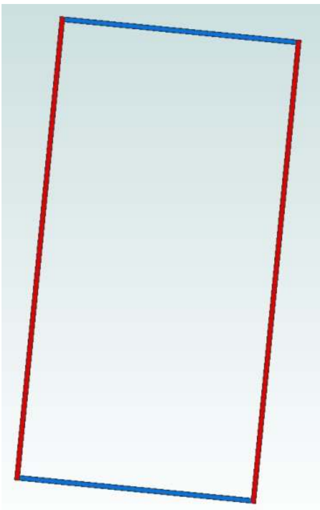
Squaring a Frame, version 3.0

By R. G. Sparber

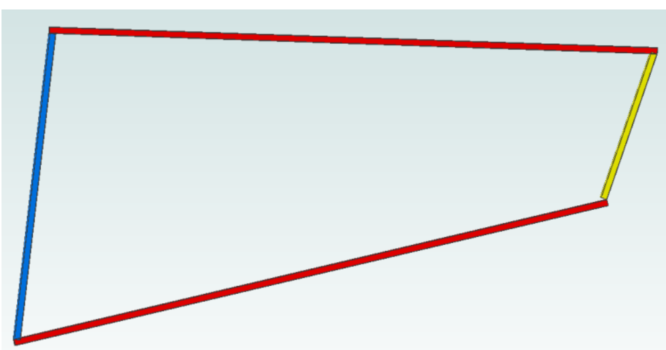


Welding up a rectangular frame like this draws on two simple rules from geometry.

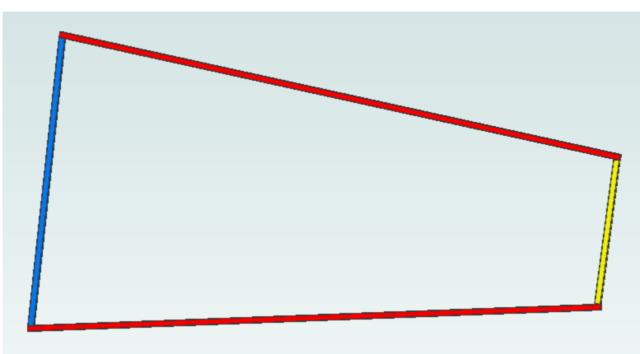
Rule 1: opposite sides must be the same length.

Rule 2: diagonals must be of the same length.

Now, let's look at what happens when Rule 1 is violated.



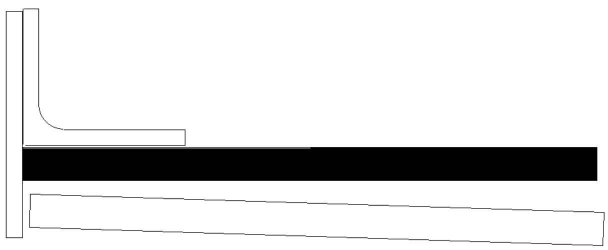
In this exaggerated example, the two long sides are equal but one short side is twice the length of the other.



If you apply Rule 2 and adjust the frame until the diagonals are equal, you will make the two short sides parallel. But you will not have a rectangle.

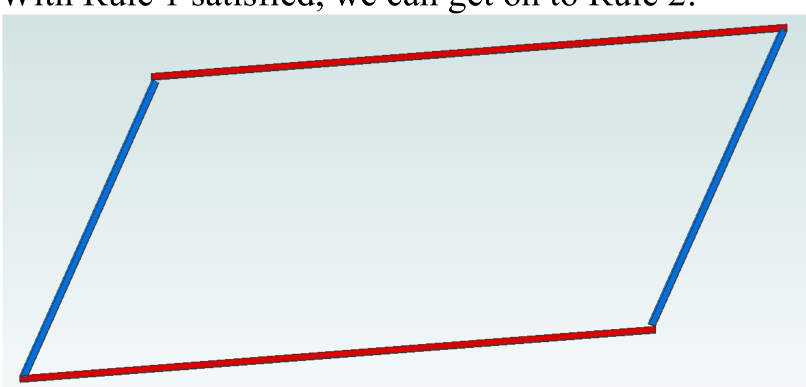
My favorite way to address Rule 1 is to carefully measure ***one*** of each length needed. I then put a mark on each piece to indicate it is my reference. Both ends are deburred.

When I need to cut one of these lengths, I use my reference rather than my tape measure. It is faster, less prone to error, and more accurate.



