Blue and Orange

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November 14, 2006

How to Build a Large Bouldering Wall

A month ago I started construction on a bouldering wall ("bouldering" is essentially rock climbing to low heights so you don't need a rope and harness and friend belaying you) in my backyard. I just finished it last night. I've been photographing the whole thing, so I thought I'd do a write-up in case anyone else out there wants to try something similar. I relied heavily on the following sites when planning my wall:

- Tradgirl's Climbing FAQ
- Chockstone: Building a Home Climbing Wall
- Indoor Climbing: How to Build a Home Climbing Wall
- Metolius's "How to Build a Home Bouldering Wall" (PDF)

If you're going to build your own wall, I'd definitely recommend reading thoroughly through the Indoor Climbing site as well as the Metolius pamphlet; they go into more detail about low-level stuff (lumber nominal sizes, spacing and dimensions for various size wall panels, etc.) than I will here.

I also relied heavily on Google Sketchup for modeling the wall ahead of time, as well as modeling joints on-the-fly during construction to measure angles with the Sketchup Protractor so I could cut them on my miter saw. Sketchup was a lifesaver, and I'm eternally grateful that Google bought them so there's a free version that fit my needs perfectly.

I've recorded the construction with photos, in a flickr set here. These are the photos I'll be inlining through this article, but there are more in that set for the curious.

Design

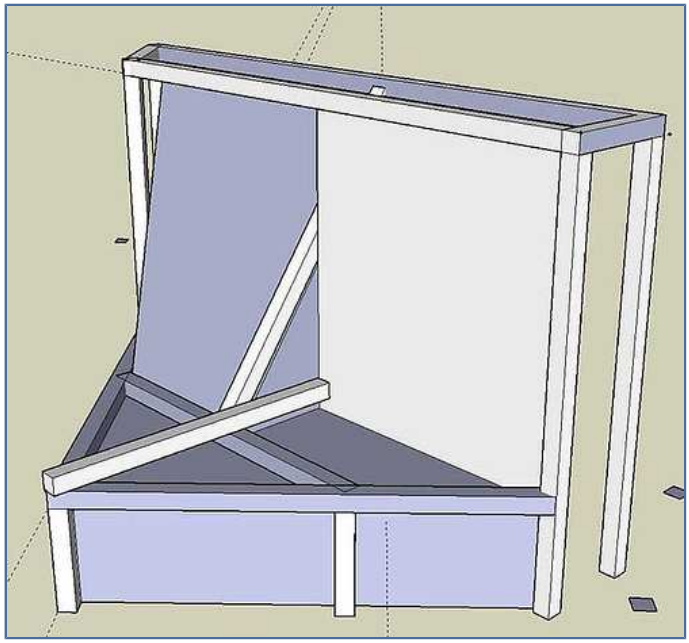
I designed the wall with a few specific features in mind: I wanted a low roof (a horizontal section so you're climbing parallel to the ground, Mission-Impossible style), a few vertical walls, and a large overhung wall at around 30-40 degrees.

I also knew it was going to be a standalone structure, since I don't trust my construction skills enough to risk damaging my house with it (or, worse, shearing a big chunk of my house off when the wall collapses sideways, pulling the house with it!)

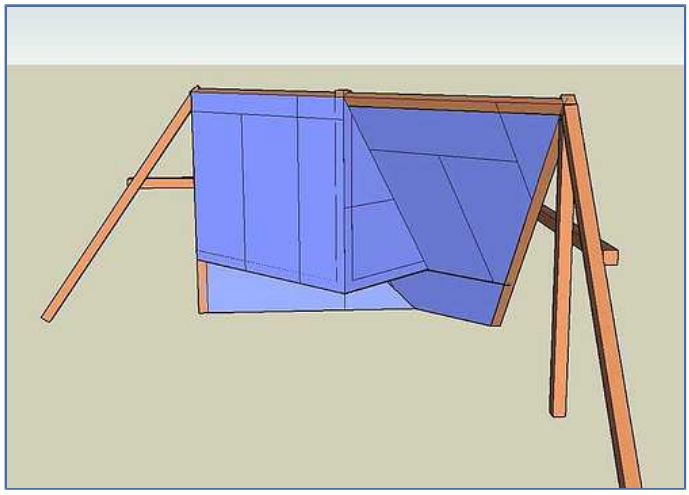
I have no formal experience designing frames. I've seen swingsets before. I've also played a lot of Bridge Builder. I'm not joking: I credit Bridge Builder with a lot of my intuition for beam structures and the way forces transfer around them. It's important to be able to look at the structure and know, "Hey, if I push sideways on this joist that is connected to this stud, the weight will transfer along this weak brace and eventually break it."

