ELEVATIONS

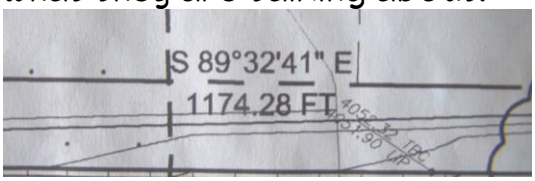
Elevations, building layouts, building lines and angles are usually done by superintendents, foremen or carpenters.

But on $15,000,000 projects like the one I am superintendent of now it is usually done by a surveyor or engineer and not always correctly.

Angles, lines and points in surveying and a lot of building layouts are measured in degrees, minutes and seconds. This measuring, calculating system is called sexagesimal, (Sex-a-gess-a-mal) (used in time and angles) and it is based on 60. It is the **product** of **3-4-5** which is what we carpenters use to check or get a square on a floor. 3x4=12, 12x5=60, this is how you get the product of three numbers.

This is also in the Bible, if you bend your elbow at 90°, from the tip of your fingers to you elbow is a cubit and your arm is also a near perfect 3rs-4rn-5rk triangle to your shoulder. Read about that in the Carpentry Book.

I am going to stay out of a lot of the engineering aspects of elevations and give you some simple procedures as to how to get elevations, but I want to explain, when you see this on a set of plans, you will know what they are talking about.



This 89º32'41" in surveying means 89 degrees 32 minutes and 41 seconds angled off of magnetic north or true north or a designated geographical line, such as a building line the architect or engineer has labeled on the plans.

One degree of a circle's circumference is divided into 60 minutes (60 segments) and each one of these minutes has 60 seconds (60 more segments) in it. Each degree has 3600 seconds. These surveying angles are measured with a theodolite (thee-odd-da-lite) or a total station, these are surveying instruments. A theodolite or total station can measure 1/3600 (60min.x60sec.) of one degree. Or you can measure 1/1,296,000 of a circle (360°x60min.x60sec.). This is a bit more accurate than the speed square that we use.

I have a theodolite and use it for aligning building lines, forms, squaring, leveling (check for level accuracy often), measuring and many other things. Rent a theodolite and you will realize what all you can do with it.

I am not trying to confuse you but it would take many pages to explain surveying and that's not what this article is about.

Now you should know that 40º 30' 0" is 40½ degrees. If you learn and study this article most of the surveyors won't look down their nose at you as much as they do at most carpenters.

Another sexagesimal equation:

If you are traveling 73 mph it will take you 49.32 seconds to go one mile. 3600÷73=49.32. Food for thought.

Now that our surveying lesson is over, we'll get on to some carpenter work.

I have over 700 concrete paving, asphalt paving and concrete form elevations that I am dealing with on this job. The original plans for this project have about 165 pages, 33"x22", quite a bit of stuff for a carpenter to be handling.

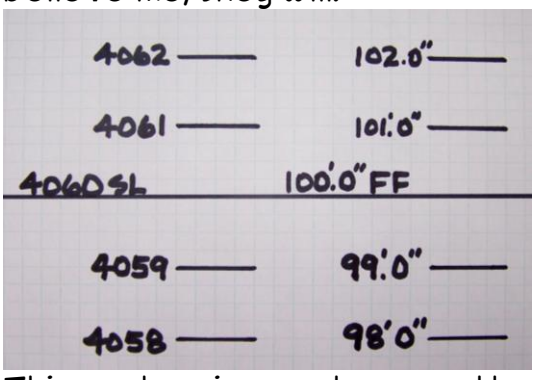
We have over 20 engineers, 40 architects, 2 surveyors, a geographical engineer that work for us and the 38 sub contractors on this job and I am head of the complaint department, I am called the superintendent, plus some others that are not mentionable.

The surveyors are hard to find and get to the job, the geo-engineer is almost impossible to get here. He tells me when I call him that "it's all on the plans Bob, and I'm busy".

So here I am with over 10 concrete, paving, landscaping, lighting foremen and many other people, all of them wanting me to give them elevations and locations. This article is to tell you how I deal with this.

