete (pouring the Dala)

If the materials are available and received early enough in the morning and enough builders are on hand, forming and pouring is generally a short one-day job.

The forms have been doubled check for screws and cleats. The castillo is flat on the top ladrillo and wired together and the top dala clips are in place.

Start mixing a full batch of concrete. While this is being done, set up the scaffolding inside the shelter. It's more convenient to place the NON ladder-end of the scaffold frame to the wall. Once the planks are set on the scaffold frames, the ladder can be used to climb up. Also, if only one x-brace for each set of frames is being used, it should be placed adjacent to the wall.

Place the scaffold so the pour can start over a short wall about two feet from the corner of the low roof long wall. The concrete mix should be a bit watery and wet enough to be easily poured into the form without having to pack it down, but not so runny it seeps out the bottom of the forms and runs down the side of the ladrillo wall. The concrete should pretty much be able to seek its own level in the forms.

The pour is a cooperative effort and done with buckets. While someone is mixing concrete, someone is wheeling it to the scaffold where someone is filling the bucket and handing it to someone on the scaffold who is pouring it in the forms. The pour itself does not take so much time, but it can be labor intensive. Once you start, don't stop except to move the scaffolding. This job has been done with as few as three and four people but six or seven are recommended.

Pour the two-foot section of the side-wall and then continue around the corner and pour the long wall. Because the concrete sets-up rather fast, we will come back to the short wall again for the second half of the pour. Someone should be on the scaffold smoothing out the top of the dala pour and making sure the form is filling adequately. As the pour continues, the castillo must be raised by hand to the center of the forms. As several feet of dala are poured and the operation moves along the wall, the next portion of castillo is also raised. The idea is to have all the castillo as close in the center of the concrete form as possible, vertically and horizontally when the pour is complete. Continue to pour the long wall, turn the corner and pour the side-wall to about 2 feet from the corner of the high roof wall.

As soon as the low roof long wall is poured, the J-bolts can be put in place. Aligned close to marks that were made on the dala form earlier, place them 3 inches from the outside face of the wall and extend the threaded portion 3 inches above the dala concrete. See the following section with more details on the J-bolts.

While the bolts are being set, move the scaffold to the area the pour began over the side-wall. The concrete previously poured at this point is starting to set-up. Start pouring here, going in the opposite direction. Before getting too far away from this spot though, try to mix the set-up and the fresh concrete at the "joint" to minimize the effect of a joint.

Pour the rest of the side-wall, continue around the corner and pour the long wall. Then place the 24-inch long L-bolts as described in the following section on L-bolt installation.

Once all is poured and the bolts are secure, there is little do except clean-up, load-up and head back to paradise.

5.4.6 Setting Anchor Bolts

Two types of anchor bolts are used in building the shelter; J bolts and L bolts. Essentially, these are ½" in diameter, are used to hold 2" x 6" plates tight against the dala so the rafters can be attached. They generally take on the character of a J and an L. The difference between the two is the length of the bend at one end. Depending on the

manufacturer, the length of the L bolt bend is substantially longer, about an 2" to 2 ½"" while the J bolt bend is about ¾" to 1".

The L bolts used are 24 inches long and are placed in the dala where the high end of the roof will be built. Two lengths of J bolts are used. 8-inch long bolts are placed in the dala at the low roof wall and 12-inch long bolts are used to anchor the buckboards in the door openings.

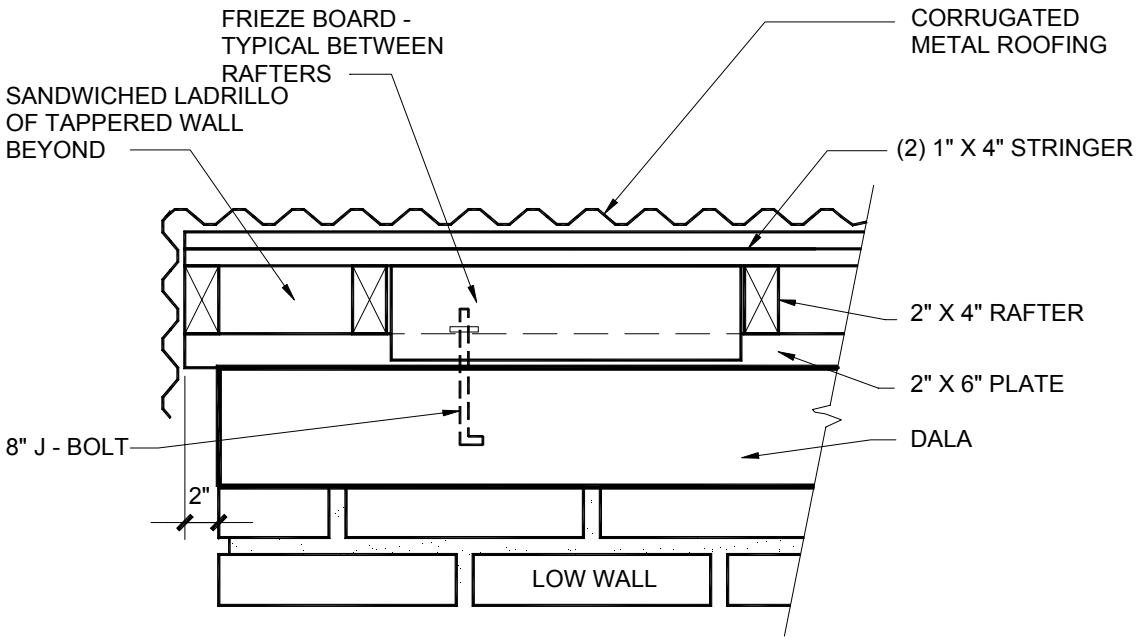
Correctly setting the anchor bolts is critical and, if done carefully, can save a lot of time and provide integrity to the shelter.

5.4.7 Low Roof Wall Dala J-Bolts

The location of all "plate" bolts being placed in the dala should be marked on the *outside* of the long wall dala form as soon as the forms are secured in place. Mark where the rafters will be located so as to avoid conflict where the rafters cross the plate. Rafter location is discussed in the chapter on Roof Installation, but will be discussed here briefly.

The plate that sits on the dala of the low roof wall overhangs the dala corner by 2 inches. Assume the rafters are a full 2 inches wide. This 2-inch overhang is where the first rafter sits tight against the outside face of the side-wall. The next rafter sits on the plate tight against the inside of the side-wall creating a sandwich of the step-down ladrillo which will be filled with mortar when the rafters are installed. The third rafter is set 24 inches on-center from the second rafter and the fourth from the third and so on until you reach near the middle of the shelter's long wall (about 16 feet). On the outside of the dala form, mark these rafter locations and do the same from the other end. The two rafters which end up in the middle of the long wall will be a few inches more or less than 24 inches apart depending on the thickness of the rafters.

Using a different color marker than used for the rafters, mark the first J-bolt location 14 inches from the inside face of the outside dala form of the side building wall. Do the same from the other end. From the first J-bolt mark every four feet for 4 bolt settings; about 14 feet distance from the outside face of the side-wall and stop. Do the same from the other end and stop after 4 bolt settings. Now, working toward the center, place the next J-bolt 24 inches from the fourth bolts. You should have ten of them marked for placement shortly after the dala is poured.



• Figure 17 - J-Bolt Installation

After the dala is poured and is firming up, insert the bolts, threads up, into the dala cement in alignment with the marks on the dala form. Since the plate is 2 inches thick, the bolts should stick up from the dala 3 ½" to 4 inches. Also, since the plate is 6 inches wide, they should be set 3 inches from the outside edge of the dala (not including the form). Try to keep them as vertical as possible while the dala dries.

5.4.8 The High Roof Wall Dala L-Bolts

These bolts are a little trickier to place since the location depends on the length of the ladrillo being used. They are 24 inches long and tend to be top heavy, so verticality is very important and near exact location is necessary. These L-bolts eventually pass through the 4 courses of ladrillo that will be laid on top the dala of this wall.

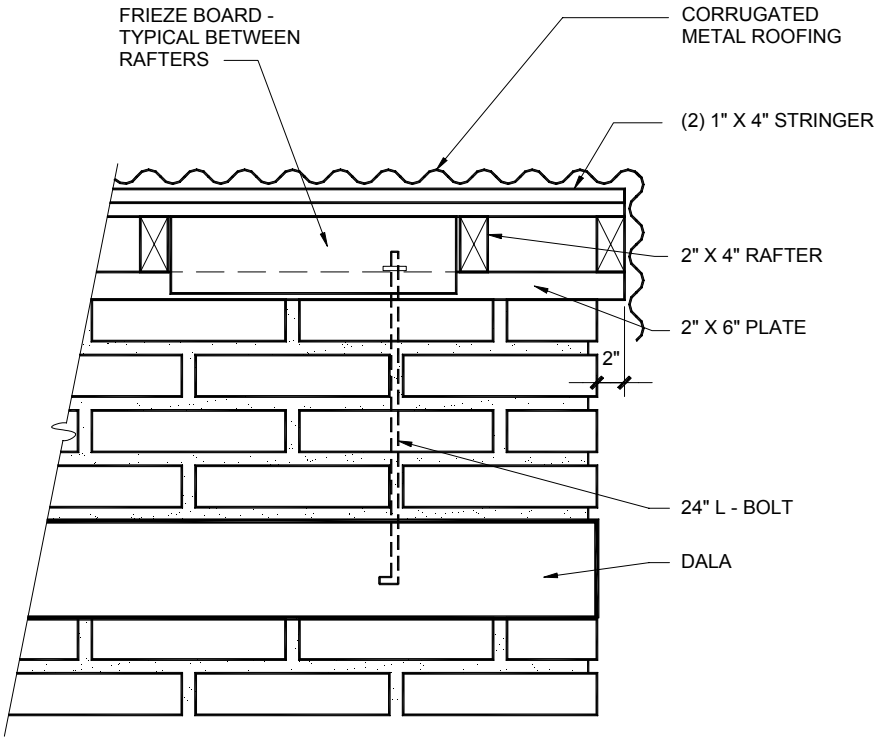
Starting 14 inches from the end of the dala, mark the rafter and bolt locations on the outside dala form following the same procedure used for the low roof wall. The bolt marks along this dala form are approximate and only serve as a reminder a bolt is needed near this location. The reason the location is approximate, is that the actual joint between the ladrillo will determine the true bolt location.

Note: The bolts are 24 inches long. The "pony" wall consisting of 4 courses of ladrillo on top of the dala will be 16 inches high and the plate is 2 inches thick. Together, the 24-inch bolt has to be set in the dala cement and extend up to accommodate passing through 18 inches of material and extend 1 ½ to 2 inches further through the plate. This allows the L-bolt to be inserted in the dala cement about 4 to 4 ½ inches. If, after inserting the bolts, they project 20 inches, call it good.

As soon as the high roof wall dala is poured, the L-bolts should be set. First, at the end of the wall on top of the wet dala cement, place a ladrillo parallel to the front wall. Place a second ladrillo and space it from the first as though you were actually laying the ladrillo in mortar. The first L-bolt is placed in the joint of these two ladrillo which is about 14 inches

from the end of the dala and 3 inches from the outside face of the long-wall. It should extend about 20 inches out of the dala cement.

Leave the first ladrillo in place and place the next ladrillo (also parallel to the *long* wall) on the wet dala cement beside the first ladrillo. Make sure the spacing between the two is similar to the space between the ladrillo in the building walls below the dala. Working toward the middle of the wall, lay two more ladrillo on the wet cement with the similar spacing between them. Since the length of three full ladrillo is about four feet, the mark for the next bolt should be nearby. Set the next bolt in the same manner as the first. Lay three more ladrillo and set the third bolt and the fourth. Because the bolts are top heavy, place a ladrillo adjacent to the bolt to help support the bolt while the dala dries.



