

Program for Modeling – Adding details to your layout

Working with a 3D Modeling Program, 3D Builder

If you have read the first three articles in this series, you should have a basic working understanding of the 3D builder program. Moving forward, I am going to expose some trial and error issues that I have experienced over the last two years in working with two different 3D printers. It has not been an easy road, especially at the beginning. I hope that my experiences will help you avoid some of my mistakes.

Going back to article 4, I commented that going out on the web and finding an object that interest you is a quick and easy way to learn how to download these files, save them, and then print them. When you open the 3D Builder program, you can click on the Open Icon to find ready to download designs. One of the categories on this page was miniatures and furniture. My wife and I are involved in miniatures doll houses that are 1-inch scale. I clicked on that icon and entered in the search bar for a sofa chair. **Figure 1** is the screen that

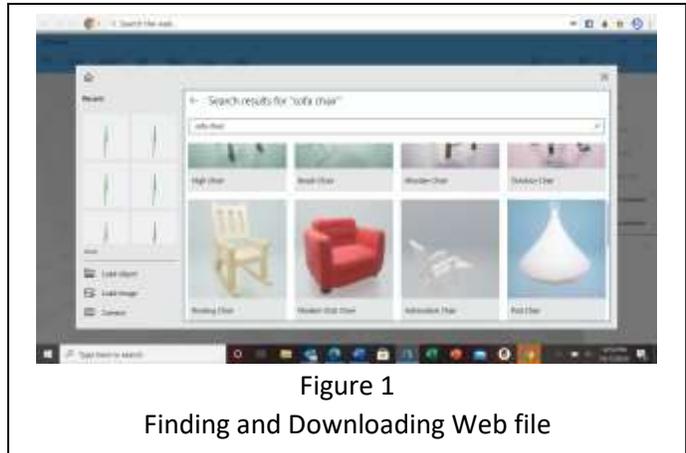


Figure 1

Finding and Downloading Web file

came up. By clicking on the picture of the chair, the program automatically opens a blank design page and downloads the file. I did not make a note of the file name! First major mistake. This file was downloaded as a 3mf file which was not useable by my printer. I had to save it as an STL file before sending it to my printer. My first printer communicated to my computer via cable and required that the computer be online all during the printing. I thought that was not going to be an issue until I saw the print time – 8 hours for a chair! And because this was all new to me, I did not attempt to open any other files and left the computer and printer run the course. My first printer was an XYZ Printer Jr and the software supplied with it took the STL file and converted it to a G code file which is used by the printer. Note that your model is printed one layer at a time. The G code is the STL coded that has been sliced into many layers with the printer printing each layer in sequence. This process is referred to as slicing the model. What I found in a later print was that this particular software did not alert me to errors generated in the G code. I did not find this out until the model would not print or printed incorrectly. Note that this model did not have any overhanging components and was a relatively easy print, the drawback for someone just starting to 3D print was the long time required to print. An interesting note when you open the print icon is it gives a cost for external printing of over \$ 200. It pays to have your own printer if you intend to do a lot of designs.

When this was done, I thought I would pick something a bit more difficult to understand how the printer worked. The file I downloaded was a V8 engine. This unit has a lot of overhang portions of the model. Overhanging is in reference to the mounting of the model to the print plate. The issue that this presents is that you cannot start printing in thin air. There has to be a support down to the print plate. This model taught me about supports printed to support the overhand parts of the engine that once printed must be removed. It took over 23 hours to print out this model. And when it was done, it had the vague shape of an engine, but lots of extra material. I took a lot of additional time to clean up the support material that far exceeded the print time. And when the support material had been removed, I lost many of the fine details of the model because of my lack of experience in working with the material (PLA) and removing these support materials. I strongly urge you to select a much simpler model for your first few prints and develop some skill in working with the materials, including removal of support material. For example, I

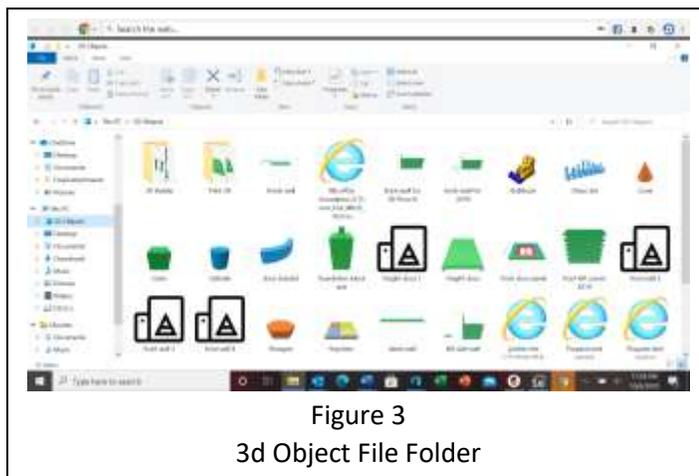
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opened 3D builder and then choose the open command. That took me to a page with several folders, the first of which was titled Kitchen. I opened that and looked for a model where supports from the build plate would be applicable to generate a good model. I choose a rocket cup. In **Figure 2**, I have shown the steps from opening and finding the rocket cup in the Kitchen folder to downloading and saving as an STL file which was then opened by the Prusa slicing program. The last view is the file in the Prusa program showing the supports from the build plate. This file took 14.5 hours to print.