If you have read the "Kodak Z710" article in Carpenters Corner you have seen that all of our exterior elevations are "sea level" elevations. In other words the finish floor of the building is 4060' sl (above sea level). The interior elevation (finish floor) is 100'0".

On some jobs these exterior and interior elevations will be all from 100'.0". Some are 100'.0' (100 feet, 0 tenths of a foot). Look closely, there is a difference, **'and", on the .0 (zeros).** Either way you should be able to get elevations, no matter how confusing the architects make it, and believe me, they will.



This drawing shows the elevations, 4060sl is finished

floor and so is 100'0". 4059' is 1' below finish floor and so is 99'. 4061' and 101' are both 1' above finish floor and so on.

You need to picture this in your mind, if the whole 20 acres that this job covers is a big flat plane, like a large flat concrete slab, 20 acres in size and all elevations are even or above or below this large planed area.

If you have a **sea level** elevation of 4051' you have an elevation that is 9' below the finish floor. Dig a hole 9' deep and you are there. If you have a **floor level** elevation of 91'0" it is also 9' below finish floor.

If you have an elevation of 103'0" you are at the top of a kitchen countertop. If you have an elevation of 107'0" you are at the bottom of the header of a 7-0 door jamb.

Confusing, may be, but that is the way we measure elevations in construction.

100 elevations in the building are nearly always given in feet and inches (not always) because doors, cabinets and nearly all interior materials are in feet and inches in the US. On the other hand, the center of a strike plate on a commercial door frame is 1 meter from the floor. Sea level elevations are nearly always given in feet, tenths of a foot and hundredths of a foot.

I have explained decimals many times in Carpenters Corner in many articles and the Carpenter Book.

I bought a brand new Stanley Fat Max 100' tape for $30 and then took a pair of scissors and cut it into pieces.

I do not understand why Stanley does not make some Fat Max measuring tapes with decimal readings, so we could use them for exterior elevation measurements. They don't know either.

I wish we would go to decimal measurements of feet altogether and do away with all of the ¼'s, ¾'s and sixteenths of an inch. Decimal measurements are what you get off of a calculator when you calculate numbers.

The feet/inch measurement did not become a standard measurement until 1958.

Following picture is the rods I use. I prefer these to a Lenker rod or a telescoping rod. The ones I make are faster and by far, easier to use and calculate elevations.

The construction of one of these rods is simple, use contact cement to apply the tape to your white 1x2x8'.

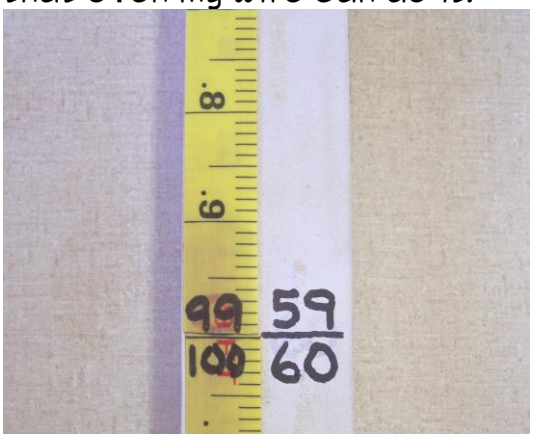
These are two of my rod targets. The one on the left is in feet/tenths; the right one is showing the feet/inches.

I'm taking 5 or 6 pages to explain to you what I usually explain to a concrete form carpenter in about 2 minutes, if they know elevation construction. You, if you are not an experienced carpenter, need to learn this, every word of this article, if you want to get paid what I get paid. I know some carpenters that wear tool bags and drive nails that make over $80,000 dollars a year. They know their stuff.

This is an LM800 CST-Berger, self leveling, rotary laser, excellent equipment.

I have set it at exactly 4' (48") above finish floor (100/4060, same elevation). If you set the laser detector at 100 (middle, 4' from the bottom) on an 8' target (rod) and go anywhere within a half a mile, the bottom of the target is exactly at finish floor, because the 0 mark of the target is 4' from the bottom.

In doing this, your elevations are right in front of you. If you need an elevation of 103.7, just set the detector at 103.7, raise the rod until the detector beeps and the bottom is at 103.7. So simple that even my wife can do it.



