A Moveable Workbench

Version 1.0

James A Crawford

Synopsis

I do a fair amount of carpentry work around my property and I also wanted a work bench which was stable enough (short of a full granite top) to do some optical work as it applies to telescope making. Since a lot of building materials come in 4' x 8' dimensions, I wanted a work surface that was large enough to work with that material size as well. I consequently built a fairly massive 4' x 10' workbench with some helpful features that come in very handy when it needs to be moved.[1]

[1] U24144 2017 Feb 25

1 High-Level Plans

A conceptual sketch of what I started out with is shown in Figure 1.

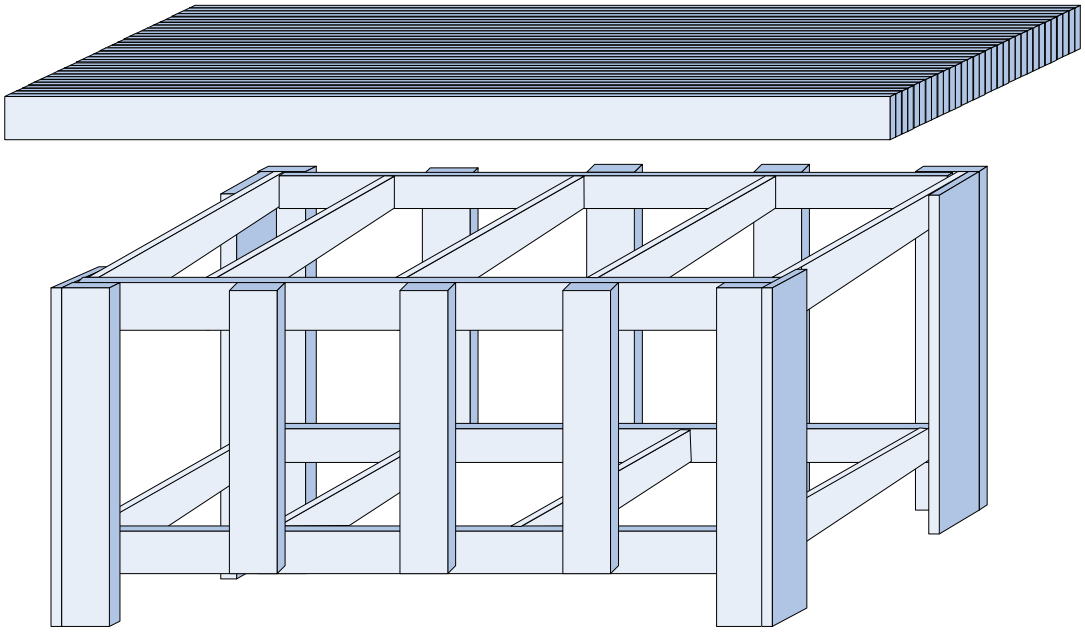

Figure 1 Conceptual sketch

Borrowing from previous lessons learned, I decided to include the following features into the design:

- The workbench had to be above floor level except for its four feet
- The bench would be a full 4’ x 10’
- The top of the bench would itself be quite massive, but finished off with replaceable sections of ½” MDF material so that if a portion of the work surface were to get seriously marred, it could be easily replaced.
- Top surface items like my bench grinder and vice would be individually mounted on standard footprint 5/8” plyboard using make-shift pegs so that they could be easily moved around the table and or completely removed as needed
- The workbench itself would be of open construction rather than building in drawers from the very outset. Any subsequent drawers would be built in their own drawer “cage” and then mounted within the workbench. Although this makes the bench somewhat heavier, it addresses the always-present warping issues that arise when using cheaper building materials like those available from Home Depot. On this same topic, I always dry out the material for a couple of weeks in advance of using just in case some of the lumber is on the green-side of things.
- Perhaps most interesting, the table had to be extremely stable and yet moveable on wheels due to its size and weight (300+ pounds unloaded).
- I decided to make the frame out of redwood for primarily aesthetic purposes

2 Pictures are Worth a Thousand Words

A bit of context is usually helpful. I built my first work bench about 3 years ago. A picture of it is shown below in Figure 2. I subsequently put together a fairly large flat-bed CNC machine which took away my first workbench as a workable space. This workbench is smaller (3.5' x 8') but still quite heavy. When the drawers are filled with hardware and tools as they are now, I am unable to move it without first jacking it up on dollies at both ends.