When I started with the 3D Builder, I open and save several files and generated a bunch of designs, just hitting save when I was done. The program saved it to the default file, 3D Objects. In **Figure 3** you can see a portion of the files that have been saved in this folder. For the moment, ignore the two sub folders as they will be reviewed later in this article. In this folder you can identify a few items that were downloaded from the internet, i.e., chest set and key chain. The files in the double rectangle are STL files and the three in the lower right corner with the circle around it are G code files. In between these downloaded files are files that I generated while learning about the program and became the start of my first major project.



In downtown Buffalo, there is a New York Central freight house built in the early 1900's that has been partially torn down and the tracks removed. From data that I have found, originally there were 15 bays, a bay being the space equal to the garage doors on the street side. Five bays of the original freight house are still in place with four of them used by a local museum (Pierce Arrow Museum of Buffalo, NY) for storage of antique cars. The bay on what was the end of the freight house has all the roof and siding removed, exposing the steel skeleton of the building. I decided to make this my first modeling effort using 3D printing. To that end, I choose to 3D print the concrete pilings, a cinder block office building, the sliding freight doors and some of the roof trim as well as the window frames. I used Plastruct and wood for walls, the basic steel work using H beam and right angle shapes, floor and roof. I started this project in January with the idea that I had lots of time to get this done before the contest I was entering closed in August. I first attacked the cinder block addition on the street side of the building even though I think this was added long after the initial building was constructed. I also choose to model only three bays, as the even the current five bays would have exceeded the available space on the club layout. And I thought that this would make it even easier to get the model finished in time.

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The first item was to decide the sequence of design, printing and construction. I decided on trying to make the cinder block building first. I did some research and found the dimensions for a cinder block with $\frac{1}{2}$ of a $\frac{5}{8}$ mortar layer is 8" x 8" x 16. In the blow up on the right side of **Figure 4** you can see the rectangles that were generated using the

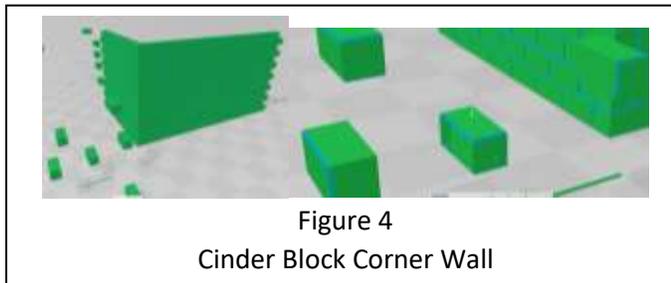


Figure 4
Cinder Block Corner Wall

insert command and inserting a rectangle. These are I used the sizing icon to size these blocks to represent a cinder block and $\frac{1}{2}$ of the mortar between blocks. I inserted a cylinder and using the sizing icon, made the diameter of the cylinder equal to the diameter of the mortar line between blocks. I then aligned it on the edge of the rectangles such that only $\frac{1}{4}$ of the cylinder interfered with the rectangle block. I then subtracted the rod from the rectangle and developed a simulated mortar line around the block. And of course, when you come to the corners, you model block becomes two dimensional in that you now have to detail two sides of the rectangle with mortar lines. Once I had a series of building blocks developed, I designed the corner section of the wall as shown. On the right side of the wall you can see the position of the blocks that would interface with the next section, allowing me to print a building whose walls were longer than my print bed could handle. Because I was new to this process, I tried to print it as shown, that is with the detail side at right angles to the print bed. I did not pay attention to the tolerances of my design that would allow the next section of the wall to mate with the first section. I printed out one corner section and one straight section. And once printed, they would not mate! Not only did I not pay attention to the tolerances to interface with the sections, I did not pay attention to the drop for unsupported blocks. I still had not learned my lesson from the V8 print experience! If I had understood the printing process better, I would have added support material to the design. However, the slicer that I was using at this time did not allow me to select adding support material during the slicing process. Providing that I had corrected the tolerances and added support material this design concept should have worked. The final roadblock in this design was that my printer was incapable of printing to the tolerances I needed to achieve this interlocking design, even with supports.

The point of the foregoing discussion is that I created and saved a bunch of files that were unrelated to each other, that is parts of a wall, key chains, just plain shapes that I was learning how to use, etc. What is shown in **Figure 3** is but a portion of my original files (there are over two screens filled with these files.