The 99/100-59/60 is the center of the 8' target. It is 4060' and 100'0".
If I set the detector pointer on the .8 (4059.8') you see in the picture and lowered the rod until the beam lined up with the detector receiver the bottom of the rod would be at 4059.8 which is the plan elevation, and the same as the rod reading.
No calculations, just a matter of reading the rod and setting the detector.

The top half starts with 9 and the numbers descend 9-8-7--so on. Numbers decrease, subtraction, taking away from the elevation.
Now look at the tenths of feet increments 1-2-3 on the bottom half of the rod. Numbers increase, addition, adding to the elevation.
The bottom tape is for elevations; they ascend, go up, .1-.2-.3—so on. If I set the detector at .23 **(this is the 2 then three of the small marks below the 2, which are hundredths of a foot, .23)** of a foot on the bottom half of the rod I would have to raise the rod .23 **(2¾")** to make the detector align with the beam. Your plans call for an elevation of 4060.23, you set your detector at 4060.23 and you have your elevation.
No calculations, just a matter of reading the rod and setting the detector.
With the laser set at 4' above FF and the detector at 4' on the rod, the bottom of the target is 4060 or 100 anywhere you go as long as the detector shows the flat line which tells you it is level with the laser beam.
Don't look at the laser beam, looking at the laser light could damage your eyesight. I don't know whether it will or not, but I am not going to find out by looking at a beam of laser light. If you are using a laser, use laser reflection glasses.

I have set this detector at 4059.3.
With this detector set at 4059.3 I will have to drop the rod .7 (seven tenths) (8½") of a foot for the detector to align the laser beam with the detector. The bottom of the target will be .7 of a foot below finish floor.
The elevation reading of this elevation will be 4059.30 on your plans and your rod.
Read this:

The next two paragraphs are for elevations above the finish floor elevation. Addition to the finish floor.

You know that the concrete floor you are standing on is at 100'.0 elevation and you have a plan elevation for a concrete form that is 100'.4. You have to build the form .4 (four tenths of a foot) (4 7/8") above the 100'.0 finish floor you are standing on. Look at your rod; if you lower the detector down to 4 (lower half of rod) and you raise the rod until the detector beeps or gives you a level bar, you have raised the rod .4. This is .4 above (addition) the finish floor. This is the height of your form. This is 100'.4, 100' and four tenths of a foot.
100'+.4 equals 100'.4

That is why from the 100'.0 mark (center of the rod) the numbers on the bottom of the rod are ascending (going up) starting at 1 then 2-3-4-5-6-7-8-9, to 1 foot above finish floor (101'). You are adding to the 100'.0 elevation. The bottom of the grade rod is going up to make the detector pick up the laser beam, and so are the numbers, To go up you add. Addition. Adding to the elevation.

These next two paragraphs are for any elevations below finish floor elevation. Subtraction from the finish floor.

Now you look at the plans and they give you an elevation for a hub floor sink drain for your plumber of 99'.3, 99' and three tenths of a foot. Slide your detector up to the 3 (as shown in the preceding picture) and now you have to lower the rod .7 tenths of a foot to make the detector go off or give you a level bar. So lower the rod until the detector goes off and the bottom of the rod is exactly at 99'.3. Seven tenths of a foot below (subtraction) the finish floor.
100'-.7 equals 99'.3

That is why from the 100' mark (center of the rod) the numbers on the top of the rod are descending (going down), starting at 9 then 8-7-6-5-

4-3-2-1 to 1 foot below finish floor (99'). You are subtracting from the finish floor elevation. You are going down. The bottom of the rod is going down. Subtraction, you are going down and so are the numbers, subtraction. To go down you subtract. Subtraction. Subtracting from the elevation.

Now I know very well a lot of you seasoned carpenters, architects and engineers are wondering why I am going into such detail explaining something so simple, to you, as elevations. To a green carpenter this is not so simple, elevations are very confusing, I know, I can remember trying to figure out and learn the calculations and procedures of elevations, and I know you can too, if you will admit it.

And there is another thing, think back and try to remember how many times did a veteran carpenter stop and take the time to teach you a procedure, not many, I'll bet. Most of the ones I worked with wouldn't tell you anything, they treated me like a toy they could make fun at and show everyone how little I knew about construction.