Figure 2 First workbench built about 3 years ago (2014)

Regarding context, I built all of the drawers from scratch. Making the drawers was the easy part it turned out. It was more tedious to actually install the drawers in the workbench frame because of minor warping that was present is some of the wooden members.

If you attempt to buy drawers ready-made, get ready for sticker shock! And generally speaking, unless you really plan your design out well in advance, the drawer dimensions you need will not be standard. The drawer sliders (shown in Figure 3) are fairly pricey as well. Consequently, a bench sporting 20+ drawers may look cool, but the sliders will unquestionably be the largest dollar figure in your bill of materials. I consequently went with fewer but larger drawers.

I routed all of the drawer fronts on the CNC machine. All of the drawers were first constructed as plain rectangular units and the drawer fronts subsequently attached. The two drawers in the upper left are actually one piece and serve as a door which provides access to the CNC controller electronics.

Figure 3 One of the drawers loaded up with CNC routing accessories. All of the drawers are quite large.

3 The New Bench

A picture of my newest workbench is shown in Figure 4. The drawers are still a work in progress and the end-cap near the air-compressor has yet to be installed.

Figure 4 New bench operational

Although the workbench normally sits with its four feet firmly planted on the cement floor in my garage, the need to also have the bench moveable was of paramount importance from the very beginning. I found plausible solutions on the Internet, but most of the concepts had undesirable features or were prohibitively expensive. In the end, I found two 2" pneumatic cylinders on Amazon for only about $35 a piece and built my design around these.

The cylinder core diameter is very important in that it is a major factor in determining how much weight the pneumatic system will be able to lift. Using more than two cylinders is of course an option, but this invites issues with unequal loading which could pose some other problems. Using two cylinders has some load imbalance issues as well, but since the cylinders are separated by almost 10' and the bench will be lifted off the floor only about 2", having a wobbly bench surface while lifting will unlikely cause anything to inadvertently fall off the top work surface.

My air compressor can provide up to 150 psi, but I wanted to stay more in the 100 psi range for margin. With 2" *diameter* cylinders, in principle I would be able to lift up to $2 \times \pi \, 1^2 \times 100 = 628$ pounds neglecting friction and other inefficiencies. My design also includes a mechanical advantage of almost 2:1 as described momentarily which makes it possible to lift up to roughly 1250 pounds in principle.

The key pneumatic design concept was the use of foldable legs with small casters as shown in Figure 5. In the wheel-retraced position shown here, the bench is fully seated on the cement floor and the foldable legs will be as shown. Once the pushing-down action of each pneumatic cylinder is in play, however, the gap between the two foldable legs becomes nil, the foldable legs are situated at an *exact* 90^o with respect to the sides of the bench, and the entire bench will be lifted about 1.5" off the cement floor by the caster wheels carrying all of the weight.

Positioning of the two hinges shown in Figure 5 is crucial for maximum weight-carrying capacity. Note that the end of each foldable leg will be situated directly underneath each hinge axle when the wheels are extended. The 2:1 mechanical advantage comes from the fact that the wheels are located about one-half way up each foldable leg. Situating the wheels even further back from the center gap would have resulted in more mechanical advantage and the bench stability would have also been better with the wheels closer to the bench perimeter, but this would have also required pneumatic cylinders with a longer stroke than I had.

Figure 5 Foldable legs with casters during construction

The next step in the construction process was to install the pneumatic cylinders as shown in Figure 6. A lot of these details would have been done more easily using custom metal parts, but that would have added additional expense.

Another key point in the pneumatic design was being able to distribute the pneumatic force evenly between the two foldable legs as the gap between them changed over the stroke of the piston. The box-like arrangement[2] I came up with in Figure 6 worked extremely well in distributing the force between the two foldable legs. Since the walls of this box were just wide enough for the width of each 2”x4” foldable leg, this arrangement also curtailed the mechanical-play that was still present with each hinge thereby strongly situating all four casters in the x-y plane. The double metal plate on the top of the box arrangement was an additional precaution taken to spread out the pneumatic cylinder’s applied force over more area of the wood.