Also, both my parents are woodworkers -- my mother did it professionally for a long time, too -- so I have a lot of exposure to wood tools and wood itself, and a decent intuition for how it flexes and machines.

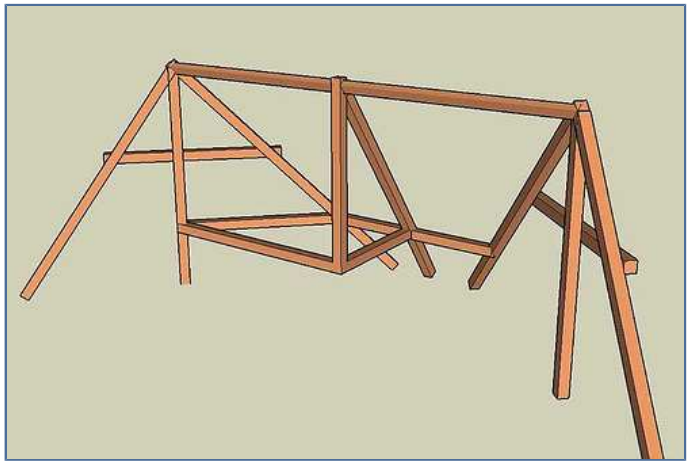
Still, I made some mistakes, and in retrospect my first frame design would have been an unmitigated catastrophe:



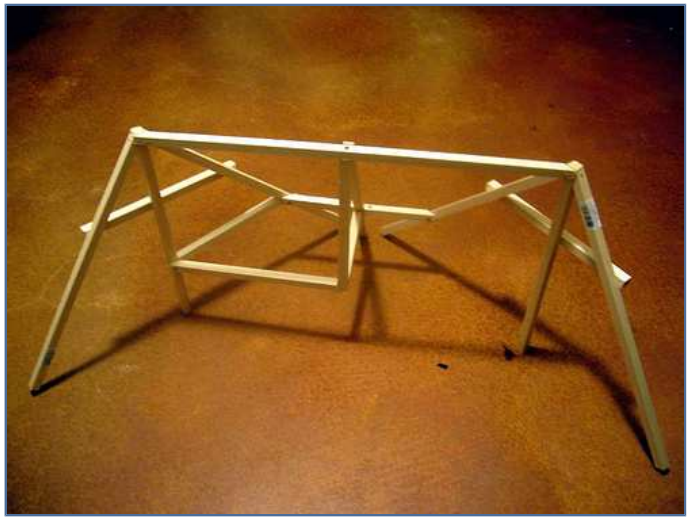
That elaborate top part and the long, vertical, relatively-unsupported beams would have just collapsed, no question. Luckily my friend Kent (Massachusetts Kent, not Texas Kent) pointed out as much to me, and so my second design was based off a swingset A-frame, rotated outwards to fit in the rear corner of my yard, and with the framing elements cleaned up substantially:



Without the plywood paneling, the frame alone came out like this:



Taking IndoorClimbing's advice, I built a scale model of the frame:

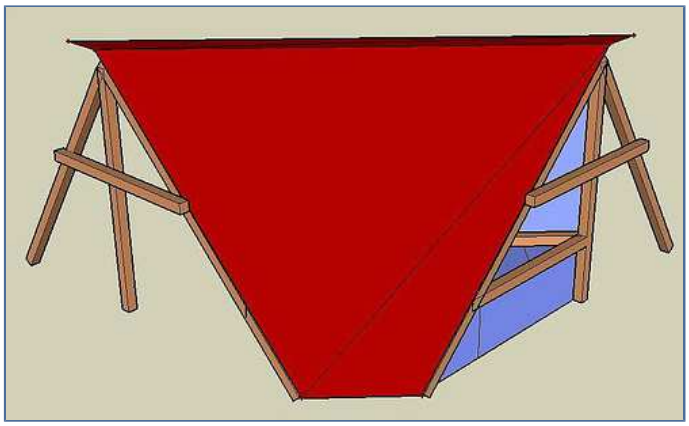


It was really useful in illustrating how tricky the angles were going to be.

Next, I emailed the Austin Building Permit Office a few times to confirm that, as long as my climbing wall did not look like a "covered deck", it would qualify as playground equipment, and would not need a permit to build. Whew!

I checked my home survey to make sure I avoided any easements, and plotted out where it would go in the yard to make sure it'd fit.

Finally, I decided on roofing: it would be too expensive to buy all the lumber pressure-treated, and I didn't want the plywood getting soaked every time it rained anyway, since even pressure-treated lumber will eventually decay, so I threw a layer of corrugated steel roofing over the model in Sketchup to figure out how many roofing panels I'd need:



The roofing was pricey enough I figured I'd just tie tarps down over the vertical sides, and only roof the slanted part.

Materials

After that, it was time to start buying the basic materials. Here's a hint: if you build something this large, do not expect to be able to buy everything at once. Also, seriously pad your cost estimates, because even hardware at this scale becomes expensive. Large lag screws, for example, are a couple bucks apiece, and they come in handy a lot. You'll assemble a joint and find it needs to be stronger and end up spending another $12 just on framing connectors for it.

Here are most of the framing connectors, bolts, and other hardware that went into the wall. And here's the lumber:

I don't have an exact record of what I bought, but it basically involved a lot of analysis of the Sketchup model and scratch paper, plus navigating around Home Depot's surprisingly good website (you can pick your local store and look at its lumber stock.)

The frame itself was built entirely of pressure-treated lumber. The As themselves were built from 4x6s, the largest things Home Depot sold. The cross-braces along the As (the part that makes it an "A") were 2x6s, since they really are there to resist expansion and compression. I used 4x4s for some secondary elements. The top beam, which I'll describe later, is made out of two 2x6s sandwiched together over 2" thick steel pipe. Then the "roof" part, the part that hangs down from the center of the top beam, was entirely made of 2x6s.

One important thing about such large-scale construction that I have to admit I did not know when I started this is that nothing ever actually works out to quite the measurements you start with. Unless I wanted to precisely level the ground, measure everything with impossible precision, and spend an hour making every cut, all my joints were doomed to be off by a degree here and there, my cuts off by 1/4" here and there, and when angles and extremely long timbers are involved, that means it's off by 5" on the other side. Luckily, I learned that early on, and never cut anything until the last possible minute, based on the in-place measurement.

I have a lot more respect for construction workers now.

Tools

It's worth giving tools their own section. I bought a lot of power tools to make this wall, and one thing I learned time and time again was that any time I found myself thinking, "Hey, that tool might come in handy," it was probably absolutely crucial. "I bet that 12" compound miter saw would help," I thought, and I can say now I would have given up a day or two into the project without it. "That collated screwdriver is kind of a splurge, but will probably come in handy," I thought, and without it, installing the plywood would have taken weeks instead of days.

In general, where you can afford the tools, they will save you a ton of time.