Figure 5 shows some changes I made to the straight wall design and tried printing again, saving the new design as revision B (a habit I now routinely use, adding revision letters as I modified a design to achieve better printing or model fidelity). I decided that building a wall with individual blocks as I started with was not very productive of my time. I designed a front wall as shown in **Figure 5** using the blocks from **Figure 4** combined into an object of three and four blocks. I stacked these with the three block sets on one row and four block sets on the next layer up, and then repeating until I reached the design height. This gave the interlocking design that I was looking for to make extended wall lengths. I have shown one of these building blocks lifted out of the wall. Because I used a single block from the original design, the mortar lines are properly placed. I also began to pay attention to dimensions of the model as it was being

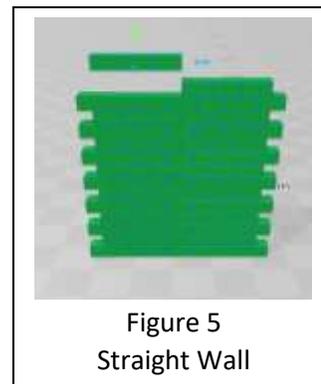


Figure 5
Straight Wall

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generated. In my first effort, I had aligned the blocks by eye thinking that this would give me the effect of a mason laying the brick. What it did give me was gaps between blocks when I tried printing. At 1:24 scale, you cannot see the small imperfections of hand laying blocks, so I needed to change my approach. I put the first block down and settled it to the build plate. I knew the dimension of this block, so I recorded the position of the first block and then inserted the second block to the side by adding the length to the X position of the first block. I repeated this process until I had the length of the section I was designing. For the second row I set the Y axis at the depth of the first block plus the height of the cinder block. I set the X dimension at 1/2 of the first block X dimension. I then repeated the insertion process in the X axis. Repeating this process in both X and Y gave me the wall size I wanted and provided perfect alignment in the X and Y direction and left no open spaces between blocks. I now had what I thought was a good design process in place. (However, reference back to the fact that the tolerances of my printer were not good enough to achieve my design goal.)

Please note that in this folder are files for the freight door, the front door to the office, and the concrete pillar with the steel plate for the upright girders to me mounted to. **Note that none of these files are grouped together and easy to find.** And the other issue that I have now come to the conclusion is that you should only use one computer to design on and save the files to, or save all files to the cloud or other mass storage that is available to any computer that you might use. An example of this problem, I was using a tower computer when I first started down this trail. After retirement, I bought a laptop that I could use for club activities, or use while sitting upstairs with my wife while I worked on the computer. In the folder shown in **Figure 5**, the window frames for the freight house are not found. They were developed on the tower computer and stored there. It makes them and other items difficult to find and reuse for another design.

Since starting my 3D printing journey, I have designed three major projects. The first mentioned was the NYC freight house, the second was CB Gizmo Mfg, and the third BLB Solutions. The first two were individual buildings, the third is complete chemical processing plant with pump houses, storage tanks, office buildings and other associated piping and outbuildings. All included a railroad spur to serve the industry.

I had not decided on how to handle saved files when I did the first two buildings and thus I now have issues when I want to go back and look for something that I used on another building that I want to use on a new design. This issue has led me to the conclusion that all projects should start as a flow chart of design folders. Because the last project is the most complex and thus the best to describe the process I have developed, I will use this as an example. Since Excel is a Microsoft program that I am familiar with, I used it to generate a flow chart. This chart is too large to include as an insert, it has been included in the reference section at the end of this paper.

In my mind the complex that I envisioned was an office building surrounded by processing and pumping buildings, storage tanks, and retorts both stand-alone and on the roof of a building. I wanted a complex looking structure that would have lots of little details to draw the eye of the beholder. And I wanted it to have some similarities to a real plant. Since I was doing this for a model railroad layout it had to be serviced by a rail spur. But I also recognized that some material and product must be delivered by truck. **Figure 6** is a concept of the complex taking some pre-designed components and using rectangles to flesh

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out my design. (Note: from the 3D Builder program, this can be printed out on paper and used for reference as you continue down the design trail.)

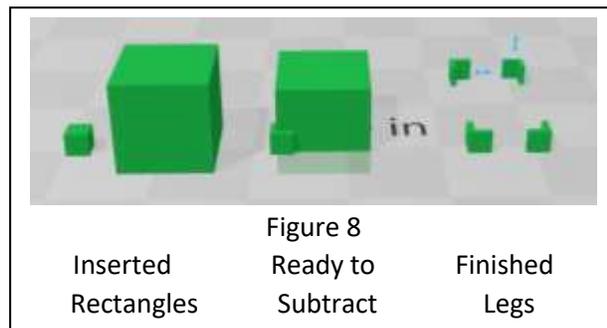
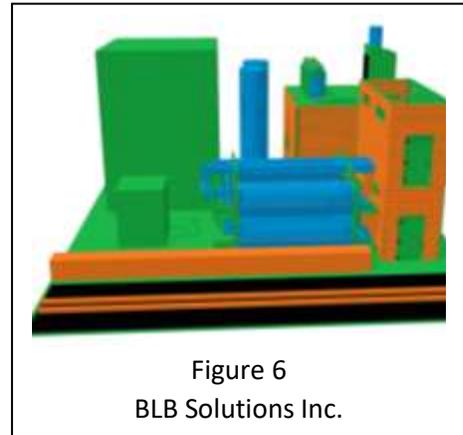
From this concept, I generated the referenced flow chart and in my 3D folder, generated folders for each component of the design. I urged you to take this approach when starting any project. It seems so simple to generate these files so that you can find items for each building I found that in two months I forgot what title I gave a design file but so long as I saved it in the right folder, I have been able to recover some of the earlier files which I then modified for a different application or building.