• Figure 18 - L-Bolt Installation

Watch the spacing of the ladrillo. If needed, carefully place several ahead of yourself to help determine the proper spacing. When the fourth bolt is set, go to the other end and start with a ladrillo parallel to the front wall and work toward the middle with full ladrillo in the same fashion until the fourth bolt is set.

It is critical to set a bolt every three ladrillo toward the middle of the wall from each direction. The plate comes in 16-foot sections and will be trimmed/cut. Since the shelter is 33' 4" long, a third piece of plate will be fit in between the two 16-footers to take up the gap.

Essentially, two bolts need to be set to hold down the short piece of plate. Here is a suggestion that seems to work: place one ladrillo next to the last (fourth) bolt, but position it perpendicular to the long wall (sideways across the dala as though it too were a half block like the first one). Allow for the spacing as before and set a bolt. Do the same thing from the last bolt set from the other end. This makes a total of 10 bolts. Bring an extra bolt if

you are not completely comfortable with the layout, because you only have one shot at it. Once the dala is set, no more bolts can be placed.

Although these may seem close together, it provides a bolting pattern allowing more flexibility in cutting the plates to size. Considering the 60+ mile per hour winds which rip through this area, at least the plates will still be there should the roof have to be replaced sometime.

Leave the ladrillo on top of the dala as they help hold the bolts from tipping. When you return to do the four courses and the roof they can be removed.

After they are placed, check each L-bolt carefully. They are extremely top heavy. If they are tilting in either direction, straighten them and if necessary brace them with something to hold them plumb while the dala dries.

The whole idea here is to place each bolt within a mortar joint of the first and third course and accommodate the plate material on top of the fourth course. The ladrillo are very soft, so those in the second and fourth courses are easily drilled with a 1-inch bit to fit over the bolt. Drilling is easy and is done with the use of a masonry bit. This is discussed further in the following section on building the pony wall.

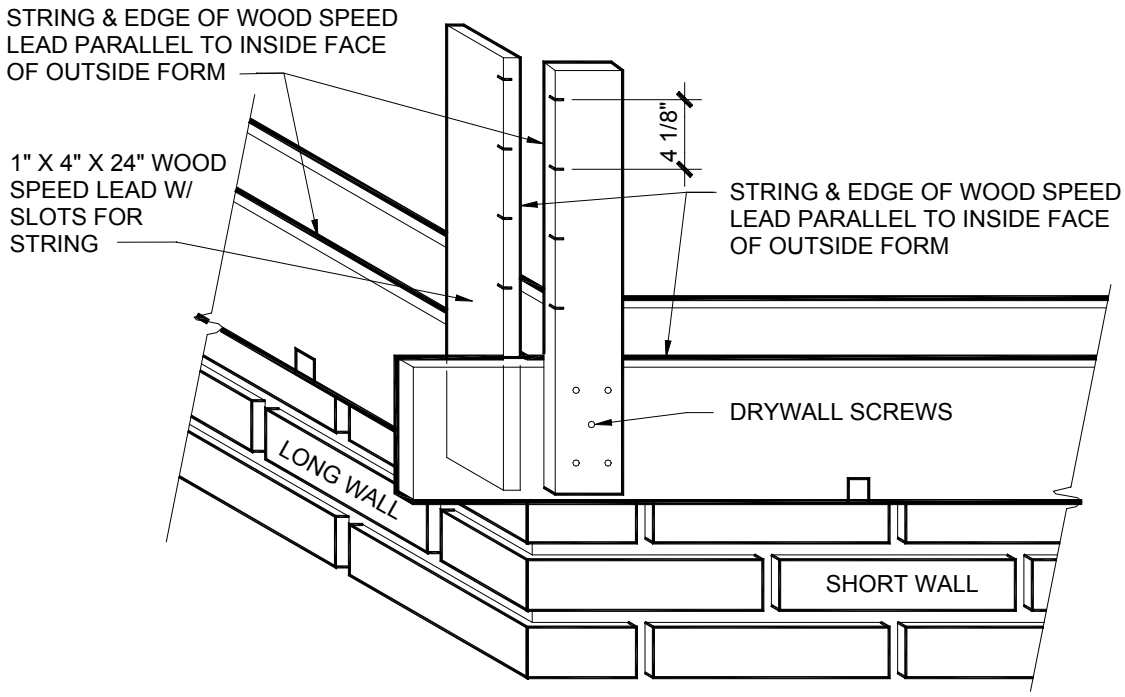
5.4.9 Building the Pony Wall

The pony wall is the last piece of ladrillo wall built on the shelter. Which side of the shelter to build the pony wall is usually determined at the time the foundation is dug. Once the dala is poured and the “L” bolts are set, it cannot be changed. While the process of building the pony wall is rather simple, it can be time consuming. It is suggested to allow at least four hours to complete the pony wall and to remove, clean, and rip the dala forms into stringer material. If you do not have this much time left before you intend to leave, it is best to save the entire pony wall for another day.

Assemble enough scaffolding to extend along the front wall and both short walls. Since the pony wall is four courses high in the front of the building and tapers back along the short walls to the back of the shelter, the use of block line is required to assure the pony wall ladrillos are laid straight and consistent with the main shelter walls. The steel speed-leads used to lay the main walls were removed in order to form the dala. For best results, leave all the dala forms in place while laying the pony wall. These forms will be used to mount makeshift wood “story-poles”.

Using scrap material (minimum 1”x 4”), cut 6 pieces at least 24” long. These pieces are screwed to the dala forms on the outside corners and used for speed-leads. The 1x speed-lead for the front wall is mounted to the outside of the short wall dala form so the front edge is aligned with the inside of the face of the front wall form. The 1x speed-lead for the short wall is mounted to the outside face of the front wall dala form.

After the four wood speed-leads in the two front corners are set, attach the last two, one in each corner, to the outside of the rear wall dala form in alignment with the short wall lead which is attached to the front wall dala form. At this point, the plan view below is worth a thousand words. See Figure 19 - Pony Wall Speed-leads.



• Figure 19 - Pony Wall Speed-leads

Now mark the height of the four courses of pony wall on the speed-leads. From the top of the dala form, place four marks on the wood leads every 4 1/8". With four courses, the pony wall will be about 16 ½" high. You are about ready to lay the pony wall, but first lay out the first course of ladrillo without mortar on top of the dala. If the first ladrillo is laid parallel to the front wall, if should be marked and drilled to accommodate the L-bolt sticking up from the dala. A 1" masonry bit is normally used to drill the ladrillo. If one is not available, a 1" spade bit can be used instead. The masonry bit will last a lot longer of course, but in a pinch, the spade will work. Lay the rest of the first course of ladrillo without mortar and mark and drill the remaining ladrillo.

Once the ladrillo are drilled and the proper spacing between them is determined, remove the ladrillo, place mortar on the dala and using block line and line blocks at each mark on the story poles, lay the first course. This course should wrap around the corner of the short side-wall and extend to within 8" of the inside of the rear shelter dala/wall (do not cross over the rear wall dala). The next course can be laid and the ladrillo marked and drilled as necessary. If the L-bolts were set correctly, drilling will only be required on every other course of ladrillo. Wrapping around the corner of the short walls again, continue laying ladrillo toward the rear wall but stop two ladrillo short of reaching the corner of the back wall. Repeat the same steps for the last two courses stopping two ladrillo short of the previous course. A taper of sorts from the top of the fourth course on the front wall down toward the back wall has been created. This taper will be filled in with mortar when rafters are set on both sides of the tapered wall. In some cases, portions of ladrillo may need to be removed should they stick above the rafters.

When the pony wall is finished, remove the wood "speed-leads", remove the dala forms for ripping into stringers and install the front and rear wall plates on the dala as described in the next section. *It is critical to extend the plates past both short walls 2".* Don't forget to strike the mortar joints on the pony wall.

5.5 Installing the Roof

Tools required:

- ruler or tape rule
- circular saw
- hammers
- chalk line
- pipe clamp or pipe wrench
- electric screwdrivers
- 3-4 caulking guns

Materials required:

- rafter plates
- 19 2"x4"x16' rafter material
- washers and nuts
- ladrillo and mortar to finish sidewall
- 1x material for stringers (use ripped dala forms)
- 16 d nails
- 8 d vinyl coated nails
- 2 ½" drywall screws
- H-3 rafter ties
- Teco nails for the H-3 rafter ties
- 3" deck screws with gasket washers
- 18 sheets of roofing metal
- 2 bundles of 2'x8' styrofoam sheets
- Roll of 24" wide insulation (R-19 or R-33)
- 3 cases of caulk
- Metal edging

5.5.1 Removing the Dala Forms

Carefully remove the dala forms and set them aside. They will be cut for stringers after the rafters have been cut. The top dala form clips should be removed and saved for use on the next shelter.

5.5.2 Installing the Plate Material

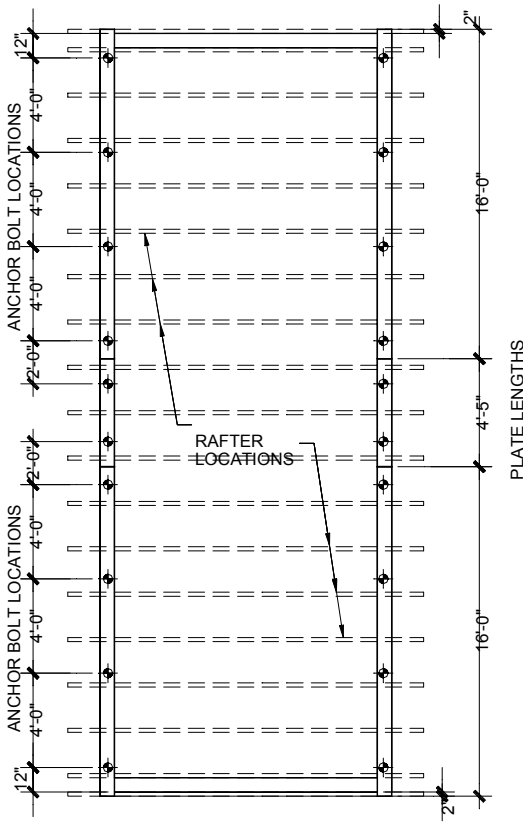
This is a relatively easy job provided the bolts were spaced right and did not move while the dala cement was curing.

Wood quality has been discussed a bit before, but keep in mind a 1 x anything or a 2 x anything do not have the consistency of materials purchased in the USA. The thickness of a 1 x is anywhere from ¾" to 1 ¼". A 2 x comes cut anywhere from 1 ½" to 2 1/8". The width is about as much a mystery as the thickness. A 4 inch width can be 3 ½" to 5" and the 6-inch wide board will vary relatively the same. The straightness of the material, the number of knots and the strength of material are never known and are always a surprise.

Plates and rafters are ordered and delivered together. Check the material when it arrives to be sure it all can be used. The quality is most always poor, and while nothing much can be done about the quality of the material, at least make sure the rafters are in one piece. If so, they will probably not break under a load and will likely remain in one piece through installation.

The plates are 2" x 6" and the longest available is 16 feet. Four of these will be used together with a piece 8 feet long which will be cut to fit between the 16's. Either lay a 16-foot plate on the dala or place it on a sawhorse. On both the low and high roof walls, the plates are set flush with the outside of the long walls and will extend past the end of the side-walls 2 inches. The first rafter will sit on the 2" "overhang" against the outside of both side-walls. See Figure 20 - Plate Installation for detailed information on the layout.

