BENDING OF THE ARCHES

The installation of the arches started with us buying 4 cubic metres of the lowest grade, almost throw away, low-cost timber planks the size was 150 &180 mm wide by 25mm thick or 6 - 7 inches by 1 inch thick. Low grade means that the timber has a little bark in the sides as it is mostly taken from outside of the log. According to Kolya this is the strongest part of the wood that protects the tree. Inside is softer and weaker. So the low-grade is actually cheaper and stronger, which is better for us. It does require a little work though and we had to clean it up with the same draw knife.

We chose the wood ourselves at the saw mill and delivered this wood with an illegal home made trailer. We also bought 3 lengths (usually comes in 6 m / 18') pieces of
18x5 cm or 7 inch by 2 inch thick board. At the same time we picked up two lengths of 4 m strong poles 20x10 cm 8x4 inches to act as our centre and door supports at the front of the arch. These large logs were cuter us fresh. The timber order was only 500 USD. You gotta scratch around to find unpolished worst grade timber, but it is out there. I know the price of timber in US has skyrocketed and that's why I mention that: should you want to build on a budget, consider buying second hand construction plywood boards that are used for formwork or quick protection fencing of the

building site. This plywood can be split with a table saw into pieces of the same width of 15 cm / 6'. The plywood bends fantastically well and is superb. One think to consider is that it does have glue, so fresh ply wood can sometimes off gas.

In fact ply wood would give you a much tighter curve and much stronger arches that any commercial wood you can purchase. Bought plywood is very expensive, considering that you will need to make cup at least 75 mm thick / 3 inches. You can get away with less as ply wood is stronger but we used this thickness on our build. It is over engineered but it is tried and tested. Engineering this method of construction would cost 1000's of dollars, du to its non traditionally.

The bending of the arches for us started by putting in 3 pegs which you should not do. The arch should be bend by a few more pegs in the ground or on the wall . One peg puts too much pressure on one point.

One peg puts too much pressure on one point. I suggest wetting them overnight and letting them bend gently by weight over another night as shown at 6:33 seconds in, here

Anyway knowing myself, I wanted the ceiling higher and therefore pushed the limit of the plank to see how much it would bend, in other words, what is the tightest circle it can give.

Tighter circle would be higher ceilings. Obviously the plank snapped. Usually for arches either a ply wood is used which is extremely pliable or wood siding of 10 mm or half inch thick. Siding does not have to have "tongue & grove", if you are buying from saw mill, then you can just ask them to cut you plants in siding size 10-12cm wide by 1 cm thick. The 1 cm thickness is what gives you more pliability, more curve as it is thinner.

Please note that if you want higher arches and you do not have money for siding, which is much more expensive than untreated low grade wood that we purchased is your best bet. Wetting it and or buying planks from Aspen tree would be able to get tighter arches

Once we estimated at which point the wood breaks we knew the maximum

height of the arch it can provide. We got 1.6 - 1.7m / 5' - 6' heights in comparison to the sides. The sides were 6.6 m or 20 feet apart. This is the same width from the centre of the log wall to the other centre of log wall. The radius of this circle is 4.2 metres +- 14 feet. Different kinds of timber can provide you with different abilities to bend.

On this drawing I also show you a slightly higher arch of 1.7 m height as measured from the sides. As you can see, when the radius is smaller, height is bigger. The planks from a typical pine, untrained, should bend somewhere in this region. This new diameter is 4052 cm. Play with you first length of your wood and see what it bends to before snapping, then release a little. Feel the timber, hear the little cracks, it tells you just before in snaps and then big BANG comes.

You could also train the wood with something heavy as shown by Human Wisdom you tube channel.

"Training arches"takes a little longer than just bending them one shot, but this gradual method could give you extra height if you need it.

Wetting the wood a little also does magic in making it more pliable. I threw my plywood into the pool before bending the face of my composting toilet. I never tried wetting timber planks, so do your research.

As you noted neither did we train the wood nor did we wet it. We used the least type of playable wood and thus got this low lying arch, which turned out pretty cool at the end for the buried home. What helped us are the many pegs that allowed the pressure of the bend to spread over a longer length of the timber plank.

The planks gave us safely a total of +- 2.7 metres or 9 feet from the submerged floor to the inside part of the arch. It was a good size room to start off with. This height even allowed for a placement of the bed on the mezzanine level

Once we estimated the radius of the circle that the arches can maximally bend towards, we placed a peg in the center of radii. During this build you will see me pointing towards my front right tire of my car which is this centre point. The center point is important two fold:

• Firstly It gave us the actual circular path that we needed to place our

wooden jig along for bending of the arches.
- Secondly, when trimming the arches at the end we used that as a cutting angle. I will speak about it later on in this lesson.