As an example of this approach to the design and documentation process, I am going to review the details of the gas house folder and in the end provide you with the file folders you can use to print out the building as is or modified to fit your requirements. I have always been interested in the small buildings that you find next to railroad crossings and at other critical areas along the right of way that contain signal equipment to control gates, signals, detect hot wheels, and dragging equipment. To me this little building is missing from some otherwise very well down layouts. This project to design and print a relay house was my first significant effort in 3D printing for my railroad. The design criteria for this building were as follows:

1. Constructed of sheet aluminum.
2. Have access door with drip shield.
3. Assume that the top of the panels clicked into a structural rail and the bottom was riveted to the structure frame.
4. Ventilation grates to allow air circulation.
5. Building designed to look like it was preassembled off site, transported to the site, and lowered into position.
6. Mounted on legs so that the bottom was not exposed to moisture from wet soil.
7. Include a masthead to bring in local utility power (assumes internal batteries when power is lost).

(Note: it is good engineering (design) practice to develop specifications for your design before beginning the drawing process.)

This seemed like an easy building to develop. My process of design was to start with the legs and then work up to the roof and masthead. Starting with a new file, I inserted a rectangle of $\frac{1}{4}$ inch by $\frac{1}{4}$ inch and $\frac{1}{4}$ high. I then inserted a second rectangle 1-inch square. Setting the second rectangle behind the first, and lowering it below the print surface, I subtracted the larger square from the smaller square to make an L bracket to be used for feet. Using copy command, I made four of these legs. Using the rotation command, I aligned



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these legs so that the L was to the outside edge of each corner. Finished legs ready are now ready to be attached to the main building structure. This process is shown in **Figure 8**.

I then inserted a rectangle of the dimensions that for the shed. I placed it $\frac{1}{4}$ of an inch off the print bed and then moved the four feet into position as shown in **Figure 9**.

I then added four lift brackets by inserting another rectangle and making a flat plate. Inserting a cylinder into the design, a sized it for a hole in the lifting plate and then centered it in the middle of the plate and to one end. I made sure that the cylinder went all the way through the plate and then subtracted it. This gave me a mounting plate. Using the rotation command, I rotated the plate 90 degrees and oriented it so it was now parallel to the long side of the building. Once this was done, I used the copy command and made three more.

I then position these on four corners so that the building could be lifted by a crane. I leave the implementation of this to the reader if you want to practice generating piece parts.

The aluminum panels were conceived to be 2 foot and 1 foot panels to make a 6 foot by 8 foot shed. In order to simulate these panels, I again inserted a rectangle into the drawing and adjusted its size to represent edges of the panels. I copied this as many times as needed, position them to represent the joint between panels for the 1 and 2 foot width. Making sure that these rectangles were longer than the height of the building and extended over the edges of the building. I then subtracted generating simulating panels. I used the same approach to simulate an entrance door.

To the door I added another series of rectangles to represent a rain shield, hinges, and a door latch.

I also used a series of rectangles to generate a ventilation grate. The last item on the core of the building was to simulate rivets on the bottom of each panel. To do that I inserted a sphere and reduced it's size to equal the head of a rivet. I then placed a series of these along the bottom on each side. Except for the roof, the building was basically done.

To make the roof, I inserted a wedge into the drawing. Using the lateral dimension commands, I made the bottom of the wedge equal to the width and depth of the building. I then adjusted the Z dimension to give me the roof slope that I wanted.

The final item was the mast head for power. That was done by inserting a cylinder equal in diameter to a large conduit of 3-inch diameter ($\frac{1}{4}$ inch dia.). I inserted a sphere with the diameter of $\frac{1}{4}$ inch and positioned it on top of the cylinder. I then copied the basic cylinder, shorted it with the length command and then put it at a 30 degree angle. I then moved it to position it in the ball at the end to generate the cable entrance connection.

I now had a complete file for trackside relay building. Note that during this cycle, there were many saves since the 3D Building program does not do automatic saving. The “finished” design is shown in **Figure 10**. It has been saved as cmf file. It was resaved as an STL file since this is the file format that the Prussia printers require.

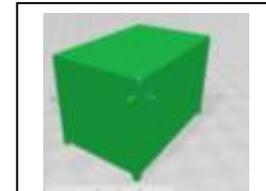


Figure 9
Legs Attached.



Figure 10
Trackside Relay Shed

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Though you may not have a Prusa printer, some of the following discussion though generated for the Prusa machine, I believe the lessons learned are applicable to any printer.

I mentioned earlier in these papers that the drawing file has to be processed by slicing it into many thin layers. For some printers, this slicing process is internal and not visible to the user. Nor do you have any control over the slicing parameters. This is particularly true of the lower cost printers.