From the end of the 2" overhang, measure for or mark the center of the first four bolts. Next, measure the distance each bolt sits from the outside wall face and mark the plate for the center of each hole. Mark the 16-footer close to the fifth bolt for final length cutting. From the other side-wall do the same. Before you cut the 16-footer, be sure the space between the two 16's will be less than four feet and has two free bolts sticking up. If there is no way to fit a four-foot or less plate between the 16s after they are cut, buy a piece of lumber long enough to fit. The center short plate of both long walls must be bolted with two bolts.



• Figure 20 - Plate Installation

Since the bolts are ½", drill a ¾"hole in the plate for the bolt to fit through. If you are certain of the length to cut the 16-foot plate, cut this too while you are drilling the holes. Install the two plates and tighten them down with washers and nuts. Assuming there are two free bolts sticking up between the two 16s and the space is less than 4 feet, cut the 8

footer to size, mark the holes and tighten. Do the same on the pony wall. Now you are ready for the rafters.

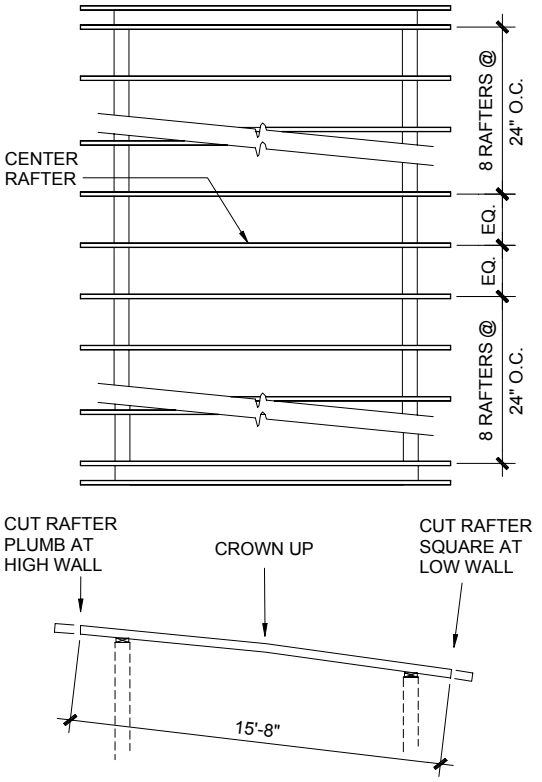
5.5.3 Rafter and Frieze Board Installation

A lot could be said of the material you just received but we will use it anyway. You should have nineteen 2 x 4's approximately sixteen feet long. Some are straighter than others, wider and thicker, too. If you have not already done so, make sure the rafters are in one piece and will not break under a load.

The first thing to do is to realize the material could have been worse. Second, put them on sawhorses, crown each one – some have two crowns due to the way they were cut – and with your pencil, clearly mark an arrow on the side of the wood pointing in the direction of the crown. If you know what a crown is, skip to the fourth paragraph.

The way to determine a crown is to hold one end of the 2 x 4 up with the end in your hand and stand with your arm extended away from you. With the 2 x on-edge (wide part of the board in a vertical position), sight down the length of the top edge of the board. No board is straight regardless the type of wood or the mill which cut it. In a curved fashion, it will either rise near the middle of piece or lower. To crown a piece of wood is to place the board on-edge so the curve in the center rises. This is the direction the large arrow will point. ALL rafters are installed on the plates with the crown pointing UP. If not, over time, the boards will sag and the roof will be sway-backed and drooping. With the crown UP, the worst thing to happen across the span is for the board to straighten itself out. The crown plays an important role in strength, for obvious reasons.

After all rafters are marked with the crown, lay them on the sawhorses side-by-side with all the arrows pointing in the same direction. Select one for a pattern and set it on the plates with the crown UP. Using a level, mark a plumb line near the end of the rafter above the high roof wall. Move it back to the sawhorses with the rafter and cut the plumb line. Make sure the line is close to the end of the board to minimize waste. From the top of the rafter cut, measure 15 feet 8 inches and make a "square cut" line. This end will lay on the low roof wall.



• Figure 21 - Rafter Layout

Using this as the template, mark all the others and cut them. Now sort them as to similar widths. As mentioned before, the widths will vary considerably. To keep the roof from looking like a roller coaster, group them as to size; narrower, medium and wider and install them in the same grouping manner starting with the narrowest (3 ½") or largest (4+") with the mediums in the middle area.

The first one is set on the 2-inch overhang of the plate on the outside of the side-wall. Measure the length of the rafter overhang of the high and low walls and get it fairly centered front to back, then nail it firmly in place. Also, secure it with 3" drywall screws driven up through the bottom of the plate into the rafter. Measure the final distance from the end of the rafter at the high wall to the plate. On the other side of the side-wall, nail another rafter in place. The two rafters on each end of the shelter sandwich the sidewalls.

Find someone who is not busy and assign him or her to finish laying ladrillo and mortar in between the two rafters. Ladrillo and mortar must be to the top of the rafters. It is suggested to use wire to wrap and hold the two rafters parallel while filling the space between them, otherwise they will spread apart from the pressure of the fresh mortar and be a problem later.

At the other end of the building, install the other two rafters in the same fashion. Next, cut sixteen frieze boards to install along with each rafter. Cut fifteen frieze boards 22½ " wide from 1" x 6" stock for the front and fifteen from 1" x 5" stock for the rear.

Because each rafter is the same length, only one end needs to be lined up, and this will be along the high wall. Run a very tight string attached to the front edge of the rafter at each

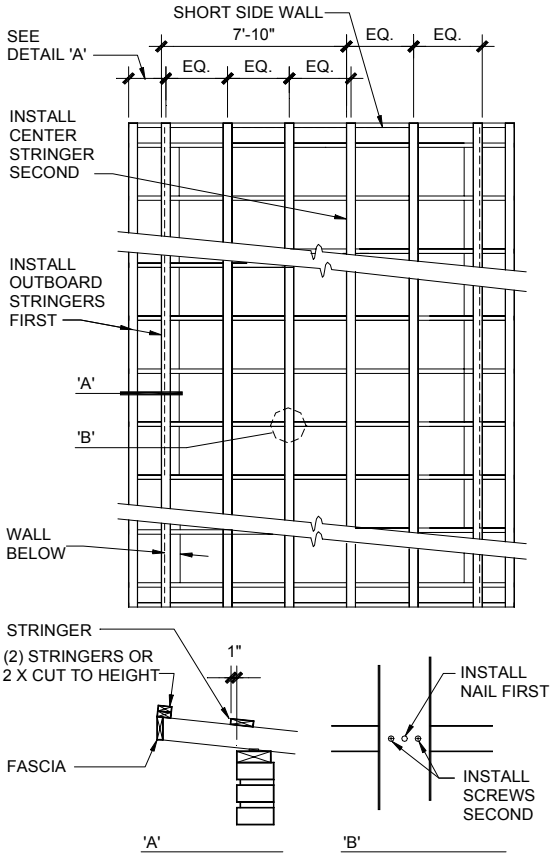
end of the shelter. The next procedure is to set the first rear wall and front wall frieze board tight against the second rafter, and using one nail tack the frieze boards in place to the plate and then set the third rafter tight against the other end of the frieze board. (Use a pipe clamp to help straighten the rafters that cannot be straightened by hand). The objective is to use the frieze board to space and brace the rafter, thereby removing any twisting of the rafter and keeping them straight/plumb. Since both hands are busy right about now, use your third hand and slide the rafter to the string (without touching it). Once the rafter is lined up, nail it to LOW/REAR wall plate only. Tack the next frieze board, align and straighten the next rafter, and nail it to the rear plate until you have a set nine of each. Go back to the other end of the first side-wall you worked on and install the rafters and frieze boards in the same fashion until you get to the ninth rafter and stop. See Figure 21 - Rafter Layout. There is one rafter left. Measure and mark the center between the two middle rafters on both plates and cut the appropriate size frieze board and install it and the rafter.

Nail all frieze boards with three nails. Now go to the inside of the shelter and nail the rafters to the front plate. The reason for waiting to nail the rafters to the front plate is selfish convenience. You are juggling the frieze board and tack nail, trying to align the rafter to the string and straightening it at the same time, pretty much like the guy at the rear wall. The string is hanging in your face and unless your neck is three feet long and your knuckles normally drag on the ground when you walk, you cannot get between the string and the wall. Once the frieze boards are nailed in place, measure, cut, and nail the four small ones to fit between the two end rafters in each corner. They should be around seven inches wide.

All rafters get a 16-penny nail **on each side to hold it to** each plate (four per rafter). After these are nailed in place, install H-3 rafter ties which further secures the rafter to the plate. This is all there is to the rafter installation. Now it is time to cut and install the fascia boards and stringers.

5.5.4 Fascia Board

The fascia is cut from the best of the dala forms. Rip enough board to nail across the high wall and short rafters into 4 to 4½ -inch widths. Before the forms can be used, they need to be cleaned to remove the dried cement from the dala pour. Using the edge of a speed square as a scraper and a hammer to pound on the boards works well. Get most of the chunks off. Any excess cement will trash a saw blade almost immediately. A chalk line works well to mark the four-inch widths for ripping.



• Figure 22 - Fascia and Stringer Layout

Cut the length of the fascia board to be installed. The piece of wood you end up with is not really straight so it has to be "walked-on" as it is nailed to the end of the rafters. Check to make sure the fascia will fit the rafters. Where the fascia meets another fascia board, they must fall half-and-half on the face of the last rafter of the first fascia, which is also the first rafter of the second fascia board for nailing purposes. To walk-on a fascia, starting from the outside rafter of the side-wall, nail the fascia to the first and second rafter, using two nails in each rafter. Apply upward or downward force as necessary to make the fascia board follow the rafters as best as possible. Nail one rafter at a time, consecutively.

What comes in real handy right about now is either a "pony" pipe clamp on a pipe 24" to 30" long or a long handled pipe wrench. If a rafter is twisted, which it most likely is, place the clamp or wrench over the top of the pipe and pull to straighten the twist. At the same time, another person can align the fascia to the third rafter by physically moving the fascia up or down to the correct position and nail (again, using two nails). Do the same with the third rafter and so on in the same manner. When this fascia is complete, start the next one and install it the same way continuing from the end of the first fascia to the other end of the shelter.

Here's a tip: to avoid splitting the ends of a fascia board when driving a nail to anchor it to the first or last rafter, partially flatten the point of the nail before driving it into the wood. (Turning the nail upside down, place the head on the plate and hit the tip with your hammer several times). Flattening the point causes the nail to act more as a punch rather than a wedge. Most every time, the nail can be driven without splitting the end/edge of the board, fascia in this case, or even a stud when toe nailing it into a plate.

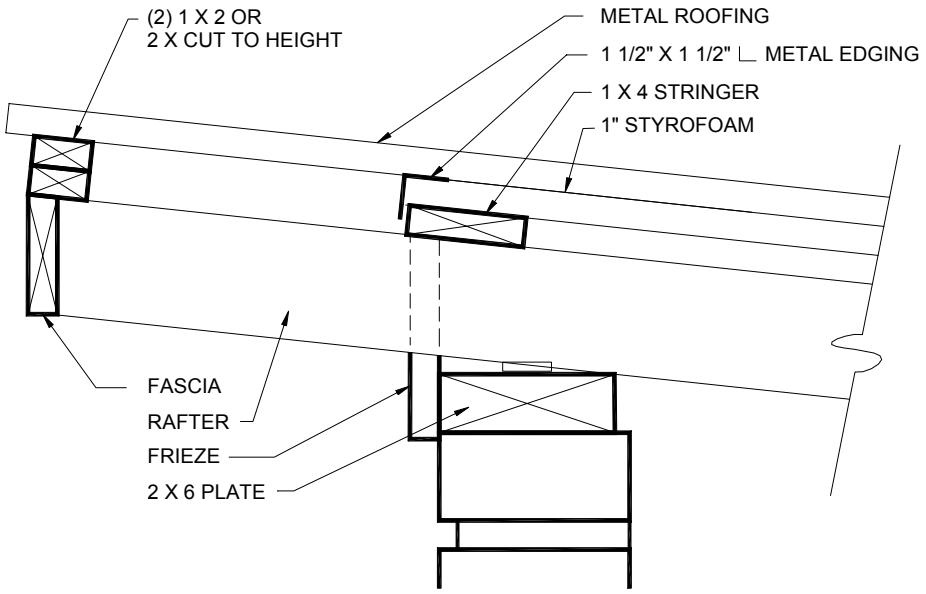
OK. You are all done with the fascia. If it is still daylight, it's time to cut and install the stringers.