So back to the wooden jig. We hammered wooden pegs into the ground, 2 pegs at a time as seen on the video. These pegs as I mentioned where aligned to the center point. I don't remember the exact distance, but the final lengle of the beam was +- 8 metres / 24 feet. The pegs were hammered in about 30cm / 1 foot into the ground with 15 cm / 6 inches sticking out.This was for clay soils, sandy soils might need a logger peg. They were about 75 mm / 3 inches in diameter. What ever works for you.

With the wooden jig I will mention it straight away, that after a few arches they start to wobble a little and then wooden wedges need to be hammered in. They are perfect for making all the arches for one of these vaults.

If you want to build a whole village I recommend making a proper jig.

The timber planks were placed at the corner of the double pegs and we inserted them one by one as shown in the video. Because of the width of our vault we had to add 1.5 m - 2 m / 5'-7' pieces to make up the necessary length of the arch. Then starting from the other end we did the same thing. This created a staggered effect binding the shorter pieces all together. The end result was a total thickness of 3 timber planks 75mm / 3 inches thick. The pieces that were joined got a little PATCH of about 1.6 m long on the inner diameter side of the arch as well as the outer diameter , outside of the arch

If you like the look of these diagonals and arches to be seen I would recommend, on the inner diameter or the underside of the arch, to use ply wood instead of these "patches". The plywoods, being only 2.4 m / 8 foot long, would need to be neath joined in one straight line to create the support for the connection of the timber as well as aesthetically cover the under side of unpolished timer plank for the arch.

This way you will have a nice finished polished look of plywood for the entire length of the underside of the arch. You could also polish up the sides of the arch, using a planer should you wish. I will not get into too much of fine finishing touches as it all depends on time and available

equipment. Obviously buying timber that is already dried and planed has a completely different price tag. We used raw timber planks bought dirt cheap directly from a saw mill. I will show you how we planed the wood.

Patches above are not a problem.

Back to the patches, these were firstly screwed to the timber arches with 50 mm screws, I recommend 75 mm screw **(get at least 1 KG of those)**
The rest was connected with nails you will need **100mm / 4 inches (at least 5 KG)** and **120 mm / 5 inches also at least 3 KG**. I can not speak of exact quantities but if you can get bulk (not from Walmart) but actual manufacturer or wholesaler. I would recommend getting 5 kg of the 100mm nails. we used them the most not just arches but also connecting the diagonal lattices and hammering the outer wood for the roof.

The long nails replaced gluing the arches. If you are sensitive to glue this is a good method. By bending the ends of the long 100 mm / 4 inch nails it made sure that these will never come out. Thus said we did not use any glue!

NB RULE OF THUMB, when screwing or nailing something in, close to the end of your timber plank, make sure you stay away by the diameter of the screw or nail multiplied by 20. I.e. a 3mm thick nail or sore should be roughly 60 mm away from the edge of the wood to safely not split the wood.

When hammering nails try and follow our advice here and the following diagram. I also though that the bigger nails the better, but Kolya, being an engineer, stated that massive nails just rip up the wood unnecessarily.

Here are a few shots of exactly how we did the archest.

1. We placed 3 timber planks in the pieces as shown
2. 100 mm nails in zig zag manner about 20 cm / 8 inches apart. The nails were wrought 25 mm or 1 inch from the sides
3. Longer 120 mm nails where hammered in the middle
4. The bending of the nails happened from the outside as the nails where hammered from the inside.

5. Wide cap silver screws were used for the patches first and then 120 mm nails were used with the screws are not strong enough to hold the patches to the planks. The nail are needed
6. The first arch took a long time and then we really got the hang of it.

We used G clamps first to clamp a section and then we nailed that section, once the nails were bend the G clamps were removed and moved further along and then the nails went in so on and so forth

It is best described in the video shots. With 3 people you could get the whole process rolling very nicely. One is moving the clamps one is hammering and the other is battering the ends of the nails.

We prepared the timber 4 lengths at a time, by debarking the low-grade timber. 4 lengths is what is necessary to make one arch. It's good to alternate what you do, cleaning up all the timber, although it would be quicker, it would be more tedious. We prepared 4 planks, then made 1 arch and then prepped another 4

All the offcuts were used as well for the patches and eventually to make walk ways in the wet clay, furniture or whatever.