The particular tools I'd say are critical for this project were:

- 12" Compound Miter Saw (not 10" - those 4x6s are big!)
- Circular Saw (for cutting plywood) plus a ferrous metal blade (for cutting roofing)
- Jigsaw with wood and metal blades (for all on-the-spot fix-up cuts for which the circular saw is too big.)
- Senco Collated Screwdriver (the kind you feed a plastic strip of screws into and operate one-handed. Hilti makes better ones but they're more expensive. I got the $99 Senco, the cheapest one.)
- The strongest hand power drill money can buy (I have the Craftsman 19.2v drill & screwdriver combo, and having the double battery w/ 1hr charger really sped things up.)
- A drill press attachment for the hand drill (for drilling T-nut holes perfectly vertical in the plywood)
- Other miscellany: a level, a hammer, a good hand saw, a mallet, a Leatherman, a pair of good vice grips, a long tape measure, a staple gun, a large straightedge (mine was 60"), a combination square, and one of those chalk lines for marking straight lines on stuff (I didn't have one, and sorely wish I did!)
- A good set of drill bits, including a very durable 7/16" bit for drilling T-nut holes, a 3/4" auger bit for drilling the largest bolt holes in the frame, a 2" Forstner bit for countersinking and drilling the pipe-hole, and a few small metal-drilling bits for pilot holes for the roofing.

I probably spent a little under a thousand bucks on tools for this, but the compound miter saw was $400 of that. All those other tools are no more than $100 each.

Frame Construction: The "A"s

First things first: building the two As.

I assembled each on its side. First, the longer of the two angled timbers (the one coming up the back, angled in at 45 degrees) was longer at 18' than Home Depot sells a 4x6 (their max is 16'.) So I cut a 2' piece off the timber that was going to be the vertical (since it only needed to be 14') and patched it onto another timber with 4 heavy corner braces, which you can see in this photo:

Then I cut the angles into both angled timbers with the miter saw.

After that, I lined them all up on the ground, and cut the 2x6 that formed the cross brace. I put it down on the three timbers, drilled holes through each with the big auger bit, and bolted it all together with 3/4" stainless steel bolts (and washers and nuts.) Here's one of those bolts. This is coming out of the 2x6, so that the excess bolt and nut were on the outside of the frame and wouldn't interfere with the climbing wall itself.

I also countersunk the bolt heads into the 4x6 with the Forstner bit where I knew I'd want to mount plywood, so the bolt head wouldn't get in the way.

After that, I took the auger bit and drilled a hole clear through all three timbers where they met at the top. I used the Forstner bit again to carve out flat countersink

spots for nuts. I had a 3/4" threaded stainless steel pole from Home Depot, about 2 feet long or so, which I then screwed all the way through the hole (this took a while!) and then used washers and nuts to get it on tight. In the photo two up, the one with the metal corner braces, that bolt sticking out of the wood is this threaded steel rod.

At this point, the A is held together by a wide 2x6 about halfway down that is bolted on and a threaded 3/4" steel rod holding the top together. It's really pretty stable.

The top beam between the two As, as I mentioned, was a 2" steel pipe sandwiched in 2x6s, and for stability I wanted the pipe to run through the tops of the As. I took the 2" Forstner bit again and, with the help of the drill press attachment for my hand drill, I drilled a hole through the top of the A at 45 degrees, right through the center 4x6 timber.

Then, it's just lather, rinse, repeat to assemble the other A, making very sure to mirror things appropriately. I actually drilled the pipe-hole the wrong way through one of the As because I got confused. Luckily it didn't damage the integrity of the frame. It just goes to show, though: measure twice, cut once.

After that, all that remained was to stand the As up. I rented an earth auger from Home Depot to dig foot-deep holes in the ground, although in retrospect digging holes is not really much harder by hand (especially since those augers are hard to hold onto and require a lot of elbow grease to really dig with!)

I got my friends Chris and Kent to come over and help stand the As up. I had a spare 4x6 I'd accidentally bought, so I cut it in the center at 45 degrees so I could brace both of the As up, one with each half, like so:

Oh, yeah, and I tied the two As together with strong rope so that a strong wind would not blow either over, one of which could have crushed my neighbor's above-ground pool and/or house.

Frame Construction: The Pipe

It was actually pretty difficult to get the pipe between the two As. I couldn't stand them both up to 90 degrees or they'd fall over backwards, so I rented 10 feet of scaffolding from Home Depot:

... put it between the As, tied each A to the scaffolding with a Rolling Hitch (that knots website is **awesome**, I referred to it regularly during the project) and progressively let some rope out and stood them up until they were both at 90 degrees.