5.5.5 Stringer Cutting and Installing

Stringers are nailed to the top of and perpendicular to the rafters. Essentially, a grid is being laid out to support the foam insulation and the corrugated metal roof. Here we use the rest of the dala form lumber and will probably need to buy more wood to complete the job.

Usually, the person who cut the rafters and fascia already started cutting stringers while the fascia was being installed. Rip the remainder of the 8-inch wide dala forms lengthwise. They should end up around 3 ¾" wide.

Cut one stringer lengthwise into two 1"x2"s. These will be fastened on top of each other and fastened to the top of the fascia and rafters, perpendicular to the rafters. The first (outside) stringer will be 1½ to 2 inches high after it is fastened. See Figure 23 - Fascia and Metal Edging



• Figure 23 - Fascia and Metal Edging

Flush the outside edge of the stringer to the outside face of the fascia and nail it to both the rafters and the fascia. Only one nail is used over the rafters and is placed in the middle stringer where it crosses the rafter. The stringer must be installed the entire length of the roof. We will be walking on these, so for strength, join all stringers on top of a rafter, wherever they come together, end to end. Use the same technique to install the length of stringers on the rafters and fascia along the low wall.

The next stringer is located only a few inches away and is used primarily to help seal the shelter from weather when the frieze boards are installed. See Figure 22 - Fascia and Stringer Layout, to show the proper layout of the stringers. On the top of both end rafters, make a mark plumb to the outside edge of the top plate. Next measure one inch from this line toward the fascia and make a new mark. Using a chalk line at the new mark, "snap" a

line on top of all the rest of the rafters. This is done on both high and low wall rafters. The outside edge of the next stringer lies on this chalk line, which is essentially 1 inch outside the edge of the plate and the face of the wall.

Four lines of stringers should be in place now. The next stringer to install is the center one. The Styrofoam is 2 feet wide and 8 feet long. From the outside edge of the second stringer of the high wall, measure and mark toward the center of the two end rafters 7'10" and snap a chalk line from end to end marking the top of all rafters. This chalk line is the high edge of the middle stringer. The location of this stringer is important since it provides support for where the two foam pieces fit together in the middle of the rafter.

With a long stringer and starting from one end nail it to both rafters which sandwich the side-wall. As you did on the first and second stringers, use only one nail for each rafter. Since a 24-inch distance between rafters was laid out on the plates, the same layout must be maintained, lengthwise, through the center of the shelter. Because the rafters are somewhat twisted and/or bowed, they should align under the center stringer in the location relative to the plate. To determine the proper location of each rafter as they cross under the center stringer, mark the stringer with same rafter layout you did for the plates. Again using one nail, physically push or pull the middle of the rafter to align with the layout AND the chalk line, then nail in place.

The next stringers are somewhat easier to locate. Evenly divide the distance between the center stringer and the ones over the frieze boards and install two more rows on the wide side, and one more row on the narrow side. The final product will be a grid layout of approximately 24-inch squares. Avoid having two stringer joints adjacent on the same rafter, as this will weaken the overall roof structure.

While the wood in this region is of poor quality, it gets even worse as is dries out. Since nails loosen and pull out, screws are used to hold the stringers to the rafters. Use two drywall screws 2½" long to attach the stringer at each rafter for the wide stringers, and one screw for the narrow stringers. Once the screws are in place, it is time to install the Styrofoam and metal roofing.

5.5.6 Caulking the frieze boards

Despite your best efforts in custom fitting and installing the frieze boards, there will likely be some large (1/4" or greater) gaps between the frieze boards and the surrounding rafters. Assign a team of 2 or 3 workers to start caulking around each of the frieze boards from the inside of the shelter. This can easily consume 20 or more tubes of caulk. Try to fill the gaps as best as you can, as this will have a large bearing on how warm the shelter will stay in the winter. It will also be very helpful for keeping the cold drafts out with the frequent winds in Agua Prieta. This is easier to do before the roofing material is on, so get started early before the roof foam and metal are installed. Once the roof is installed it's a little more difficult working up in the small space available around the frieze boards.

5.5.7 Installing the foam and roofing metal

Two types of Styrofoam insulation sheets are available for the roof system. Both are 1" thick. One type comes 4' x 8' with standard straight edges and the other comes 2' x 8' with tongue and groove along the 8' edge. The preferred type is the 2' x 8' because they are easier to handle in the wind, easier to manage and set, and the tongue and groove helps hold the edges together for a consistent and sturdy fit.

Styrofoam sheets are very fragile. We will discuss the wind issue at the end of this section. Imagine holding a potato chip out the window of the car traveling 60 miles an hour and keeping it from cracking or breaking, while keeping the rest of the chips in the bag with the convertible top down, *while you are driving*.

Both the metal and Styrofoam are set at the same time. The 2' x 8' Styrofoam will come stacked in a bundle and wrapped in plastic. You will need two bundles and you will use 34 pieces. It is strongly advised that you **do not** remove the plastic covering, as the covering does a good job of keeping the pieces, particularly in the wind. It is always handled in the bundle form. The metal is corrugated or contoured and come in pieces about 26" by 16 feet long. You'll need about 18 pieces of metal. The edges of the metal sheets can be quite sharp and should always be handled with gloves. They are also surprisingly heavy and should generally be handled one at a time.

The first step is to place the metal and the Styrofoam on the roof. If these are not placed properly so you can grab each piece conveniently, the rest of the operation will probably resemble a poorly planned fire drill in a mud-wrestling arena. Remember, you are standing and stepping on the rafters and stringers.

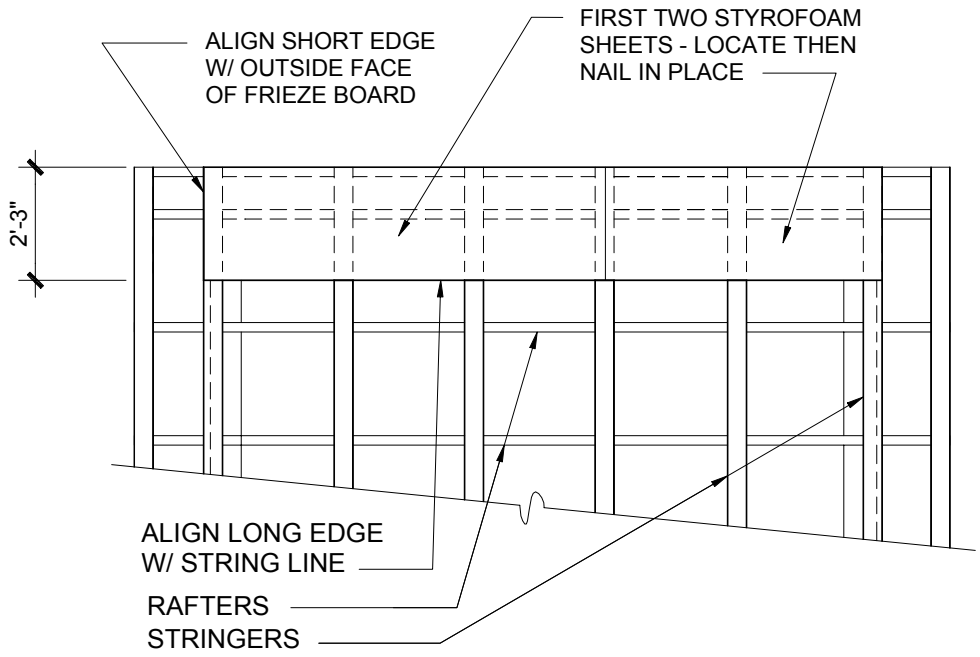
On a calm day tacking down the roofing will take 1 ½ to 2 hours. If the wind is not blowing yet, one can assume that it could start blowing before the job is finished. The prevailing winds in Agua Prieta come from the south. If the length of the shelter is south to north, it is suggested that the roofing be put installed from north to south. If the wind is perpendicular to the length of the shelter and blowing strong, it's going to be tough.

Warning: If the wind is blowing, never attempt to pick up a sheet of the metal sheeting or Styrofoam off the roof more than a few inches. Hold onto it TIGHTLY. If the wind catches the metal, anyone down wind may be seriously injured.

Let's assume there is no wind and you will start on the north end of the shelter. Carefully pass the corrugated roofing to others on the roof. Neatly stack 9 sheets near the center of the roof and the other 9 about three feet from the south end of the roof. Next, pass up a bundle of Styrofoam and place it in the three-foot space near the south end of the roof. Pass up the second bundle and place it just south of the metal sheets stacked in the center of the roof.

Next, pass up four 1 x 8s or similar material to use as weights on top of the Styrofoam bundles in case the wind picks up. (Also, if a dust devil comes by, everyone available should spread-eagle over the materials to keep the materials from being damaged. If you are familiar with the desert, these can come in a moment's notice. If you are new to the desert, think of it as a memory in the making.)

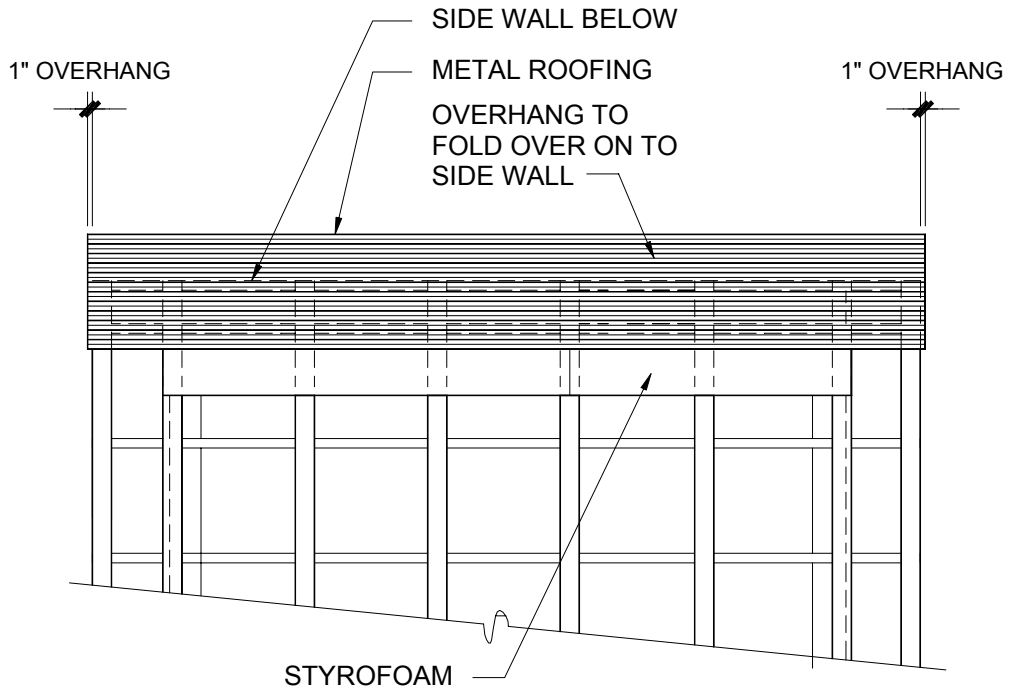
Measure 24 inches in from the end of both long wall fascia stringers and snap a chalk line across the stringers, parallel to the side-wall. This line is used to set the first two Styrofoam pieces. See Figure 24 - Styrofoam Placement. Place the first piece flush to the outside face of the second stringer of the high wall with tongues facing the side wall/edge of the roof. Butt the next piece end to end. It will overhang the rear fascia about 2 feet. It is best to measure and pre-cut the second piece of foam before it is installed. Cutting it ½" to ¾" short is recommended to ensure a good fit. Since the stringer that is located under the butt joint of the two foam pieces is 4 inches wide, there is some room to adjust the fit. The second sheet of foam should be placed to be even with the outside edge of the second stringer from the low wall. Any gap should be made up or provided for where the two foam pieces butt together over the middle stringer. Making sure the first one is still flush, both are still aligned on the chalk line, and the tongues are facing the edge of the roof, use several 8-penny nails and nail the Styrofoam in place so it won't slip around. No other Styrofoam pieces need to be nailed beyond these first two pieces.