Especially when cutting long pieces, I clamp a piece of angle plus a plate to the end of my reference bar to act as a stop. It saves a bit of walking to verify the far ends are lined up. Do watch out for burrs that can prevent proper alignment.

With Rule 1 satisfied, we can get on to Rule 2:



Here we have opposite sides of equal length but the diagonals are not equal.

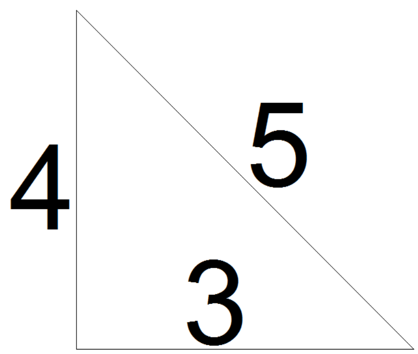
Standard Practice

If you measure each diagonal, add them together, and divide by 2 you will have the diagonal that will give you a rectangle.

Adjust the angle between adjacent sides until the calculated value is measured. Then, just to be safe, measure the other diagonal to be sure you get the same distance. If the two diagonals are not equal, repeat the process. Something shifted.

The attraction to this procedure is that you only need a means of measuring the diagonals. No special fixtures or tools are needed. And if you are going to make another rectangle of the same size, you can use the welded up first rectangle as your fixture.

What do you do if your tape measure isn't long enough to span the diagonal?

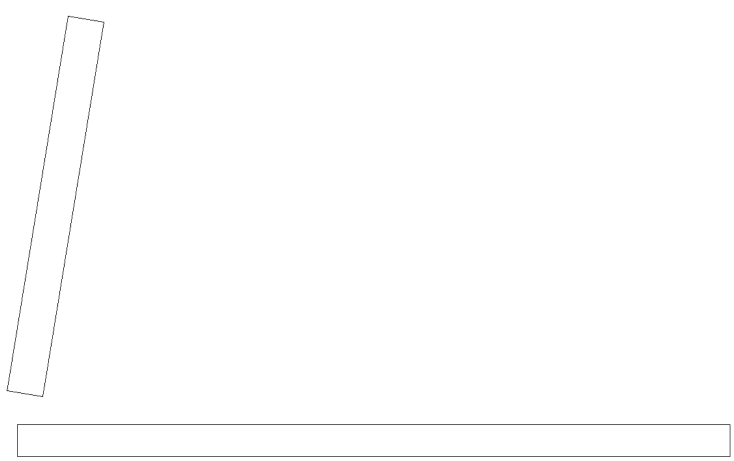


One way to solve this problem is to recall that a triangle with sides proportional to 3, 4, and 5 must be a right triangle.

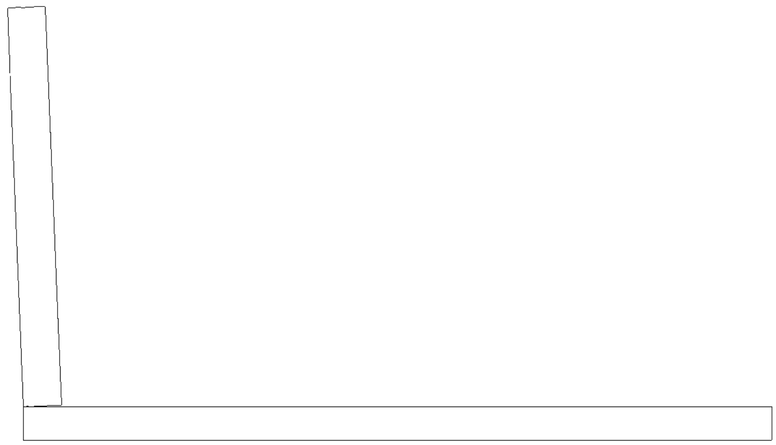
We get this set of number from the Pythagorean theorem: $A^2 + B^2 = C^2$ where A, B, and C are the sides of a triangle. If this equations is true for a given ABC triangle, then you have a right triangle. In this case we have $3^2 + 4^2 = 9 + 16 = 25 = 5^2$. Many other sets of numbers also work.

You could mark off 2' x 3 = 6' at the base, 2' x 4 = 8' tall, and adjust the frame until the hypotenuse is 2' x 5 = 10'.