The pipe comes in 10-foot sections with ferrules on the end, and the distance between the tops of the two As was about 22 feet, so I cut one of the three pipes down to about 4 feet long (so there'd be a foot sticking out either side) and screwed it all together, and brought it up onto the scaffolding.

Further complicating things, the 2x6 coming down from the center of the steel pipe (to form the low roof) had to be very securely attached, so I decided to drill a hole through it (with that Forstner bit) and thread it onto the pipe before putting the pipe through the As. Suffice it to say, the 24-foot-steel-pipe-with-9-foot-2-by-6-hanging-off was pretty unwieldy.

Subsequently getting the pipe in took Erik's help for multiple hours, but suffice it to say we finally succeeded.

I used a 7x16" metal drill bit to drill holes through the pipe right outside each A, and then put about a 9" length of 3/8" threaded steel rod through there and secured it with locking washers and nuts. That way, neither A could fall outwards off of the pipe.

Frame Construction: The Sandwiching

To make the steel pipe into a beam I could actually attach stuff to, I sandwiched it between 2x6s with grooves cut down the middles. I don't have a table saw, so I did this with my circular saw and the rip guard. I just made one cut, moved the rip guard out 1/16", and made another cut, ad nauseum. It took a long time. A table saw and dado head would have saved several hours here, especially since I had to do it to 44 feet of 2x6 (sandwiching 22 feet of pipe, remember?)

Then I drilled holes down the lengths of the 2x6s, hauled them up onto the scaffolding, and clamped them together around the pipe as I used the mallet to knock bolts through, and tightened them with a socket wrench. Here's a tip: make sure those grooves are deep enough. I had to recut some because you do not want them to be **too** snug around the pipe, or the 2x6s will start to crack. Undesirable for a key component of your frame.

Frame Construction: Secondary Elements

The next step was the final 4x6, the one that I call the "spine" that runs up the back of the wall in the center, hitting the top beam right where that 2x6 was dangling down to form the low roof. I dug another hole and concreted him in, and made some careful cuts so it fit snugly up against the sandwiched 2x6s and the dangling 2x6, and connected it with a boatload of framing connectors. More 90-degree corner braces than you can shake a stick at.

You can see that spine timber, plus the two 4x4s connecting it to the As, here:

You can also see a diagonal brace in there that was not in the original Sketchup. The top beam, at this point, was flexing far more than I was comfortable with, so it was a spur-of-the-moment addition. I used one of the two 4x6 halves I'd originally used as braces to keep the As standing up (the one I bought by accident -- lucky accident!)

Attaching all those 4x4s around the low-roof height on the frame took some work with the miter saw. I finally arrived on a process where I'd just take scrap wood and my first guess at the right miter & bevel and see how it fit onto the frame, and then keep adjusting until I found it. At this point, the frame was off by enough that my Sketchup numbers were only very rough guesses for precise angular cuts.

To connect the 2x6 dangling from the middle of the top beam to the A-frame and the spine, I used four more 2x6s, two running along each direction. I knew I had to screw studs in facing each direction (both vertically and horizontally, for the vertical faces and the low roof) so I didn't want to use a big timber I couldn't put screws through. I made a rail out of two 2x6s, one facing up, one facing forward, so they joined at a right angle, and connected that rail to the A (and another to the spine) and both met at that dangling 2x6. Again, I used more 90-degree corner braces than you can shake a stick at to secure it all together.

If that's not totally clear, it may be in the full-size version of the next photo down, so keep reading.

That's it for the frame. Onto the studs!

Studs

The studs were all built from **non-pressure-treated** 2x6s. Pressure-treated lumber here would just have been cost-prohibitive.

For the most part, the stud construction is rather unremarkable, except to say that the miter saw again got a good workout (often holding the wood in unconventional, potentially dangerous ways, like inserting it into the saw head-on instead of sideways, to make very high-angle cuts.) I secured all of the studs on the vertical faces and the horizontal low roof with 3" coated decking screws.