The Prusa software allows for some significant settings in the slicing process. **Figure 11** shows the screen that comes up when the software is opened. The upper right are where you can enter various settings. To the left side at the top there is a bar that has a box with a star next to it. When you click on this box, it generates a path to find the STL file you want to print. When you select a file, it will appear on the right side below the screen with the slicer settings. At the bottom is the command to slice. For the Original Prusa printer, the sliced file, called a G code, is downloaded to a memory card. When the card is inserted into the computer, a symbol will appear in line with the slice command. Once slicing is complete, there is a command to download the G code. If you highlight the memory card, it will open the card and ask if you want to save the file to it.



Figure 11
Prusa Opening Screen

When you say yes, it downloads it to the memory card and a icon will open next to the memory card icon that will dismount the memory card from your computer.

But before we slice the model, we must set the slicing parameters in the upper right as shown in **Figure 12**. At the very you can select the level of experience that you are comfortable with. Remember that the higher the level, the more control you have over the printing. In this example, I have chosen Expert. The next is print setting. You can select from a drop down menu the diameter of the filament and the quality of the print you want to make. In this case, I have set it at 0.15 dia filament and a quality print.

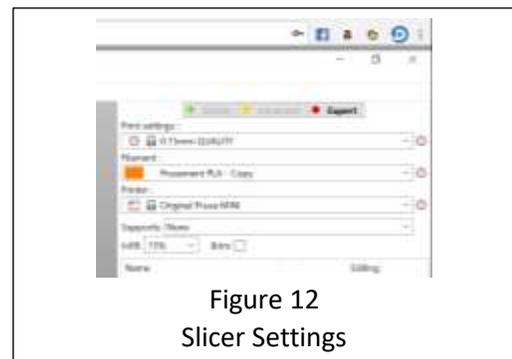


Figure 12
Slicer Settings

The next input is the type of filament that you are using.

Again, a drop-down menu gives you all of the options for different materials and thicknesses. Because most of what I am doing is not going outside for long time periods, I am using PLA. Note that if you are doing a building for outside, PLA is not recommended. There are other materials that will withstand the constant UL rays of the sun as well as the temperature gradients of changing weather.

The next box allows you to select which printer you are using. Currently they only have two printers, the Original and the MINI. If you one printer of each, this is a critical setting as they have different print beds and the slicing is slightly different. Enough so that the wrong selection will print out something that is not

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your design! (I have done this way too often and after a 4 hour print only to find out I selected the wrong printer, it hurts!)

The next box allows you to decide if you need supports and what kind of support. The options are none, build plate only, support enforces only, or all support. The support enforces only would provide for supports within the model to support overhangs that do not exceed the foot print of the object on the print plate. The build plate only allows support of overhangs that can be supported by a structure from the print plate. For the relay cabinet, that was the rivets, the door hinges, the drip shield, and the ventilators.

The next line has two items to be selected. The first is the infill of the object being printed. If we were to make the relay building solid, we you use an excessive amount of filament with no benefit to the model. The program prints an internal pattern that reduces the fill. The program default is 20%. As you can see in this example, I am using a 15% fill. The second item on this line is a check box for a brim. Brim is a first layer deposit around the perimeter of the model. For large structures like this building, a Brim is not needed. However, I still use it as I seem to get better bottoms around my model. It is particularly important for tall thin objects such as pipes that are printed vertically (I find that horizontal pipe printing does a poor job in creating a round uniform pipe).

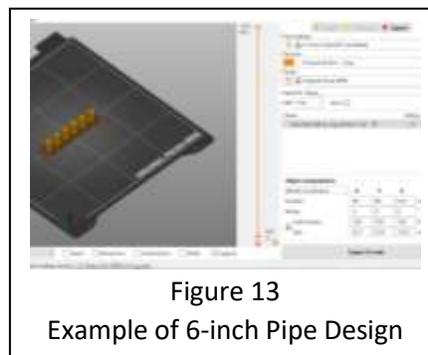
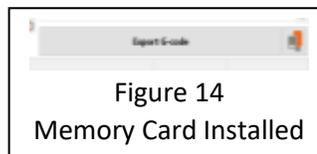
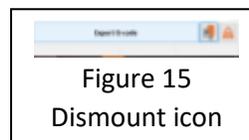


Figure 13 shows a screen shot of a series of pipes needed for one of my chemical buildings. Note the hole in the middle of the pipe.

I use pipe pins and insert these in the center hole to align the pipes prior to gluing. The importance of this figure is show the Brim around the base of the pipes. On the right side you can see the name of the file that was downloaded to the slicer. The table below the file name is data on the placement of the model on the printing plate. At the very bottom is the command to export the G code. I inserted a memory card into the computer and the icon showed up in line with Export G-code (see **Figure 14**).