After the arches are made we found the middle point and then we got the exact length between centre of log to centre of log. For us it was 6.6 metres. The arches were made +- 1 foot longer on each end. This allowed us to trim them exactly so that the distance of the the outer edge of the outer plank edge to the opposite outer edge would be exactly centre log to centre log.

The cutting angle for the ends of the arches also can not be random. It followed the SAME CENTER POINT of our radii . The reference point as I mentioned is the front right tire of my car. There we placed a peg. So when cutting this wood we made sure that the direction was bang on towards this centre point.

The reason for this is so the outer rib edges of all the 3 planks are in full contact with their entire surface. I.e. if the angle was any different only 1 edge of 1 plank would be in contact with the socket in the log and the rest would be hanging in mid air. This would make the connection much weaker. What I am trying to say is that the arch is only as strong as the

entire 3 timber planks, thus please make sure that the 3 planks are landing into the socket and touching it entirely, the contact surface fully meets the socket.

MAKING OF THE SOCKETS

Before installing the arches we had to make the SOCKETS. These are the cut out parts from our logs that would receive the arches, without allowing them to slide outwards. Should you wish to place your timber vault on the super adobe wall, then there would be a different scansion with either bought brackets or custom made one. I will be doing this method on my own build and thus will share with you what I end up doing in a couple of months.

Back to our sockets that were cut from the logs

1. We found the centre line of one of the top log on the left wall and measured out a parallel line on top of the right log, i.e. on the opposite wall.
2. Then we market out 5 equal distances for 6 arches
3. Then Kolya used the same timber plank to mark out the socket
4. He cut one socket out and shaved the bottom so it can be in full contact with the arch. The arches not being glued adjust slightly, so your angle can be close by but not exact. You can get this angle from a quick front sketch or bye eye balling it as it is the same angle when you precept the arches.
5. He then attached one plank to this first socket and when driving in the chainsaw at the bottom, he aligned it to the first plank as shown in the video. By placing a temp plank to the newly cut socket you can see if the bottom of newly cut socket aligns to the first guide. If not, then use this shaving motion with a chain saw to get the angles the same.

We made a **big mistake** by removing the HAND PULLER RATCHET HOIST MECHANISM from the arches. We did that as we wanted to prepare all the arches as we can put them up the following day. Over night they "relaxed" outwards a little as we did not use glue.

It was a big mission to get them back it shape. Look at how we struggled and eventually broke an ENTIRE ARCH. We pulled and we heaved, we

placed a support pole, we tried this and that. Yes we broke a whole arch which takes just over an hour to complete and 4X lengths of timber.

Other arches were MUCH easier to install as we used the hand puller ratchet hoist again on the arches, to bring them back to the original size and even slightly smaller distance by roughly 2.5 cm 1 inch smaller then the outer edges of the sockets. The center log to center log distance.

To make sure you do not repeat our mistake it is best if you can make an arch, connect the hoist ratchet mechanism as it is already sitting in the PEGGED OUT JIG reduce by 2.5 cm / 1 inch and then place the arch straight on the wall into the sockets, then make another arch and place it straight away and so on

Our method resolved in one extra step, we made all the arches then removed them from the pegged out jig, and then put them back into pegged out jig to connect the ratchet and get them slightly smaller so that they fit in.

Another problem we encountered, that you can avoid can be seen by this cracked timber plank. Because the wood straightens out over night or the arch 'relaxes' outwards, trying to get back to its original straightened state, when trying to pull them back, with a ratchet hoist mechanism the timber planks did not like it. If they are already in the pegged out wooden jig then pulling them just +-2 cm / 1 inch in will not make much of a difference , but after they straightened out by 50 cm or almost 1 foot, pulling them slightly smaller than original state meant big bend for all of them, and we heart some of the planks cracking slightly during this step.

INSTALLING THE TENSION WIRE

The tension fire is designed to pull the vertical pole towards that rebar we hammered 1.2 m / 4 feet into the ground

It is done with 4 strands of 5 mm 1/5th of an inch wire. The wire is connected as shown in the video and crowbar is used to twist it so it tightens and pulls that log towards the rebar, thus snugging and holding these logs from top end from ever falling in. Remember that from bottom end the vertical log is held by the stones that we hammered in.