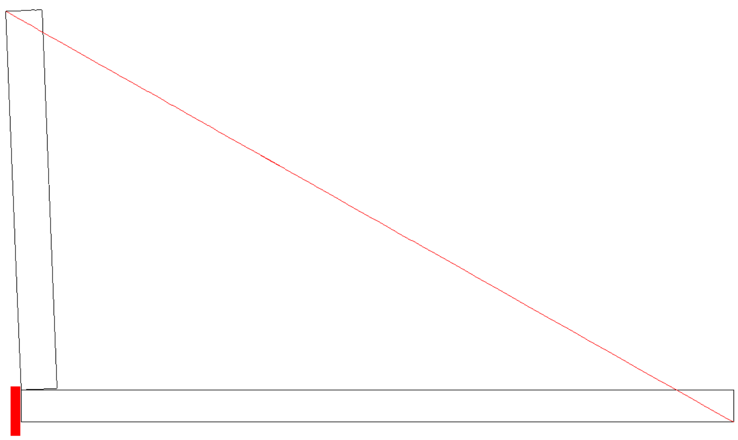
A Very Old, New Approach
This approach draws on both the technique of measuring diagonals and the Pythagorean theorem. I am trading the use of an iterative process, (measure diagonals, average, adjust frame until diagonals are equal) for a single pass process that uses the Pythagorean theorem. When done, it still makes sense to measure and compare diagonals as a final check.



I start by setting down two sides.



I get the two sides to touch and set an angle slightly greater than 90°.



The corner is lightly clamped plus a stop is added to prevent misalignment. This might be a good place to use magnets.

The outside dimensions are measured and the hypotenuse calculated.

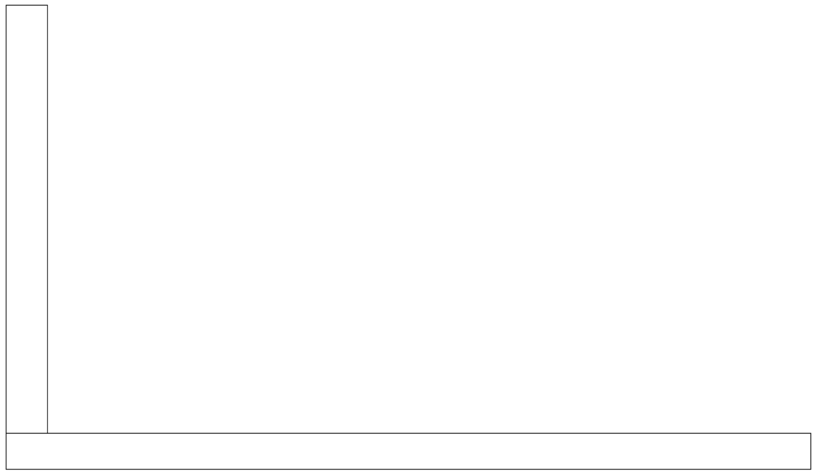
$$hypotenuse = \sqrt{base^2 + rise^2}$$

where base and rise are the outside dimensions of the frame.

Back in the days of using tables of numbers and slide rules, even this simple equation was to be avoided. But most calculators today have the square and square root functions so we are really talking about pressing a few more keys.

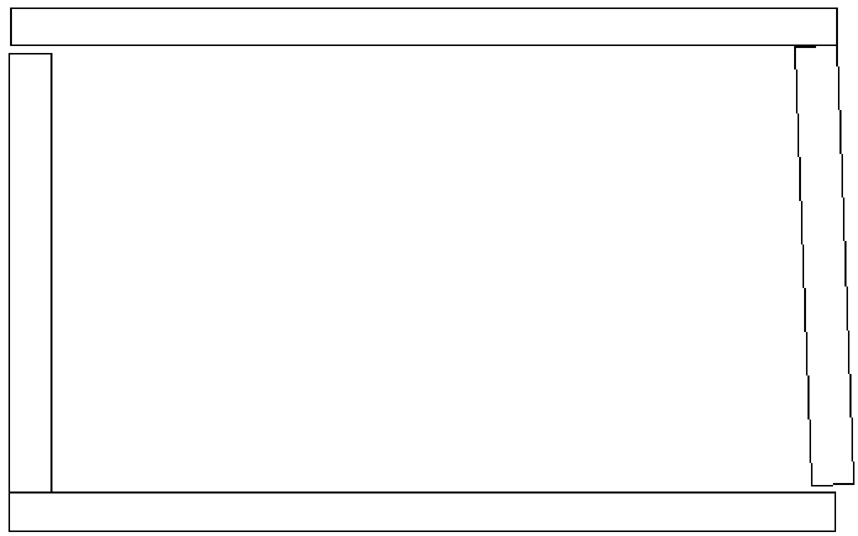
I anchor the longer side so it does not move and attach my tape measure so it reads out the hypotenuse as represented by the red line shown above. Then I slowly pull on the tape measure until I read the calculated value.