• Figure 24 - Styrofoam Placement

Note: The Styrofoam will not bear any weight. If you need to support yourself by putting your hand on the Styrofoam, make sure your hand is placed where a stringer passes under the Styrofoam. Should a piece of Styrofoam break beyond repair, replace it with a new one. If you know you won't have an extra, carefully repair/replace the broken section and doctor it the best you can. If you fit it the best you can, in most cases it will stay-put after the others are set. Also, it is suggested that the person that broke the piece not be heckled because one of two things seem to always occur. The person feels bad, gets down from the roof and leaves you one person short. Or very soon, you will be the next to put your own hand through a Styrofoam sheet. It's some kind of rule of averages. You will see.

Similar to setting the first two Styrofoam pieces, the first metal sheet also sets the reference for aligning the remaining roof materials. See Figure 25 - Metal Over Styrofoam. After nailing the two Styrofoam pieces in place, move a metal sheet onto the Styrofoam. The metal sheet will overhang 1 inch. This overhang makes a nice finished edge and helps protect the fascia from the elements. The rafters were cut to 15 feet 8 inches long based on the metal sheets being 16 feet long. Given the fascia on both long walls are 1 inch thick, the metal will overhang the front and rear fascia 1 inch.



• Figure 25 - Metal Over Styrofoam

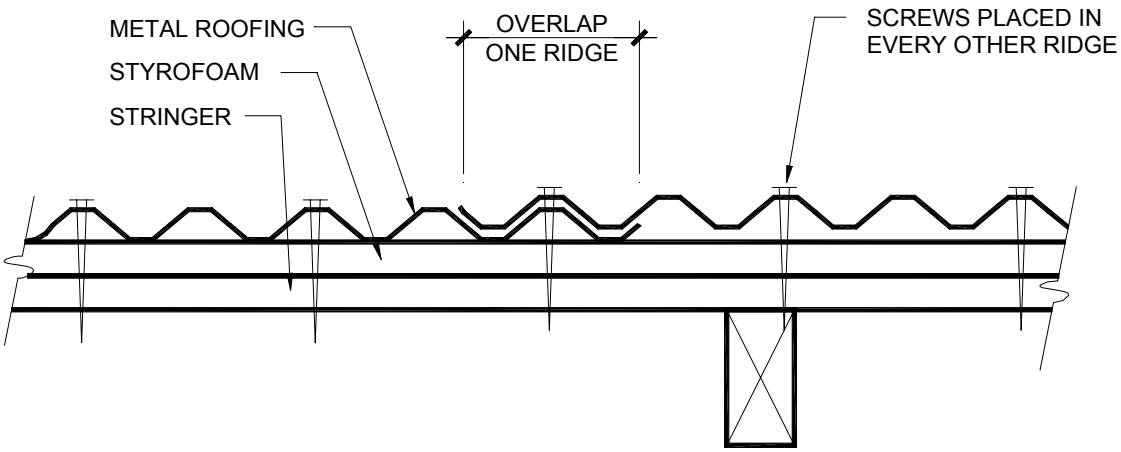
The first metal sheet has to be rolled-over over the end rafter of the shelter and fastened to the end rafter to protect the end of front and rear plates and to create a reasonable seal for the side of the shelter. How far the edge of the sheet rolls over is not critical, but it must remain straight, evenly rolled, and cover at least the end of the plates plus a few inches.

With builders on top of the roof holding down the main portion of the sheet, “test roll” the sheet over the edge. Remember to keep the sheet straight. It is helpful to use the outside edge of the two Styrofoam sheets as a guide/reference.

Once you have it properly positioned, release the rolled-over edge. Use galvanized deck screws with washers and screw-down the top of the sheet to all the stringers along the edge of the roof. The metal sheet tends to buckle a bit when it is finally rolled-over, therefore the entire sheet should be screwed down before setting the second sheet. A screw is placed through every other ridge of the metal sheet. DO NOT PUT A SCREW THROUGH THE LAST RIDGE OF THIS FIRST SHEET until the second sheet is in place.

The washers used with the screws are special. They are metal on one side and rubber on the other. Approximately a thousand will be used. If they are not already pre-assembled for you, have some of the kids (or builders acting like kids) install the washers on the screws ahead of time.

One of two types of metal sheeting is used, either conventional corrugated sheeting or contoured sheeting (see sketch below). Screws are drilled through the ridge (highest point of the rib). If the screws are placed in the valley of the corrugation, rainwater will eventually leak through under the screw and washer. The best way to install screws is with battery-powered screwdrivers. The screws have a very sharp tip that makes it fairly easy to start them. Put pressure on the screw and it should puncture the sheeting after a few revolutions. If the screw is stubborn, use a hammer to tap the screw to start a hole for it.



• Figure 26 - Roofing Material Overlap

Once the sheet is screwed down to the stringers, roll the sheet back over the end rafter. It may take several builders to hold it in place. Using the same type screws, screw the sheet to the side of the end rafter. Instead of screwing through the ridge (as you did on the top of the roof) run the screw through the valley of the metal sheet along the side of the rafter. From the middle, work in both directions and fasten the sheet to the side of the rafter every 12" while checking the roll-over along the way. The Styrofoam does not get placed on the side of the rafter where the metal sheet is rolled over.

After this sheet is screwed down, place the second sheet into position. See Figure 26 - Roofing Material Overlap. Overhang the fascia one-inch and overlap the first sheet just one ridge. If you are satisfied that it is set properly, run a screw through the overlapped ridge. Do your best to place the screw in the middle of the underlying stringer. Once the stringers are completely covered, the screws will be your only guide to their location for the placing of additional screws. You will be going through two layers of metal at this point, so it may be a bit tougher to get the screws in. Install screws in every stringer along the overlapped ridge.

By now you should have enough room on the roof for at least four builders. Two will be CAREFULLY walking on the stringers and rafters maneuvering Styrofoam and metal sheets in place, while two will hold the unscrewed side of the sheeting off the stringers so Styrofoam can be set. These two will also be screwing in deck screws as necessary.

The next step is to install the next two sheets of Styrofoam. Holding the side of the metal sheet up off the stringers, the two walking on the stringers can set the Styrofoam nearly in place. All four on the roof will probably need to assist in inserting the tongue into the grooves of the first two sheets. Make sure that one is flush to the front fascia and both are butted together end to end.

Next, lay the third metal sheet down on the Styrofoam, count every other ridge and place a screw about in the middle of the sheet aligned with every stringer. Every other ridge eventually gets screwed down, but you can come back after all the sheets are set and finish them. Placing one in every stringer along the same ridge assures a good alignment for the remaining screws when they are installed in the other ridges.

Continue setting Styrofoam and metal until you get near the other end of the roof. The last sheets of Styrofoam will need to be cut to fit flush to the edge of the roof. A sharp knife with a serrated edge works well to cut the Styrofoam. Measuring to fit and cutting them

before setting them works best. Measure the distance to the edge of the roof, mark the Styrofoam, snap a chalk line on the Styrofoam sheet, cut, and set.

When setting the last sheet of metal remember to account for the "roll-over" to cover the rafter and the ends of the plates. It is better to roll over too far than not far enough. Once you figure there is sufficient metal to roll over, overlap with the closest ridge and fasten the entire sheet to the stringers. Lastly, roll the sheet over the side and fasten, starting in the middle of the sheet, like you did the first sheet.

This operation will take about 1½ to 2 hours if the winds are calm. If other builders have not yet started, you can go back and start screwing down the rest of the roof. Seal any places where screws missed stringers and are not tight, or screw holes are empty with siliconized caulk.

There's a good chance you will encounter wind during this operation. Not paying attention to the wind and wind gusts can result in damaged materials and possible injury.
Here are a few hints should have to install a roof in the wind.

The procedure to install the material will not change, but you will need more help on the roof. Be careful getting the metal sheeting up there and remember to stack it carefully on top each other. You don't want the wind catching a corner of it. If stacked well, the metal should stay put provided you keep it in a low profile, **never lifting it more than a few inches above the roof to slide a sheet in place**.

The Styrofoam, on the other hand, can be a major challenge. Remember to leave the bundle wrapped in the plastic wrapper. Make a slit in the long side of the plastic covering so only a few pieces can be removed at a time. This way if the wind picks up during the roofing operation, the slit can be turned down wind, weight can be placed on top of the bundle and the bundle will not be jeopardized. Remember to have several heavy boards on the roof and handy should you need to weight the bundle down. If it is blowing fairly hard, you may want to have someone constantly holding down the bundle.

Before the side of the metal is lifted to slide the Styrofoam under it, it is suggested that a few additional screws be put in place to assure it will not get out of control. Here comes the fun part. About the only way to get the Styrofoam from the bundle to under the metal sheet is to sandwich <u>two</u> pieces of Styrofoam at once between two fairly wide boards that are about seven feet long. Using the bundle for a shield from the wind, set one board on the stringers down wind of the bundle. Two builders together <u>carefully</u> remove two sheets of Styrofoam at once. Keep them pressed together and hold them down on the sandwich board you laid across the stringers. Move the other sandwich board on top of the two Styrofoam sheets. Now carefully <u>slide</u> the sandwich toward the metal sheet. Ever so slightly, lift the side of the sheet up and slide the Styrofoam sheets under the metal sheet. Keeping the metal sheet close to the roof helps control the Styrofoam and minimizes the amount of wind that can get under it. Working both sheets almost simultaneously, insert the tongue into the groove, flush to the front fascia, butt the ends, lower the metal sheet tight to the roof and run a few screws in it to keep it from lifting. This is fairly difficult with the 2 foot wide sheets, with the 4 foot wide sheets it's nearly impossible. Any Styrofoam extending more than 12-inches from the underside of the metal sheeting (before the next sheet can be set) should be physically held until the next metal sheet is put in place. The wind has snapped little extrusions like these and sent them north to never to be seen again.

After the metal and Styrofoam has been put in place, it is time to install the metal edging to protect the exposed edge of the Styrofoam from the birds. The edging is installed as indicated in Figure 23 - Fascia and Metal Edging. It is secured in place with #4 galvanized

nails approximately every 3 to 4 feet. Take care not to drive the nails too deep or the edging will be dimpled.

Don't let the wind deter you from installing the roof. It just takes a little longer to complete the job. If you take your time and work with the wind, you should be successful in completing the roof job. The opportunities to roof in dead air space are few, so don't waste a lot of time waiting around for them. A little common sense goes a long way here, if your hats are blowing off it may be time to call things off and wait for a better day.

5.5.8 Installing insulation against the frieze boards

After the roofing material is installed and the frieze boards have been caulked as best you can, insulation is stuffed in to the openings behind the frieze boards on both sides of the shelter. 24" wide rolled insulation cut in to 12" long pieces works well. When stuffed in to the frieze board area it helps make a reasonable air seal, especially where the air gaps were too large to effectively caulk around. Using a scrap piece of lumber as a straight edge to compress the insulation works well when cutting the rolled insulation with a utility knife.