I made up my mind when I wrote the Carpenter Book that I was not going to be that way.

I am taking the time to show these young carpenters the proper way to work as a carpenter, and that is why I spent over 1000 hours writing the Carpenter Book.

You should do the same thing, teach them and don't make fun of them.

Now for you veteran and green carpenters, this is a story about a procedure few know. I, in over 40 years of construction, have met very few that used or knew this simple, time saving procedure:

You have to memorize this set of numbers and decimals, and it is not as hard as you would think, write them on a card three times a day for a week, you probably already know about half of them:

1" equals .083 (thousandths of a foot).
2" equals .16 (hundredths of a foot).
6" equals .5 (tenths of a foot)
For you that don't know; if you have a decimal .123, the 1 is tenths, the 2 is hundredths, the 3 is thousandths.
Here is the list you have to learn and memorize:

1"= .083 (83/1000)
2"= .16 (16/100)
3"= .25
4"= .33
5"= .41
6"= .5 (5/10 of a foot)
7"= .58
8"= .66

9"= .75
10"= .83
11"= .91
12"= 1'.0' One foot, zero tenths of a foot.
To get these decimals, for instance, 10", you divide 10" by 12 and you get .83.
Remember this, between each of the numbers and above is eight 1/8's. Look at the 9", next to it is .75 then you see .77 to get the inches you add two 1/8's to the 9 and you get 9¼". You'll be within a 1/16".
Look at these:
.33 is 4" and .34 is 4 1/8" and .35 is 4¼" and .36 is 4 3/8" and .37 is 4½", I added 4/8's to 4, (.33) which is 4 and got 4½".....

.93 is 1 1¼" .97 is 1 1¾"
.62 is 7½" .65 is 7 7/8"
.47 is 5¾" .43 is 5¼"
.87 is 10½" .93 is 1 1¼"
Being able to do this, it is so easy for me to be able to translate to a carpenter using a regular measuring tape and give him elevations in inches in a couple of seconds.

I know how confusing these elevations can be, believe or not, I can remember being 40 years old and trying to comprehend this information. No one would completely explain it to me as I am doing with you.
Look at the last picture closely. Think about the bottom of the target (FF) only, if the bottom (FF) goes down/the numbers (60-59-58-57) go down. If the bottom of the target (FF) goes up/the numbers (60-61-62-63) go up. (60 is the same as 100)
The 59 (4059') is above the 0 (center of target) mark and the 60 (4060') is below the center mark. The bottom section of the target is 60+, the top section is -60.
You have an elevation on your plans of 4060.25. Go to the 60 area and find 2, then count down towards the 3, 5 of the little marks (tenths of an inch) and you have found 4060.25. By the way, .25 is a quarter of a foot **(3") (decimal list).** There are 4 of these in a foot. You will have to raise your rod a quarter of a foot to get this elevation. The 4059.50 is easy. Go to the 59 mark and there is a 5 above it. You lowered your rod a half a foot, .5 (6") of a foot below FF to align with the laser. 4059.5' elevation.
If you look on the back of the targets I build out of 1x2 and