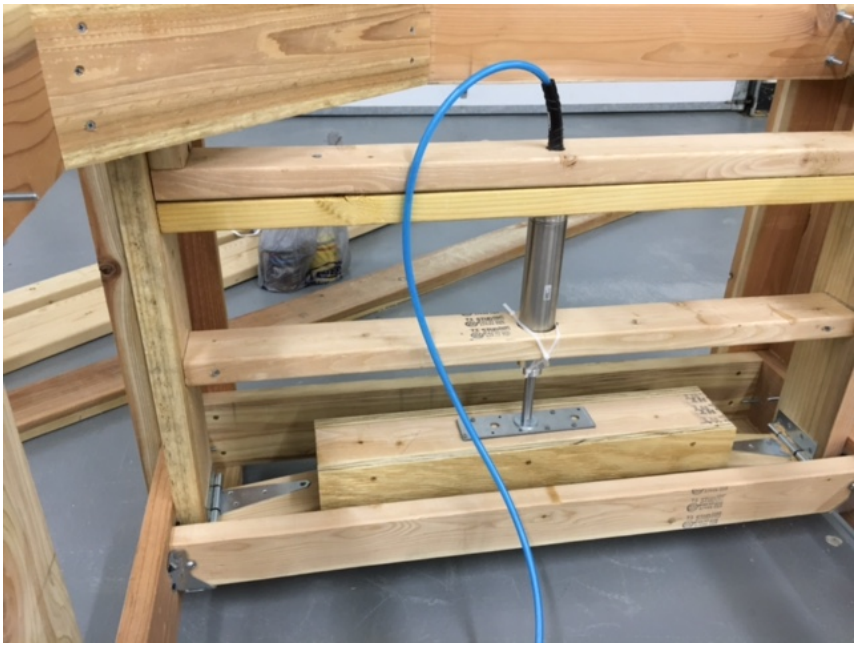

Figure 6 One installed pneumatic cylinder with force-distribution box clearly visible

I took fairly extensive measures throughout the assembly process in order to maximize strength. No nails were used- only carriage bolts, wood screws, and glue. I also carefully measured during every step to keep the members square. I used diagonal tensioning when doing the final gluing to keep the overall assembly square to better than 1/16”. Using foot-pads at each of the four bench corners helped to mitigate irregularities in my cement floor as well.

[2] Actually, a square upside-down U.

Figure 7 Workbench frame completed with foldable castor-legs situated at each end of the bench

Figure 8 Side view of Figure 7 showing the pneumatic cylinder and force distribution areas more clearly

4 Additional Details

Some devices like a vice are usually attached to a workbench permanently. I did not want to give up my large top work surface, however, for attachments like a vice so I came up with an easy way to have it both ways. I adopted a hole pattern for “surface pallets” that I use to mount a would be vice or any other device on the work surface. I used carriage bolts as make-shift pegs as shown in Figure 9 to secure the wooden pallet to the top of the workbench. Removing the vice can be done within a minute. Since the workbench top is almost 5” thick of solid wood and the holes are precisely drilled, the tools behave as if they are permanently attached to the workbench.

Using the same hole pattern for other device pallets like my bench grinder makes it easy to rearrange the location of each tool on the workbench surface as well. Their locations on the benchtop are completely interchangeable.

Figure 9 Vice is pegged in place using carriage bolts as pegs

Figure 10 Bench grinder is pegged in place on the workbench using carriage bolts as pegs. The hole pattern is identical to that used for the vice (and other work surface attachments)

I can be a neatness-freak when it comes to my work areas, so having a means to easily repair the top of my new workbench was also important to me. Consequently, the top layer of the workbench top consists of tightly-fitting sections of plain old MDF wood panels which I added a hard seal to for more durability. Each section is attached to the workbench using wood screws. In the future, should I want to tidy up the benchtop surface, it will be easy to replace an old MDF panel with a new one.

Figure 11 Top of the workbench with MDF sections easily visible thereby making for easy restoration if one or more panels get overly disfigured