It's important here to make sure that the studs all form a flush face, since the plywood isn't really very flexible stuff. Working around all the peculiar angles in the frame was a challenge, but luckily once I got one of the studs figured out, the rest in that face were roughly the same angles (slight variations for frame flex excepted.)

I was concerned enough about the strength of the 35-degree wall that I bought and used joist hangers for every stud:

I didn't do this for the low roof, even though it's subject to even more weight, because the way I made those right-angle rails out of the 2x6s for the frame meant that I could screw the roof studs in very securely, right through the backs of the frame 2x6s. The 35-degree wall studs were running between a 4x4 and that sandwiched steel pipe, neither of which I could drive screws all the way through.

Here's another picture of the studs, because it is pretty:

For the lowest panels of the wall, I put the studs in with a 2x6 joist running all the way along the bottom, to make sure none of it actually came in contact with the ground (non-pressure-treated wood wants to stay clean and dry, after all.)

I actually assembled this particular panel on its side, and then stood it up, and used my car jack under each stud to get it snugly raised into place, and then toenailed screws in to hold it to the 4x4 above.

Oh yeah, when putting the studs in, I was always careful to put in a double-stud where a board would end and another would start, so they'd both have something to screw into. Again, make sure to read the IndoorClimbing and Metolius literature on this. They go into more detail on that.

The Saddest Unplanned Support

I'd really hoped to keep all supports away from the front of the climbing wall itself, but when I'd put all the studs in, it still swayed and sagged more than I was comfortable with, so I took the leftover steel pipe from the top beam and mounted it under the point of the low roof like so:

I dug a very deep hole (mostly so I wouldn't have to cut the pipe again), put a few steel plates at the bottom (some leftover framing connectors), drilled two holes through the steel pipe and put some leftover threaded rod through them and clamped it on with nuts and lock washers, and mounted the pipe to the frame by screwing a steel pipe coupling to the bottom of the wood and screwing the pipe into that.

Then I filled the hole with 120lbs of concrete. No way I was going to have to put **two** supports on the front.

Roofing

It was threatening to rain, so at this point I switched gears and put the roofing on. My friend Kent (Texas Kent, not Massachusetts Kent) came over and helped put the top roofing on. It was an inexact science: hold the panel in place, drill a pilot hole, put in a roofing screw (the weird ones with the metal washer over the rubber washer, so the rubber expands to seal perfectly when you tighten it.)

In retrospect I wish I'd been a touch more precise about this to get a 100% seal with the roofing, but the back of the wall wasn't totally flush, with the spine timber and studs poking up, and anyway a can or two of Dow's "Great Stuff", the expanding foam crack filler, and I think I'm basically good to go.

I originally cut the roofing with the metal blade of my jigsaw, which made noise that sounded like twenty cats being skinned alive. I switched to using the steel-cutting blade on my circular saw and that was much quieter, faster, and made cleaner cuts. It was actually not that hard to do cuts in place (standing on a ladder, trimming corners off of mounted panels) as long as I wore clothing and gloves and protection to cover my whole body and face from the shower of metal.

Plywood Paneling

Putting up the plywood paneling was more tedious work than technique. I measured out each panel, what size it needed to be, then cut it to size with the circular saw, then used marking crayon to draw lines where the studs would be behind it, and drilled holes for the T-nuts where the studs wouldn't be. Then, I flipped it over and hammered the T-nuts into the back. I got Chris and Kent to help out with the plywood a bunch, both because hammering the T-nuts takes a while, and then actually holding it up to the wall is very difficult.

I liked Metolius's suggestion of bolting a couple jug holds to the panel to help hold it in place, so we did that, then they'd hold the panel up and I'd use the Senco collated screwdriver to put enough screws in that it was up on its own, and we'd move on. Later I went back over and put in a screw every 6 to 12 inches along every stud.

I filled cracks with thin strips of plywood screwed on, if the cracks were big enough, or with more expanding foam and drywall joint compound if they were small.

Paint

After all the plywood was mounted, Erik helped me plug all the T-nut holes with golf tees (a handy trick!) and then prime the whole wall, which didn't take long.