When this icon is clicked, the file will be transferred and a second icon appears (**Figure 15**). Clicking on this icon will initiate the text box that says unmounting was successful and the memory device can now be removed from the computer and transferred to the printer. I suggest that you load the file into your computer and slice it for your printer and print it out. There are very small differences in the length of the pipes, so it will give you an idea on the tolerances you can achieve with your printer. I would open the 3MF file and highlight each pipe while having the icon highlighted for changing dimension and record the Z dimension (what, you think I am giving you all the data?). You will need a micrometer to do this. Then compare this dimension to the printed part. The difference between measurements will provide a measurement if the tolerances that your printer can achieve.



Hopefully you were successful in printing out these pipes and have a feel for creating a file, saving it, slicing it and downloading it to a transfer media such as a memory card (Original Prusa) or USB stick (Mini). To create the pipe I had several versions until I got the object I wanted properly printed. *I will note here that*

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of the new designs, but a lot of those were because after slicing I was missing an element. There were also multiple versions as I learned how to mate panels together to make larger buildings than could be printed on the print plate.

Since I was using a silver speckled gray filament, I did not need to paint the items as the finished looked like aluminum plate. So, with the three finished parts, I assembled them using a super glue. The glue I use is ZAP (Zap-A-Gap) medium CA+. if is good for gap filling which works out well with the 3D prints.

If the shed is to be used outdoors, you should use a different filament as recommended by Prusa for outdoor use. I would recommend PET/PETG material, as it has many of the same print characteristics as PLA but is a harder material and can be used outdoors. Please note that I have not used this material and the model may require some fine tweaking to have the same results as achieved with PLA.

The files for this shed are found on the BTO web site. Feel free to download and print. ***These files are meant for personnel or club use and not for sale to the general public.*** Feel free to print them out for yourself and other club members.

In the next article of this series, we will pick up on the process of starting with the relay shed and converting it over to the gas house for the BLB Solutions model.

Note: If you have questions or comments about this article, please email me direct at cbartel@roadrunner.com. Hopefully this will shorten the total time needed to get an answer to your question(s) and incorporate any comments in future document regarding 3D printing. Questions that have universal appeal to 3D printing will be posted along with the answer, but the person submitting the question will not be listed.