Stanley tape you will see feet/inches and ⅛"s. Same thing goes for this side.
Bottom of rod goes down; numbers go down (100-99-98-97). Bottom of rod goes up; numbers go up (100-101-102-103). Again, 100 is Finish Floor.
Let me tell you how a superintendant's headache is produced.
You have an elevation of 101'.7 **(101 feet and 7 tenths of a foot)** on the plans. The carpenter finds the 100 elevation on his feet/inches store bought rod (feet/inches), adds 7 inches, sets the target mark at 101'7" and sets the forms and pours the concrete. Only thing is that when we go out there, we find the $2000 worth of concrete is at 101' 7", 1⅜" to low. .7 tenths of a foot is not 7". Multiply .7x12 and you will get 8.4" or 8⅜". He should have set the forms at 101' 8⅜". This happens thousands of times a day in the world of construction.
Don't confuse this .4 that is next to the 8 with the list (.4 tenths of a foot is 4 7/8") of decimal transitions Kenneth and I gave you. This .4 following the 8 is four tenths of an inch and to change it to sixteenths you multiply, .4x16=6.4/16" or 6½/16ths". You can use 3/8 or 7/16, I doubt seriously if a thirty second of an inch is going to matter on a concrete form.
If it bothers you too much to be off a thirty second of an inch on a concrete form, you are in the wrong business.
Another one; you have an elevation of 4059.60. Same carpenter, using an optical automatic builder's level.
He makes a mark on a 2x2, while the 2x2 is setting on the finish floor. He knows when this mark is in the sight line of his optic level, the bottom of the rod is at finish floor. Good. He **thinks he knows** he needs to take off .4' to get this elevation. He makes a mark down from his FF mark .4' (4 7/8") and marks it. Only problem is that he went the wrong way. Makes sense if the elevation 4059.6 is lower, you mark on the lower part. I have seen this a many times and I have done it, until I finally learned, to lower the elevation you have to mark on the upper part of your rod from your optic site line, to raise the elevation you have to mark on the lower part of your rod from your optic site line.
This is why you have to burn this in your memory:

Bottom of rod up/ascend, numbers go up. **Addition, additional elevation. Increase.**

Bottom of rod down/descend, numbers go down.

Subtraction, reduced elevations. Decrease. Remember, Sub means below.
I hope you now see how confusing and how easy this procedure can be, but by using a set "4' laser elevation" it can be so simple. You can use a store bought rod (it **should** have 0 in the center 99 above the 0 and 101 below the 0), **(it won't)** but the secret to this procedure is setting the laser at 4' above FF. Don't worry, I know if you have an elevation past 4' you will have to reset your level. **This is just common sense. If you think about it, it solves a lot of calculations without having to calculate something like 1 1¾" plus 38 7/8"- 1¼".**
You set your detector to the same elevation as to what your plans read, how could this be any simpler.
The good part about this home made rod is that you can have four targets on one rod. 4060'.0", 100'.0" in feet/inches, 4060'0', 100'.0' in feet, tenths.
In college, we spent over two weeks studying what I have given you in one hour and this is not something you will learn overnight. Our instructor (26 years old and he had never had been a carpenter) was so confused after that he was wondering if even he knew what he was talking about, and we were more confused than he was.

This elevation stuff is something you have to learn and it is not easy until you do it.
You'll realize this one day when it is you doing the calculations and elevations of a 10 million dollar job. You can do it, just learn these procedures before you get in that situation. Practice and make this information I gave you automatic in your mind.
I have given you the good, the bad and the ugly procedures of elevations and you need to know all three to do proper elevation construction. You have to know the correct way to do something if you are going to recognize when someone is doing it the wrong way and you are going to be responsible for their actions and mistakes.

I have gone through this lesson talking about a rotary laser (automatic leveling) level. It you spend the approximately $300-$1800 to get one of these, I strongly suggest that you also get an adjustable tripod, they have a crank on them and you can set the laser at exactly 4' or whatever elevation you want.
You can do the same thing using an automatic optic (one you look through) level (auto-optic levels have a gyroscope or pendulum built in them and automatically level the site tube) or a dumpy level (dumpy

levels have a bubble (vial) on the site tube you have to set in the middle to get them about level).

But let me tell you something about using a site level. Unless you set the level whereas your site tube center is at 4' you are going to have to calculate every single elevation and this eats up a lot of time and tremendously adds to your chances of a mistake in elevations. The carpenter running the level can read wrong, the carpenter holding the rod could mark wrong, all adding to your chances of setting a form or stake at the wrong elevation.

I know, I did this for over 30 years and didn't even know what a rotary laser was.

The main thing is that you have to have at least 2 people or 3 people to set your elevations. I have set a lot of elevations by myself using a rotary laser level.

Another thing, this LM800 level has never made a mistake in the 2 years I have had it but I have had many carpenters read the rod wrong and set the wrong elevation, many.

I also check the thousands of dollars worth of lasers I own before each job with a $2 water line level and so do the calibrators at the factory.

My email is on the website, if you have questions, let me know.

Website:
http://carpenterbooks.com

Bob Johnston, carpenter