### MakerSpace and Shelter 2.0 cutting instructions

The Shelter 2.0 design that the MakerSpace is based on is a digitally-fabricated structure designed as a transitional housing option for the time between initial emergency response with tents and temporary housing, and permanent reconstruction. It has a raised floor, doors for security, open space in walls for insulation, and is built from materials that give it a lifespan much longer than many other options. It was also designed to be constructed by unskilled labor with minimal tools, and the pieces sized to efficiently fit in a shipping container.

More information can be found at [www.shelter20.com](http://www.google.com/url?q=http%3A%2F%2Fwww.shelter20.com&sa=D&sntz=1&usg=AFQjCNHGmt5wvycYHUu8Pm-v3tZeb_JMYw)

##### FORMATS:

We supply files in three formats.

* The easiest to use are the ShopBot part files ..the OpenSBP format...that are ready to cut. They are the same files we use when we are cutting MakerSpaces and Shelters, and we’ve done all the work on them.
* We also supply the PartWorks/VCarvePro files for those of you that want to do your own toolpathing.
* The last format is dxf CAD drawings that can be used if you need to modify the individual pieces

If you are cutting with a machine that only reads g-code, we’ve included a VERY rudimentary convertor that will convert just the commands we use in your sbp files to gcode. We make no guarantees that it will work for your needs...there are lots of dialects of g-code...so use it at your own risk and test the output files thoroughly before using them in production.

##### MATERIALS AND HARDWARE:

There are 3 material thicknesses used in a MakerSpace and Shelter 2.0

* **¾” Advantech -** The framework and floor panels...and the optional endwalls... are cut from material that's nominally ¾”. The material that we use is actually 0.72” so our files are toolpathed to cut 0.74” deep. All these file names start with “threequarter\_”
* **½” plywood -** The inside wall panels are cut from nominal ½” material, in our case actually 0.47” thick, so these files cut 0.50” deep. All these file names start with “half\_”
* **⅛” acrylic** - You'll need one 48" x 96" sheet of material for window inserts. We use 1/8" acrylic, but you can use whatever you want. A full sheet is enough to cut 6 window inserts which is more than you need...you can either cut the extra ones as spares or save the extra material for another project.
* **⅛” plywood or tileboard -** for an optional inside ceiling

For the 3/4" material we use [Advantech](http://www.google.com/url?q=http%3A%2F%2Fwww.advantechperforms.com%2F&sa=D&sntz=1&usg=AFQjCNEZREUpAbR5uLDed6usYU2lsofsDQ) from Huber and really like it...it's stable, stays flat for easy CNC cutting, is environmentally sound, and is strong and weather resistent. The ½” side panels are cut out of Plywood, and we like AraucoPly for it’s strength and consistency

We’ve experimented with OSB and REALLY wanted it to work because it's really cheap, but it just doesn't have the strength or stability needed for long-term use. Your mileage may vary.

Here are the required materials for one shelter

***Basic Structure:***

|  |  |
| --- | --- |
| ¾” Advantech: | 25 sheets |
| ½” Plywood: | 4 sheets |
| 1.25” x ⅜” hex bolts | 140 |
| 3.5” x ⅜” hex bolts | 16 |
| ⅜” flat washers | 312 |
| ⅜” hex nuts | 156 |
| 15’ x 25’ tarp | Optional. If used you’ll need line or cable ties to attach to frame |
| 2’ x 8’ corrugated metal or plastic | Optional. If used buy panels with 7/16” corrugations. |
| 2.5” drywall screws | approx. 2 lbs. |

***Endwalls:***

|  |  |
| --- | --- |
| ¾” Advantech | 9 sheets |
| ⅛” acrylic | 1 sheet |
| 2” x ⅜” hex bolts | 90 |
| ⅜” hex nuts | 90 |
| ⅜” flat washers | 180 |
| clear silicone caulk | 1 tube for windows and trim |
| 3” hinges with ⅝” rounded corners | 4 pairs |
| latches and locks | misc to suit location and application |

***Optional Ceiling:***

|  |  |
| --- | --- |
| ⅛” white tileboard or equivalent | 8 sheets |
| small “gutter screws” to match panels | 32 |

##### LAYERS:

The Partworks 3 toolpath files are created with layers for the various cutting depths. The layers for the end wall parts are:

* THROUGH\_CUT: This is for lines that are completely cut though the material, and are the actual edge of the part. Part profiles need to be toolpathed to the outside, and holes in those parts will be toolpathed to the inside. The parts on this layer should all be BLACK
* CUT\_HALFWAY\_THROUGH: This layer is the half-depth pockets that connect multi-part assemblies like stringers, ribs, sleepers, etc. The parts on this layer are RED
* MARKS\_ON\_FACE: This layer contains all the identification marks that are etched into the surface of the parts. The parts on this layer are BLUE
* MARKS\_IN\_POCKET: This layer contains all the identification marks that are etched into the face of the half-depth pockets. The parts on this layer are GREEN
* POCKETS\_FOR\_HINGES: In the door and trim layouts are pockets for 3” hinges that should be cut 0.125” deep. They have already been offset for a ⅜” bit and are a continuous polyline and are toolpathed to cut ON the line. The parts on this layer are CYAN
* POCKETS\_FOR\_WINDOWS: On the window frames sheet there are 0.125” deep pockets for the glazing material you select. We usually use ⅛” acrylic but you can choose whatever works for you. They have already been offset for a ⅜” bit and are a continuous polyline so should be toolpathed to cut ON the line. The parts on this layer are ORANGE
* HINGE\_BARREL: The barrels for hinges have to be cut a little deeper than the flat leaves, so in the door and trim sheets are lines that are cut 0.25” deep to allow for that. They should be toolpathed to cut ON the line. The parts on this layer are MAGENTA
* LAYER1, 0, or DEFAULT: They are sometimes generated by your CAD program by default and if you find them should be double-checked to make sure they are empty, but are almost always safe to ignore

##### DRAWING NAMES:

The name of each ShopBot Part file include the material thickness, the parts in that drawing, and the number of times that the sheet should be cut for one Shelter or MakerSpace.

##### MATERIAL HOLDDOWN:

We use a homebrew vacuum holddown system powered by central vacuum system motors...the kind used in whole house vacuum systems. We get them from [Lighthouse Industries](http://www.centralvacuummotor.com/lighthouse.htm) and use two [LH7123-13](http://www.centralvacuummotor.com/Lighthouse/LH7123-00.JPG) in a single zone on each of our 4'x8' tables, which holds our parts pretty well. As with most things you can never have too much vacuum for holddown, but this works well for us.

##### TOOLPATHS & BITS:

To make sure that ShopBot files can be cut on a variety of tools, old and new, and with a variety of bit geometries, the part files do not have cutting speed or spindle RPM commands in them. They will use the cutting speeds that are set in the ShopBot Control software and, if you use a spindle, the RPMs in the VFD. You can modify the cutting speed using the VS command, and the spindle RPMs directly in the VFD or using the ShopBot Spindle Speed Controller

We tend to cut almost everything we can with a ⅜” bit, so the files for the ¾” and ½” material are created for that diameter bit. You can re-toolpath for a different bit, but unless you have a strong philosophical issue with ⅜” bits we recommend sticking with that. If you still want to use a different size bit there are two issues to be aware of.

* The hinge pockets in the Door and Trim sheets are offset for the ⅜” bit already, so if you use a different bit you'll need to re-offset them.
* The bolt holes and "dogbones" in the corners are sized for the ⅜”. You can re-toolpath and cut with a smaller bit without a problem, but if you want to cut with a larger bit they will have to be resized.

The two exceptions to our ⅜” bit rule are for the acrylic window inserts and the optional ceiling panels. Both if these use a ¼” bit. There are bits specifically for cutting acrylic but since edge quality is not much of an issue...the acrylic is housed in a sash frame...just about any ¼” bit will do.

##### ASSEMBLY TOOLS:

You really don’t need much in the way of tools to assemble a Shelter or MakerSpace

* You’ll need two 9/16” wrenches to tighten the ⅜” bolts, and if one is a ratchet life is a little easier.
* A drill to screw the floor and sidewall panels to the ribs and the trim to the endwall panels...preferably a cordless one. The correct size drill bit to drill pilot holes for the drywall screws is needed, and the correct screwdriver tips for the drywall screws you have...philips, square, or Torx.
* A rubber or plastic mallet is helpful, mostly for “persuading” pieces together that are being stubborn. Don’t get too carried away with it though...light taps are what are needed.