5.6 Finishing the Window Installation

Tools required:

- Trowel
- Hammer
- Level
- Caulking gun
- Straight edge razor blades
- Chisel
- Wheelbarrow
- Mixer (or mix in the wheelbarrow)

Materials required:

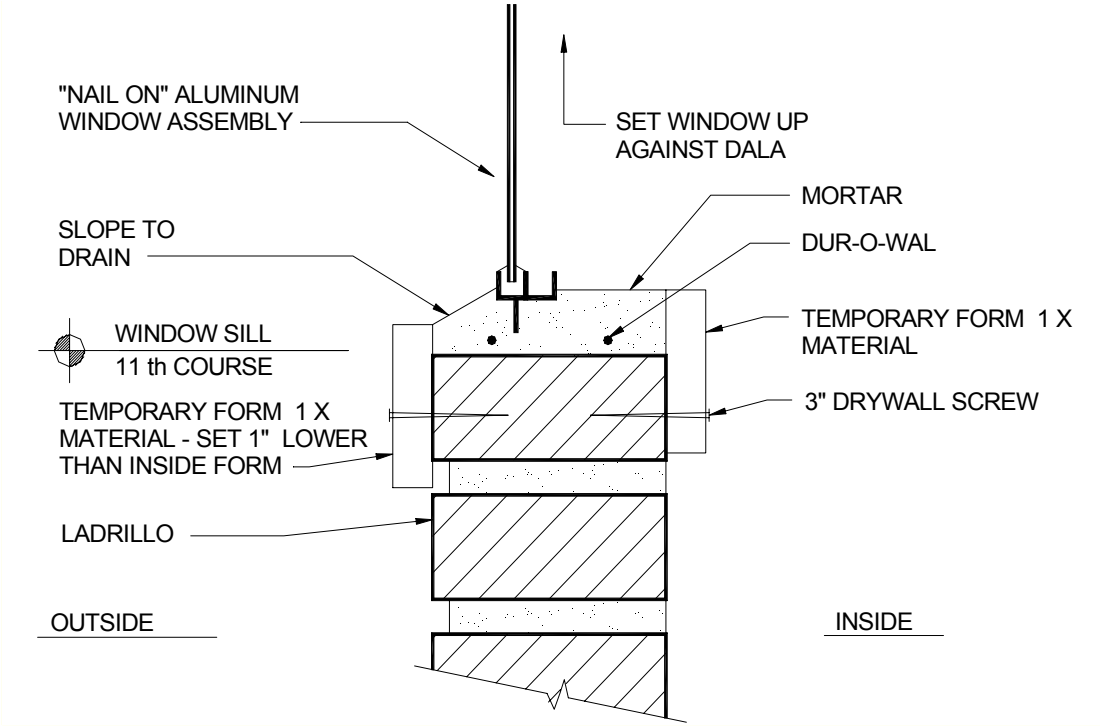
- 1 bag of mortar mix
- Mortar sand
- Several tubes of caulk
- Scrap 2x4 lumber
- 3" drywall screws or nails
- Windex/paper towels

5.6.1 Building the windowsills

The inside windowsill is built flat to provide a surface to set things near the window. The outside windowsill is sloped at 45 degrees so rainwater will run off quickly.

The inside sill is built using a simple form. Find a relatively straight scrap of lumber, a 1"x2" or 2"x4" and about 6" longer than the window opening is wide. Use nails or drywall screws to secure this to the ladrillo so the top edge is flush with the bottom of the window frame. See Figure 27 - Windowsill Form. Place a second form on the outside of the wall approximately one inch lower than the form on the inside.

Mix up a batch of mortar. Take a bucket or can of water and thoroughly douse the ladrillo under the window to allow the mortar to stick.



• Figure 27 - Windowsill Form

Use a trowel to fill the inside cavity made by the form and work the mortar to make a smooth windowsill. Try to keep mortar out of the sliding track the window slides in, as it will have to be cleaned out later. Use a trowel to form the mortar to approximately a 45-degree slope from the window frame down to the edge of the outside form.

The mortar may crack as it dries. Depending on the temperature and humidity you may need to apply some water to the mortar to slow the drying process, or rework the mortar some to fill in any cracks that may appear. After it has set for at least an hour the forms can be removed. Any rough edges should be smoothed out at this time.

5.6.2 Caulking

Thoroughly clean the edges of the window frame on the inside and outside. Apply a small bead of caulk on all 4 sides of the window, both inside and out, and carefully smooth it out with your finger for a good seal and nice look.

5.6.3 Cleaning and screen installation

It's amazing what a difference clean windows can make as the shelter nears completion. Use glass cleaner and paper towels to thoroughly clean the windows inside and out. A single edged razor blade may be required if gummed labels are on the window. Clean the screens if necessary and carefully re-install.

5.7 Installing the Doors

Tools required:

- ¼" masonry bit (to drill stem for threshold)
- ¾" and 1" wood chisel (if needed for door hardware)
- ¾" deep socket and ratchet (for J-bolt nuts)
- ¾" spade bit (for J-bolt holes in buck boards)
- 1" spade bit (for knob set bolt hole, if necessary)
- 1 ½" spade bit (for countersinking buck board J-bolt washers)
- Battery powered drill
- Caulk gun
- Chalk line or 7-foot straight edge (to cut down door buck boards)
- Circular saw
- Combo hole saw set for door knob hole
- Four-foot level
- Hacksaw and several blades (if no power available)
- Heavy-duty electric drill
- Masonry chisel
- Nail or framing hammer
- Pencil
- Phillips screwdriver
- Phillips screwdriver bit for drill
- Sawhorses
- Sawsall (with wood and metal cutting blades)
- Speed square
- Tape measure
- Utility knife

Materials required:

- ½ lbs. 1½" drywall screws
- ½ lbs. 2" drywall screws
- 2" x 6" material (straight) two 41" four 84"
- 6 (green) plastic hole-insert anchors for fastening threshold to stem
- All-weather caulk
- Four packages of wood shims
- Nuts and 1½" washers for ½" J-bolts
- One dozen 3" drywall screws
- Six (small screw hole for #8 screws) hinges
- Two 36" wide solid-core wood doors
- Two keyed-alike security door knob sets
- Two sets of interior screw-on metal frames
- Two sets of metal frame trim
- Two thresholds (two piece - smooth metal surface bolted to the stem wall, adjustable under-the-door sweep. Combined height before adjustment not to exceed 1 ¾".)

5.7.1 Hanging the Doors

This can be a rather simple operation depending on how careful you or the builders before you were in laying the ladrillo to the doorway opening. We have found doorway openings in about every imaginable condition. The best openings are built by builders who have had to install doors and frames in previous shelters. Often builders finish the shell and leave before experiencing the consequences that result from out-of-plumb, under- or oversized openings; sloppy or improper J-bolt placement, etc.

Having experienced door hanging, the piece of advice most useful to anyone building a shelter is to take your time on the openings to be sure they are plumb and the width is consistent. If you end up hanging doors on the shelter you or some else built and the opening was NOT built with care, you will be reminded of this advice again.

The mistakes made with door openings as well as with window openings will be discussed at the end this section because it will provide some suggestions on how to adapt to mistakes while overcoming the desire to wring someone's neck. I imagine more text will be written discussing corrective measures than actual door and frame installation in a properly built opening.

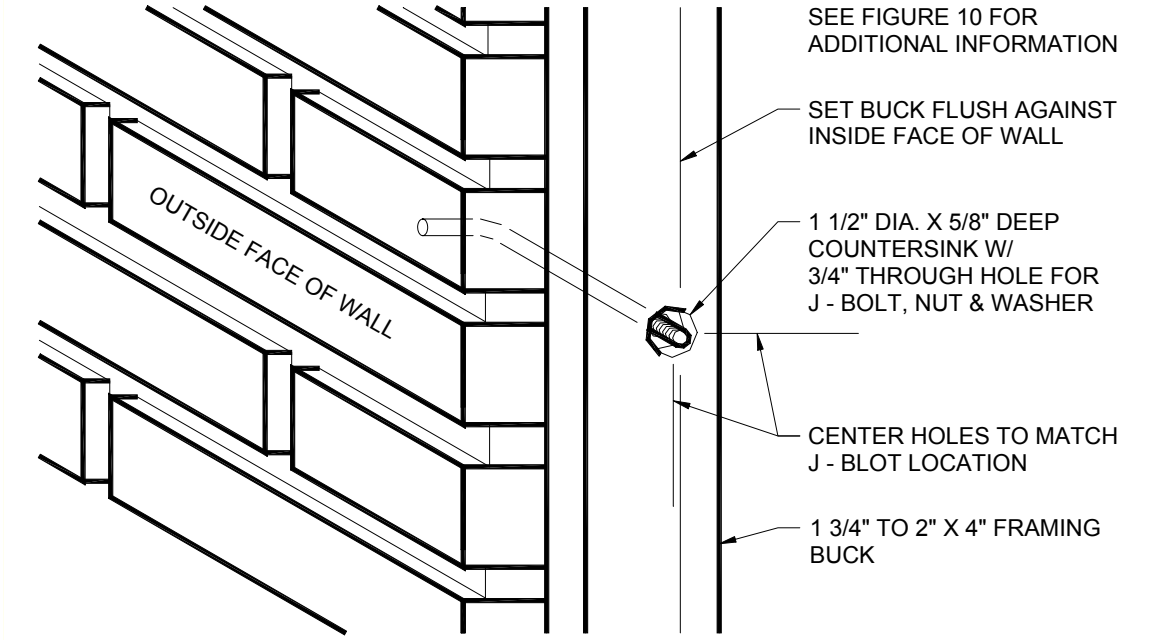
In an effort to compensate for the poor quality of wood materials available and the ladrillo being very porous and unstable, we have attempted several techniques in installing doors. Most techniques we tried worked OK, but some took too much time relative to the quality of the end product in terms of how long the installation will weather against the elements and extraneous use. We also have to remember regular maintenance by the shelter owner will probably not occur due to the lack of tools, materials and know how.

Through our most recent experience, we found using solid core 36" x 80" wood doors, 4-inch metal interior frames with snap-on trim, and smooth metal thresholds with bottom door sweeps work best in terms of cost, speed of installation, and durability. This type of door and frame will likely be waiting for you thanks to the many contributions and donations made by the Tucson building industry.

Let's assume the door opening is reasonably plumb, close to 41 inches wide and the J-bolts are placed properly. The height of the opening should be close to 84 inches. The bucks or wood framing inside the opening is bolted on first. The board thickness will be anywhere form 1 ½" to 2" thick. Select the boards you want to use. Determine the header board to be used and set it aside. Measure the opening height at each side, deduct the thickness of the header and deduct another 1/8 inch. Mark and cut a board for either side. Rip the board to 3 7/8" wide.

5.7.2 Installing the Buckboards and Header

The buck is installed flush with the inside wall. See Figure 28 - Buckboard Installation. Mark the J-bolt locations on the buck (measuring from the inside of the wall). Drill a 1 ½" hole to countersink the washer and nut of the J-bolt, approximately 5/8" deep. Next, drill a ¾" hole the rest of the way through for the J-bolt. Clean the J-bolt threads, fit the buck over the J-bolts, install the washers, and tighten the nuts. Double check for plumb, and shim as necessary. Repeat the same procedure for the other side of the opening. Next, measure the header, cut to fit (on top of the side bucks), and toenail through the inside and outside edges of the side bucks and fasten the header in place using 3 inch long drywall screws.