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Reference Figures

Full Size

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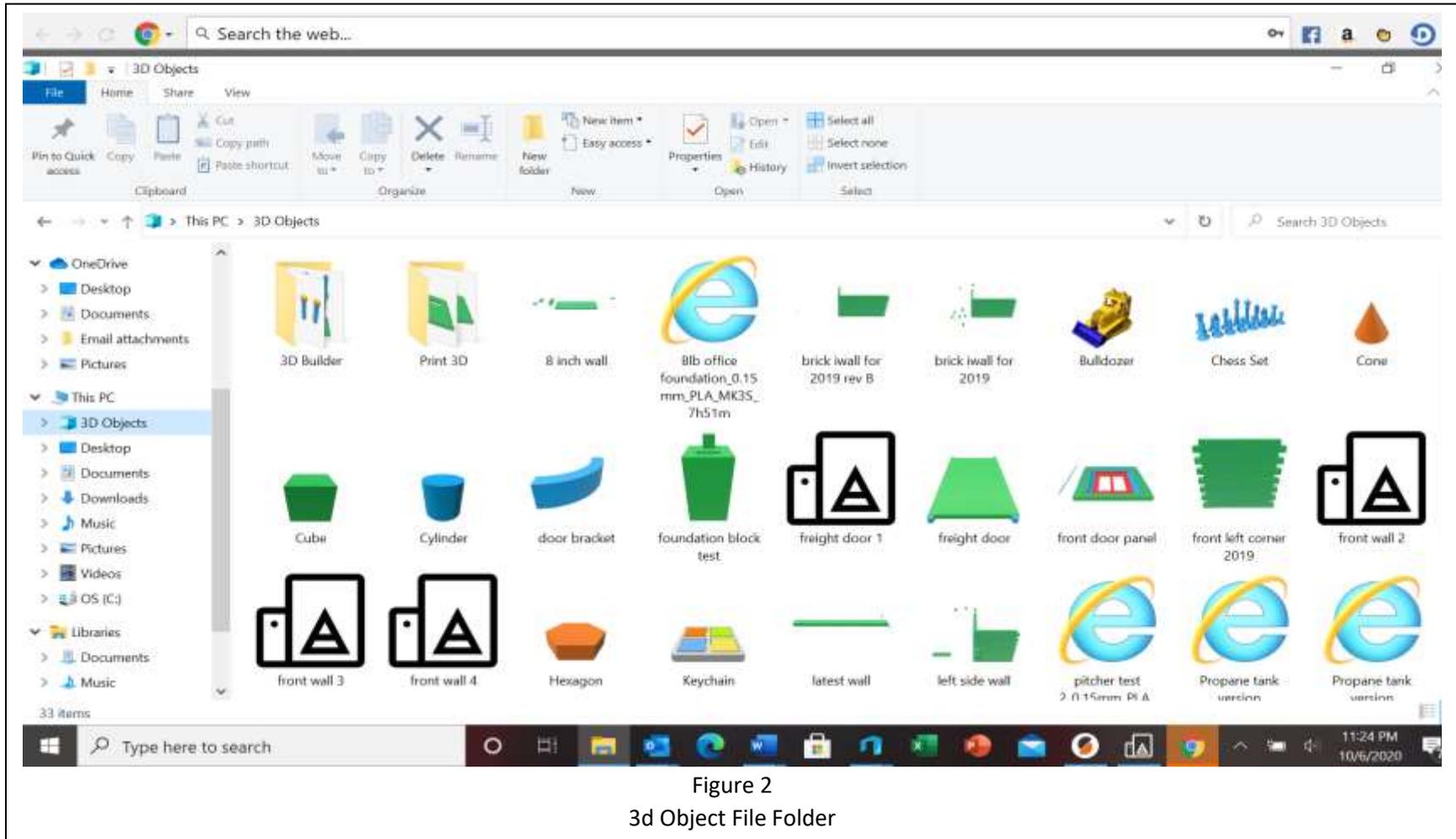
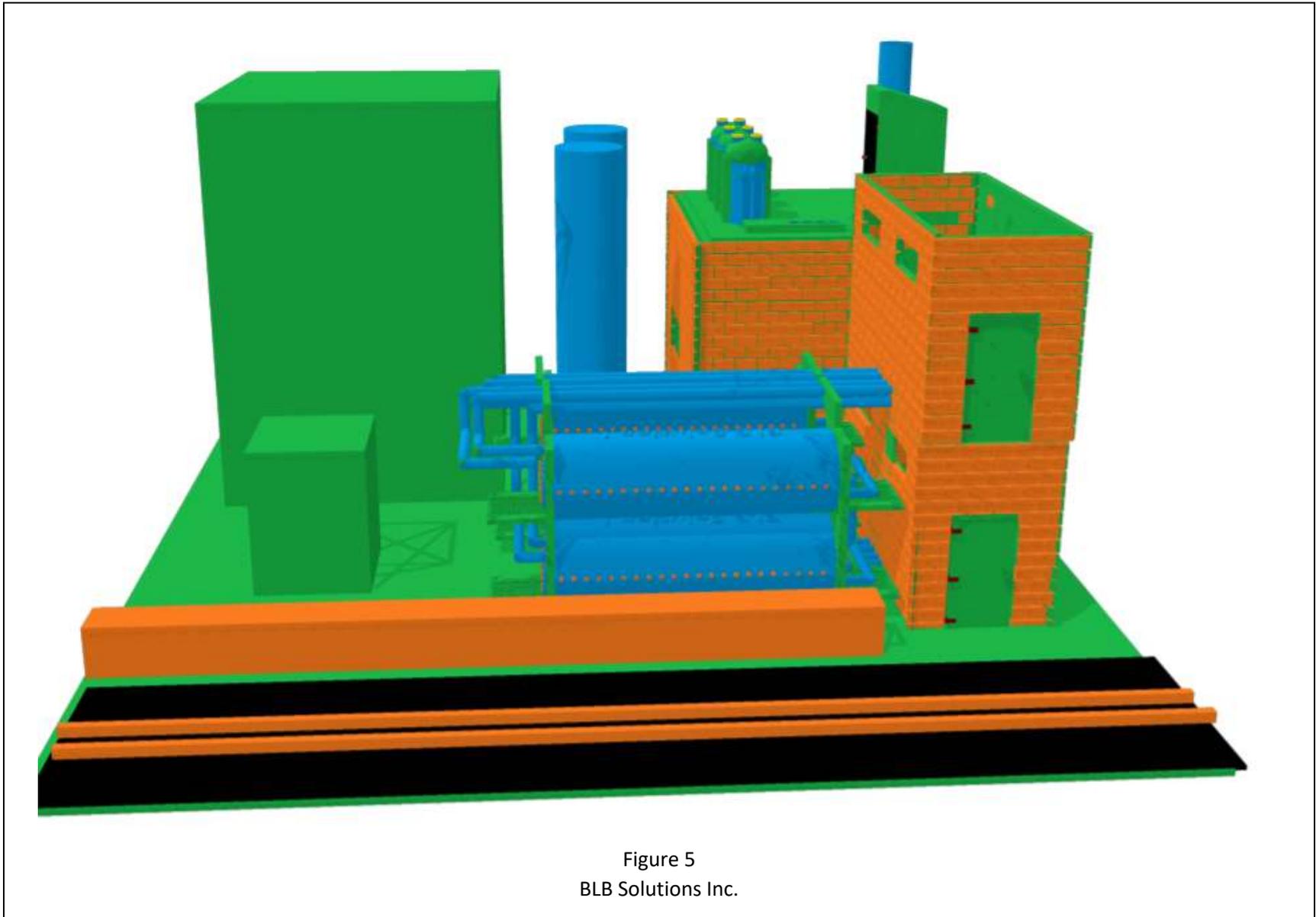


Figure 2
3d Object File Folder

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Figure 7
Prusa Opening Screen