The next day, I painted the wall with flat-finish exterior paint mixed 10-to-1 by volume with normal playground sand. It's nice; it gives it just enough texture to feel like I can smear, but it's definitely not as good as a real climbing gym, let alone real rock by any means.

The painting took far less time than I'd feared, which was pleasant, given that everything else took me far longer than I planned.

One Last Unplanned Support

I added the final unplanned support at the very end. For those counting, that's 3 supports I ended up adding that were not in the original design: the one running down at 45 degrees from the top beam to the left 'A', the steel pipe running down into the ground, and this one. The problem was that if you stood on one side of the wall and pushed on the outside of the 'A' rhythmically, you could get the whole structure to sway back and forth, and if you really did it hard enough for long enough I bet you could have built enough momentum to do some damage. I assumed this wouldn't happen since the As are perpendicular to each other, but such long 4x6s flex pretty well, and that's a lot of sideways force to expect them to resist, 14 feet up from the ground.

You can't see this extra support in any of the photos, but what I did was just to take that last piece of leftover 4x6, screw it to the outside of the vertical timber of the left 'A', and run it down into the ground, so it's facing directly in against the A, preventing it from swaying side-to-side. I dug it a foot or two into the ground and concreted it in. After that, the structure is completely immobile. You can't get it to budge in any direction no matter where you push or how hard.

I probably would have put a matching brace on the other side, except that it would run down into the ground right into a utilities easement, which I can't build on. Thankfully, the single brace on one side did the trick!

Finishing Touches

I weatherproofed the sides of the wall with tarps cut to size, grommets added, and tied to the frame, and then I got some heavy vinyl from a fabric store and cut foot-wide lengths of it that I stapled onto the frame so it hangs down over the tarp, so water can't get in between the frame and the tarp. I'm happy with how it came out. Neither the metal roofing nor the tarp/vinyl are 100% rainproof, I don't think. During Austin's heavy spring storms I'm sure some rain will get in, but it can all drain out, there are openings at the bottom for it to get out, and the wood will dry. I think it's all good enough that I won't need to do any maintenance on it for years.

I did put in an entire wall of studs that I didn't make climbable, just so that I could put a tarp over it so it was secure from anyone wandering in. This was after doing a bit of research and finding out that my climbing wall is what a lawyer would call an Attractive Nuisance, whereby a child "of tender year" wandering onto my property is no longer a trespasser, but always implicitly invited, because the climbing wall is so attractve, and if that child gets hurt on my property, it's my legal liability. So I put that wall in and then built hinged fence to close over the entire front of the wall so there's no way to get in other than cutting the tarp, breaking the fence, or otherwise vandalizing the thing. I'd like to think this offers me some legal protection, but who knows. Oh, and I painted giant warning signs on the fence, too:

That's with the fence open, and here's with it closed:

Holds

Oh yeah, climbing holds. This doesn't really relate to the construction, but bears mentioning. I bought a bunch of sets from So Ill Holds and Nicros. Here they are, in all their glory:

That's only about 75 bolt-ons, and the wall has over 500 bolt holes, so I have some... room for expansion, let's say.

Conclusion

It took me a full month of fairly solid work (probably a few hundred hours) to build this wall, but on the upside I was able to do it all myself save for a few parts (standing up the A-frame, putting the pipe in, and holding up the larger plywood panels.)

I spent probably $3000 on all the materials (including about $600 on holds), and another $1000 on tools. On the upside, now I have a very robust wood shop. And a big bouldering wall in my backyard.

If you are working on your own wall and have questions about any of this stuff (obviously, there is plenty of detail I didn't go into here), feel free to email me at **bsharp 'at' blueandorange 'dot' org**.

Posted by bsharp at November 14, 2006 01:08 PM

Comments

I have been wanting to make my own for quite some time now but most sites i found werent quite what i was looking for and didnt look as safe as i would like. Yours looks great and you have given me some brilliant ideas thanks a lot.

Posted by: James at November 16, 2006 01:49 AM

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