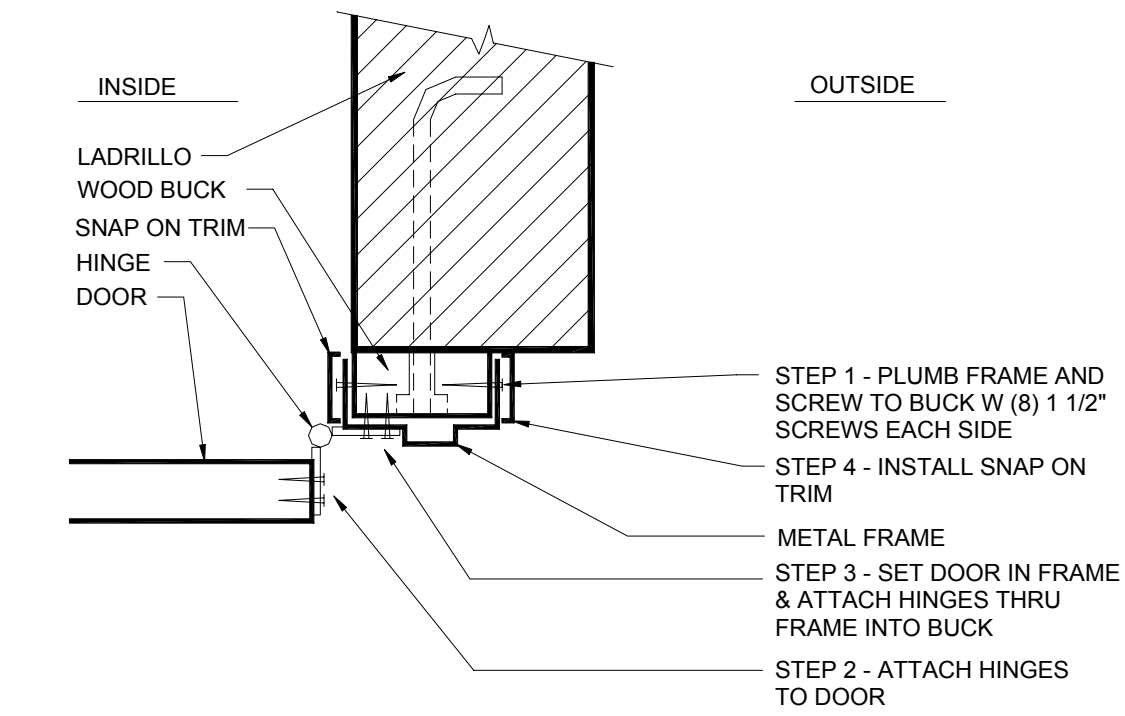


• Figure 28 - Buckboard Installation

5.7.3 Installing the Metal Frame

The metal frames come in three pieces. Make sure they match. Lay the door on sawhorses. If hinge pockets are already cut in the door, align them with the pockets in the frame. The total height of the door should be 80 inches. If necessary cut the frame so it is about 1/8" longer at the top and 1 ¾" to 2" longer at the bottom (depending on the threshold and door sweep thickness). If there are metal clips attached to the backside of the hinge pockets of the frame, remove and discard them. The clips are for machine screws and will not be used. Next, align the strike plate part of the frame with the door's bolt hole, if one has already been cut, and adjust the frame the same as the hinge side.

Next, install the hinged side of the frame by setting the frame piece on the stem wall in the opening and sandwiching the buckboard. See Figure 29 - Door Frame Installation. Plumb the frame piece and temporarily screw it to the buck through the outside face of the frame flange with three evenly spaced 1 ½" drywall screws on the inside and outside. Put the header in place using a few screws for now. Install the hinges on the door usually using #10 or #12 wood screws which ever fits the hinges you are using. Then, holding the door in place and the hinges in the frame pockets, using #10 or #12 - 1 ¼" long wood screws, fasten the hinges by running the screws through the holes in the hinge pockets of the metal frame and into the wood buck. Be careful not to tweak the metal frame by running the screws to tight.



• Figure 29 - Door Frame Installation

Next, install the other side of the frame. Set it on the stem wall, fit it over the buck, and check for alignment with the strike hole in the door and spacing between the edge of the door. Adjust either or both of the frame pieces as necessary to relatively center the door in the opening. Once confident the door functions and the clearances will accommodate normal swelling and shrinking due to weather, AND there is sufficient clearance for the threshold and sweep on the bottom, screw all three pieces of the frame firmly in place and install the snap-on metal trim.

The threshold and the sweep are next. Assuming the stem wall blocks were placed level and grouted good and solid, mark and cut the threshold to fit. Mark the stem block for drilling the screw holes to hold it down. ¼" holes work well and using the green plastic anchors in the holes are sufficient. Install the sweep under the door.

5.7.4 Finishing Up

The last thing to do after the doors are installed is caulk the gap between the buckboards and the ladrillo wall opening on both sides and the top. Insulation can also be tucked in the space. Install the knob and strike hardware and you are done.

Door installation is very labor intensive. It is recommended to plan a day with two people working on two doors. Really, no more than four people (two on each) can install the doors unless there is a person assigned to monitor, make coffee, run for donuts and otherwise just hang out. If you are so lucky to have this extra person or two, give him the Windex, paper towels and caulking guns and have him clean and trim the windows. When he finishes, have him clean and rake the floor of the shelter.

We tend to spend the fall months finishing units started by others during the spring and summer in an effort to house the families patiently waiting to move in. We have completed roofs and other things but primarily the doors need installing. The following are examples

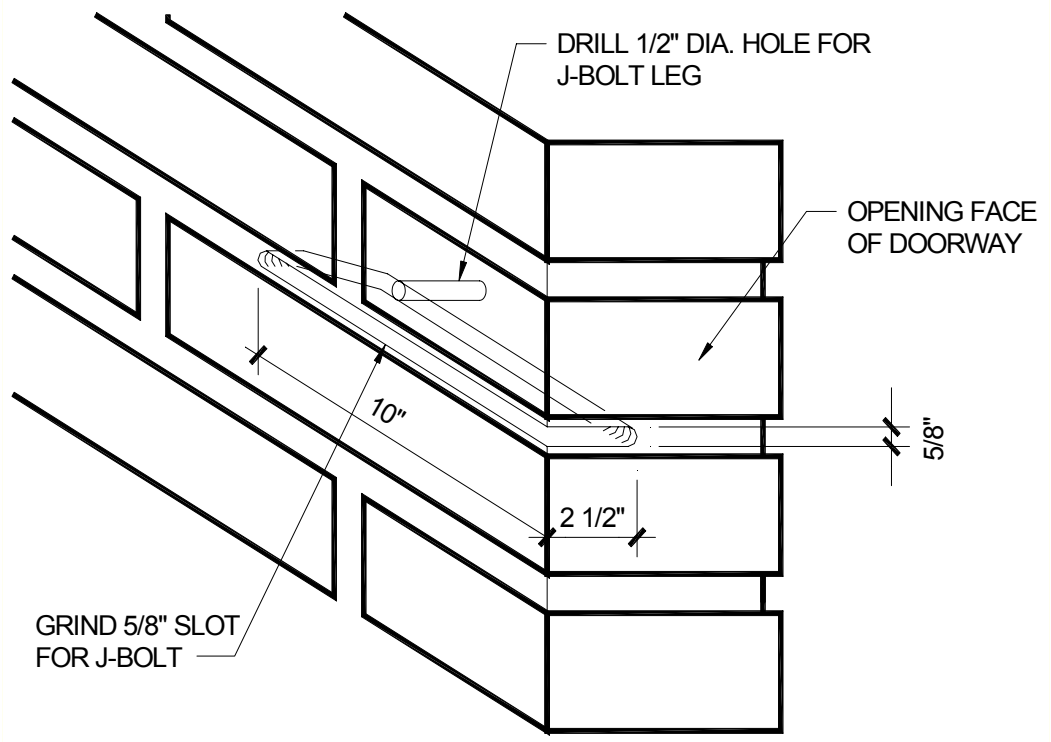
of what we've encountered: wavy or slanted doorway openings, out of plumb to the interior, exterior and even into the opening, i.e. 37" to 43" top to bottom, missing mortar joints, missing J-bolts (now this is scary), misplaced J-bolts (either sticking out too far, in too far, too close to the outside face of the wall to hold a buckboard, stem wall block broken out at the threshold, stem wall block not level at the threshold, damaged J-bolt threads and minor things too many to mention.

If a doorway is wavy or slants into the doorway opening to the extent the bucks cannot be installed and accommodate the metal frame, the ladrillo need to be cut. Depending how far out of alignment the opening is, this is not quite as tough a job as it may sound. Always carrying a saws-all with us has been a great help. The ladrillo are rather soft and can be cut easily. Scribe a line and cut the excess ladrillo away. Sometimes small rocks get into the ladrillo while it is being made and will kill a blade in no time. In the worst case, several blades get used.

5.7.5 J-Bolt Problems

With missing mortar joints, mix up a bit of mortar and pack the void well. If a J-bolt is involved with the missing mortar, just be careful not to jeopardize whatever hold the bolt has. If the J-bolt hold must be compromised, use Quick Drying Anchor Cement and pack the J-bolt in place and let dry, usually 10 minutes or so. And, for the scary part, where there are no J-bolts or several are missing – NEVER drill into the ladrillo in an attempt to set a shield and lag bolt. The ladrillo is much too porous to hold any number of shields tight. There is hope though. To install missing J-bolts, locate where they should have been placed and using a grinder (at least a 4") remove 5/8" of the mortar from the center of the joint of the inside wall. See Figure 30 - J-Bolt Fix-up. The mortar is hard, several sparks will fly and dust will cover you and anything near the opening.

We mentioned the normal setting of a J-bolt is 1 ¾" to 2" from the inside face of the wall. You need to grind about 2 ½" into the joint and at least 10 inches back from the opening. Set the J-bolt in the slot you cut and leave it sticking out into the doorway opening 2 inches. Mark a reference point in the joint where the J-bend occurs. Drill a hole further into the joint with a ½" bit for the J-bend to fit into. Lay the bolt back in the joint with the bend inserted in the ½" hole and pack the joint with the Quick Drying Anchor Cement.



• Figure 30 - J-Bolt Fix-up

Another technique, which is a judgment call on your part, is to grind a ½" slot in the ladrillo instead of the mortar joint, drill the ½" hole, insert the bolt and pack with Quick Dry. This often works well, but since the ladrillo is so porous, it can fracture under the pressure of tightening the nut against the buck. If this happens, the bolt cannot be tightened or used.

If the J-bolt is located too far to the outside face of the wall to hold the buck, cut it off. Then follow the procedure above to reinstall a new bolt.

If the stem wall block is broken out and a threshold cannot be secured properly, form the broken opening after the door is hung and pour it full of concrete. On a return trip, the threshold can be set.

5.7.6 Caulking Around the Door Frames

Generally there will be some rather large gaps between the door frame material and the adjacent ladrillo. When the door installation is complete, grab a box of caulk and a caulk gun and have at it. If the door frame was well built it will only take a few tubes of caulk to seal around it, if not, it may take several tubes. Stuff some insulation or rocks in to any particularly large openings before applying the caulk. This will seal the opening better and save some caulk. A good seal around the door frame will be greatly appreciated by the owners when the cold winds come in the winter.

NOTES

NOTES

6 Glossary

24-inch Centers – A method of laying out boards (in this case rafters) so the distance from the center of one board to the center of the next board is 24 inches. This method insures the joints of the roofing material, which comes in two or four-foot sizes, will occur in the middle of a rafter and be hidden when looking up at the ceiling inside the structure.