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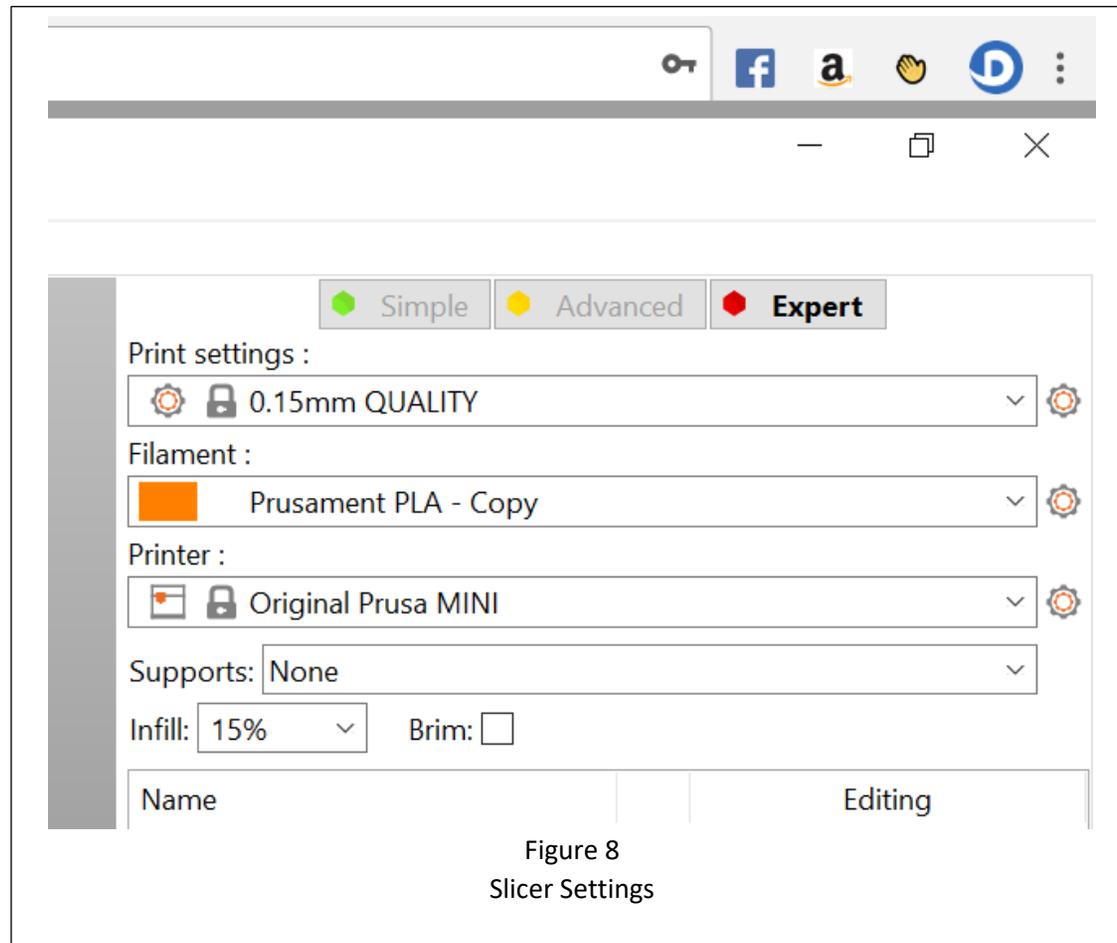


Figure 8
Slicer Settings

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1											
2											
3											
4											
5											
6	Folder	BLB Solutions	Pump House #2	Storage tanks	Office Building	Gas house	6 inch piping				
7	Description	Pump house with I/O to pump house #2. I/O to retorts. To have internal control panel seen through window, as well as tanks and pipes. Truck loading/unloading, on street side. Double equipment door required. Roof details with additional retorts, roof pipes to pump house #2.	Pumps to/from tank cars, to/from BLB Solutions building where chemicals are processed, to/from storage tanks. Two story building with roof access, roof pipes to BLD Solutions.	Storage tank for raw material and final product. Lots of pipe work.	Three story building with attic equipment level. First floor maintenance/rep air, shipping/receiving desk, reception desk, file cabinets. Second floor office sales, administration. Third floor engineering activity. Roof access with air conditioning. Three floors with window access lite. Internal stairway fire	small shed based on trackside realy building with a 12 inch gas main coming in and two 5 inch mains going out with globe valves on these two mains.	5 inch piping chosen as default piping for application. Straight pipes of various sizes (hopefully not having to cut to length) with centering hole and pipe pins to assist in assembly pipe configurations. Includes ball vales, gate valves, elbows, extensions.				
8											
9											
10	Folder	Retorts	fixtures	track support	roof parts	Furniture					
11	Description	large vertical tanks with input/output pipe lines for material and product, platforms for maintenance, hatches for internal access and gas lines for	This folder reserved to files created to assembly project components. Example, pipe spacing between storage tanks and pump house # 2, rial spacers for	Tie plates with four spikes, three spikes and two spikes to represent slightly low maintenance issues.	Roof parts that may be used in other projects or shared between buildings on this project.	Standard office furniture, i.e., swivel chairs, desk, 3 and 6 drawer file cabinets, phone, books, waste can, etc.					
12											