Clamp the corner.

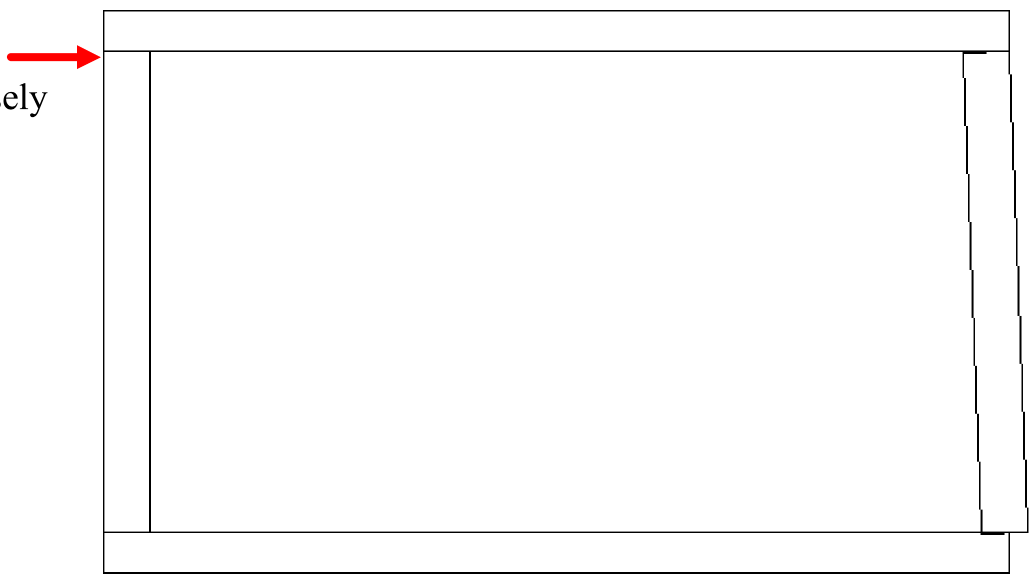


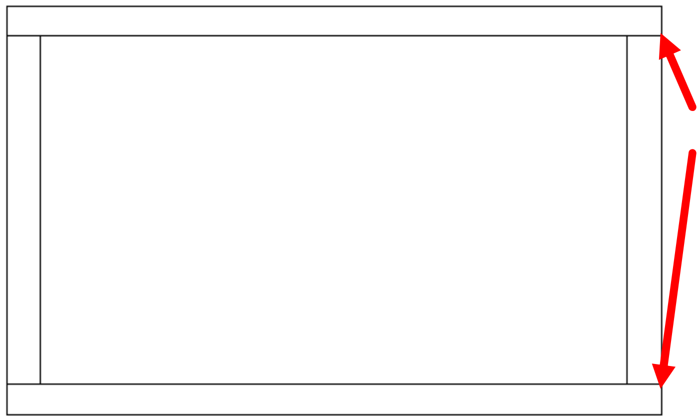
We now have our first corner set to 90°.

The other two sides are then placed down.



One corner is aligned and loosely clamped.





Then I align the second and third corners and loosely clamp them.

I can now tightly clamp these three corners. The frame is square.

As a final check, measure the two diagonals to verify they are equal.

Of course, if opposite sides are not equal, you can never true up the frame.

One annoying problem with measuring the diagonals is that the end of the tape measure does not always stay put.

I use a small magnet placed near the corner.

The steel on the end of the tape measure holds fairly well to this magnet yet I am still able to make small adjustments from the other end of the tape.

You can see in these pictures that I will butt weld the square tubing. A stronger joint can be formed by mitering these corners.

Acknowledgements

Version 1 of this article was essentially scrapped after I received a number of very helpful comments. Such is the risk of showing people what you are thinking. I would like to thank Brian Lamb, Bob Harbour, and Les Garlinghouse for their input.

I welcome your comments and questions.

If you wish to be contacted each time I publish an article, email me with just "Article Alias" in the subject line.

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