Although the arches with the vaulted roof above them will do the same function by pushing those logs outwards, as it is a method that Kolya developed and learned int he military, I did not question it. It also fits with my model: ***rather over engineer than be sorry!***

INSTALLING THE ARCHES

The first arch was carried from the back of the room and then temporary diagonal support were installed.

We used two planks as shown on the video to slide the other arch, that was now carried from the front side of the room.

Once the arch is standing this is the procedure.

1. Horizontal support on the top was screwed in connecting the 1st and the 2nd arch.
2. Remove the "rails" that assisted us in lifting the arches.
3. Hoist ratchet mechanism released
4. Long 20 cm nails (you will need at east 1.5 KG of those) went in to bind arch to wall in
5. 2x diagonal supports, per side, went in straight after.

In this video you see us bringing in the first arch, that's the furtherest back after the 2nd arch, that's because we broke the first arch and had to redo it completely, thus we installed the 2nd arch next to try out our new method by utilising the ratchet hoist mechanism, as explained above.

Kolya had to remove 20 cm nail on each of the sides with a crowbar after the broken arch was carried out and away.

Once all the arches were installed we temporarily covered them with a vapour barrier textile which made the wood softer so it does not tear the plastic. Then we covered with plastic, to protect from rain. Crisscrossing with ropes to those rebar rods in the corners and planks on top did the job. Walking in wet clay is 5 times more difficult and slower than on dry earth.

PREPARING AND INSTALLING THE T RAFTER

In the workshop we polished up the large planks to be used for constructing of the T-beam. It is made by connecting two 18x5 cm long timber planks 6 m long. We polished those up with a planner as it is something that will be visible. Doing the plaining in the workshop is much easier than trying to do it afterwards, working on the ladder.
The T-beam was delivered on op of my car.

To install it we first had to place the bottom logs that act as support foundation for the non load bearing front and back walls of the vault.

Cleaning out the soil and preparing the ground by hammering stones so that the logs are not placed on wet earth. Doing a gravel trench or super/ hyper adobe stabilised earth bag would do the job even better.

As we were tight on time, I just threw in some stones and battered them into the clay to provide a slight lift for the logs. But in wet clay anything would sink in eventually.

We installed the plastic for the front sa it is most prone to water. For the back log we did not as it is meant to stay dry because we extended the plastic roof on the back by +- 3 metres / 9 feet.

To install the T-Beam raft we made a quick platform that resembled somewhat "peace sign" shape and stabilised it with wooden pegs so that it does not slide off. We placed a strong jack onto another triangular shaped support footing. We also pegged it in as seen in the video as wet clay makes things slide.

We lifted the T-beam and connected it with rope first
Then we measured a temp log and used it to crank the T-beam rafter up tight against the arches. The temp log was placed under the second arch from the back as the column would go on the first arch

I then climbed up and screwed the T-beam with long screws (100 mm long) 2 on each side i.e 4 per arch.

We prepped a nice beam for the back and cut out a rectangular piece so it can fin the bottom part of T-beam. The method to cut a piece out

looks exactly like this.

We then prepared a little cut out footing so that the vertical beam would not slide along the log.

We placed the bottom part first and then battered the top as to would lift everything up by about 10 cm / 4 inches. This does not have to be exact height. If it is not working to push the arches that high then remove , cut off an 2.5 cm / 1 inch and try again

2x 20 cm / 8 inch nails went in to secure the column from the bottom. This made sure that this vertical beam would not slide forward or back. Everything in construction makes logical sense and that's why I love natural building.

Because of those patches or other irregularities, some of the arches did not connect snug to the T-beam. To fix this we placed a wooden piece to cover the distance as seen in the video.

The same procedure was carried out on the front . The temp support with a jack was installed under the 2nd arch from the front and then we cut out a placement for the bottom part of T-beam out of that nice timber column 20x10 cm / 8 inch x 4 inch

We used it to mark the footing so the front bottom foundation log receives it, in the same way as the back one.

For the door we cut out a piece that was slightly longer than the arch by 10 cm / 4 inches and then we placed it, cut out the piece for the footing . We also at the time penciled the inner part of the arch and placed a temporary wooden support piece on the arch itself. This allowed for the door column not to slide in, when mounting.

We brought the column to the floor and cut the curve of the arch, that we penciled and then with a heavy duty digging bar gave it a slight lift using a lever function. We then battered it into the place with hammers. Once in place a long 20 cm nail / 8 inches went straight in from the top securing it in lace. The temp wooden support can be nw unscrewed.