3-4-5 Right Triangle Method – A method of obtaining a square corner. If a triangle is laid out with sides of length 3 ft, 4ft, and 5ft, the angle between the 3 foot and 4 foot sides will be 90 degrees (square). Multiples of this will also work, such as 6 ft, 8ft and 10ft. The longer the sides used, the smaller the resulting error of the 90-degree angle. This can be done by measuring 3 ft along one edge of the footing, 4 ft along the adjacent edge and using a 5-foot string to connect the two ends. Another ratio that works is 5, 12 and 13.

Adobe – See ladrillos

Agua Prieta – A city of approximately 150,000 people in the state of Sonora, Mexico. It is directly south of Douglas, Arizona.

Buck-Boards – Vertical boards used to hold a door in place.

Block Line – String used to provide a reference height for setting the ladrillo in mortar. The string usually comes in several colors and is quite strong. It must be strung very tight to prevent sagging in the middle of the wall.

Bond Beam – A reinforced concrete beam providing strength to a structure. In the Agua Prieta shelters, this is a horizontal beam that goes around the perimeter of the shelter on top of the 20th course of ladrillo. The bond beam also serves as the lintels for the doors and windows in the shelter. In Spanish this is referred to as the 'dala'

Builder's Level – (Also referred to as a transit.) This is an optical instrument allowing you to accurately determine the elevation of items at the building site. This is a critical tool when initially determining the elevations at the site and setting the proper depth of the footing and stem wall.

Castillo – Reinforcing steel used in the construction of the dala. It consists of heavy gauge wire formed in to a cage, which is cut to length and placed on top of the 20th course of ladrillo before the dala forms are put in place.

Caulk – Silicon or latex based sealant used to seal around the door frames, windows, and frieze boards (and any place else it's needed)

Caulking Gun – Tool for dispensing the caulk from tubes.

C-Clamp – Clamping tool used to firmly hold together the window frame guides as a single piece.

Cleat – Small strip of wood used to give strength to the dala forms. This is generally a piece of 1"x2" stock attached with drywall screws at the joints of the dala forms.

Concrete – A mix of cement, gravel, sand, and water used to form very strong rock like structures. Almost always reinforced with metal bars (called rebar) or heavy gauge wire. It is very strong when cured, but also brittle. The metal holds it together firmly when it cracks due to thermal expansion/contraction or shifting in the ground or structure. Concrete is not interchangeable with mortar. For the proper mix of ingredients, see section 4.2.1, How to mix mortar and concrete on page 9.

Concrete (Form) Stakes – Long metal stakes, usually two to three feet long and approximately ¾" in diameter with holes drilled through them to enable concrete forms to be nailed to them after the stakes are set in the ground. We generally use them to tie the block line to when laying out the foundation and setting the cinder blocks in the stem wall. Also used to anchor the speed-leads where they sit on the corner of the stem wall when needed.

Counter Sink – Drilling a beveled hole in to wood to allow the head of a screw to be recessed below the surface of the wood. We use this frequently to set the screws used to attach the door-frame and trim to provide a better finished look.

Crown Direction – The direction of bow of the 2x4 lumber used for the rafters. The rafters should all be pre-marked so they can be installed with the crown up. The load of the roofing material tends to straighten them out, rather than causing the roof to sag.

Dala – The bond beam above the 20th course of ladrillo. See definition for bond beam

Dur-o-Wal – Reinforcing steel used in between courses of ladrillo to give the wall additional strength. Formed of heavy gauge wire in the shape of a four-inch wide ladder.

Fascia – 1"x4" boards attached to the ends of the rafters to protect the ends of the rafters and to give the roof a more aesthetically pleasing look.

Float – a small piece of wood with a handle attached used to work concrete down in to the footing trench and smooth the surface of the concrete. It's very important to work the concrete down in to the trench to eliminate voids (air pockets in the concrete), which will reduce the strength of the footing.

Foam Insulation – Styrofoam sheets used in the roof. They are placed on top of the stringers and under the corrugated roofing material. It comes in 2ft by 8ft or 4ft by 8ft sheets 1-inch thick. It provides thermal and acoustic insulation for the roof.

Footing – Steel reinforced concrete base for the shelter, which is 8" thick by 14" wide with reinforcing steel inside. Provides the foundation for the stem wall.

Frieze Board – Also called bird boards. 1"x5" or 1"x6" inch boards attached above the plate in between the rafters to provide a weather seal around the rafters.

Galvanize – A process for treating steel to make it very rust and corrosion resistant.

Gasket Washer – Steel washers with a rubber washer attached to provide a water seal for roofing screws used to attach the corrugated metal to the stringers.

Grade Delta – Vertical difference between the highest point of the existing terrain where the shelter will be built to the lowest.

Grouting – Filling the joints between the cinder blocks or ladrillos with mortar.

H-3 Rafter Ties – Stamped sheet metal pieces designed to attach rafters to the plates. Generally have 4 nails into the rafter and 4 nails in the plate.

Jacks – The end pieces of a scaffolding assembly. They come in a variety of sizes that are connected together with an X-brace to form the scaffold.

J-Bolt – 8" bolt with a 90-degree bend on the non-threaded end to provide an anchor in to concrete. They are placed in the dala when it is still wet and provide anchors for the plate to be attached to. Longer versions are called L-Bolts.

Joint – Generally used here to describe the layer of mortar used to set ladrillo or cinder blocks.

Kiln – Structure for firing the adobe and turning them in to ladrillo. The local ladrillo makers generally stack 3,000 or so adobes together in to a special arrangement with 2 fire channels at the bottom of the structure. The outside is sealed with mud and manure and fire is burned in the channels for approximately 30 hours. The adobes change from brown in color to a pinkish orange. As soon as they cool they are weather resistant and ready to use.

Ladrillo – A mixture of clay, sand, sawdust, and water mixed and formed in to blocks. They are made locally in Agua Prieta. Prior to being fired they are referred to as adobes. Unfired adobe can be used as a building material but it must be sealed to protect it from the elements or it will erode away over time. After firing they are called bricks. In this document we refer to the fired ladrillos as simply ladrillos.

Lattice Pattern – 90-degree crossing pattern of the stringers on top of the rafters. The stringers provide the base for the corrugated roofing steel to be attached to.

L-Bolt - 24" bolt with a 90-degree bend on the non-threaded end to provide an anchor in concrete. They are placed in the dala when it is still wet and provide anchors for the plate above the pony wall to be attached to. Shorter versions are called J-Bolts.

Line Blocks – Small plastic or wooden blocks used to attach the block line to the speed-leads or other reference point. Designed so the line can be wrapped around the block and then fixed to the reference under tension without using any knots in the line.

Lintels – Rigid support above openings in the walls for doors and windows. Can be made of wood or metal beams, but in the shelters the dala servers as the lintels for all openings.

Mortar – Mixture of cement, lime, sand, and water used to attach the cinder blocks and ladrillo together. Mortar is not interchangeable with concrete. For the proper mix of ingredients, see section 4.2.1, How to mix mortar and concrete on page 9.

Mortar Joint – the layer of mortar between the blocks being cemented in place.

Mortarboard – typically a 30" by 30" piece of ½" plywood used to hold mortar for immediate use by the masons laying block. 3 or 4 8"x8"x16" cinder blocks standing on end make a nice portable stand to set the mortarboard on.

Mud – Another term for concrete or mortar. Common usage is "We need more mud!".

Nail-On Frame – Common, inexpensive window assembly. Designed to be nailed to a wooden frame opening in the shelter. We fit the frame in to specially cut slots in the ladrillo window opening to form a very solid mechanical support for the window.

OSHA – Occupational Safety & Health Administration. The working environment in Agua Prieta isn't quite up to OSHA standards.

Plate – 2"x6" piece of lumber bolted to the top of the dala on one side of the shelter and to the pony wall on the other to provide a base for the rafters to attach to.

Plumb – Literally "vertical". Generally measured or verified with a 4ft level, but can also be done with a plumb line, a string with a weight attached to the end. In many stages of the shelter construction, maintaining plumb is very important. Structures that are not plumb can look shoddy and be very difficult to complete.

Pony Wall – A ladrillo wall with 4 courses of ladrillo built on top of the dala on the side of the shelter that has the higher side of the roof. Generally it is desirable to build this high side to the interior of the lot so the owner has the option of adding a 2nd shelter later to double the size of the home.

Rafter – A 2"x4" piece of lumber spanning the opening between the front and back of the shelter and holding up the remaining roofing structure. It attaches to the plate with nails and H-3 rafter ties.

Rebar – Reinforcing steel placed in concrete for additional strength. Generally measured in a numbering system counting the diameter of the bar in multiples of 1/8". We generally use #4 bar, which is 4/8", or ½" in diameter. #3 does not have sufficient strength, and #5, while stronger, can be a bear to work with.

Rebar Bender/Cutter – Special tool capable of shearing pieces of rebar in two and making nice tight 90-degree bends. It is hard to stress how handy this tool is when the foundation work is being done.

Rebar Chairs – Small pieces of plastic that clamp on to the rebar and hold it a few inches off of the ground. The rebar must be elevated someway. If it sits on the bottom of the trench and is not surrounded by concrete, it will not give the concrete strength. Rocks or broken pieces of block can be used, but the chairs are inexpensive and work better.

Rebar Ties – Special pre-cut pieces of wire with a loop at each end to tying pieces of rebar or castillo together. With the use of these and the rebar wrapping tool the rebar tying the work goes quickly.

Rebar Wrapping Tool – Special tool the catches the loops of the rebar ties and with a quick spin ties rebar together tightly. The tools are less than $5 at the Home Depot or similar stores, and $10 will get you a lifetime supply of ties.

Sawsall (Reciprocating Saw) – Heavy-duty version of the jigsaw. Generally can cut just about anything with the correct blade. Because the ladrillo are so soft a Sawsall will go right through them, which is handy when they need trimming at a door or window opening. Sawsall is actually a brand-name, several manufacturers make adequate reciprocating saws.

Scaffolding – Metal and wood plank structures used provide an elevated work platform. Generally, above the 13th course of ladrillo or so and scaffolding becomes necessary. The

metal forms support 2"x12" planks which will support considerable weight. Extreme care should be used to the planks are set over the ends of the metal supports and no one is hurt by objects falling off of the scaffolding.

Schneiderville – Our affectionate term for the area of Agua Prieta south of Hwy 2 where we work to build structures. Named in honor of Roger Schneider.

Sheet Metal Cutter – Hand held manual tool for cutting sheet metal. Basically, very heavy duty scissors. Also called tin snips.

Speed-leads – Metal poles set on the corners of the stem wall to provide reference heights for the courses of ladrillo. The block lines are attached to the speed-leads. Handy if they are pre-marked. Ours are pre-marked and slots are cut for the block line at 4" intervals.

Stem Wall – Initial part of the shelter wall built directly on the foundation using cinder blocks. The stem wall must be above the existing grade level all the way around the shelter to prevent the ladrillo from being in direct contact with the dirt.

Striker Plate – A small metal plate attached to the door frame that the door latch slides against and then enters when the door is closed. Without this plate the door frame would quickly wear down and the door would longer close securely.

Striking the Joints – A process of removing the mortar to a specified depth from the joint on the outside of the shelter walls. This is simple to do with a small block of wood with a nail head protruding about ¾". Really make the outside of the wall look nice.

Stringers – Pieces of 1"x4" lumber running perpendicular to the rafters, providing the base for the roofing roam and corrugated metal.

Toenailed – A method of attaching to pieces of lumber together when you cannot drive a nail or screw completely through one piece of lumber or the other. Accomplished by driving a nail at approximately 45 degrees through the side of one piece of lumber and into the other. Generally followed with a more secure attachment later. Toenailing is used to initially hold the rafters in place; later they are attached securely with H-3 rafter ties.

Transit – See Builder's Level.

Trowels – Metal hand tool for working with mortar. Comes in a variety of shapes and sizes. In Spanish, "cuchara".

X-Brace – A metal "X" which holds the scaffolding end pieces together.