

Stairs 103

CONTENTS

Flared Stringers
Framed Circular Stair
Magic Circles
Formulas
Stair Layout
Circular Framing
Conclusion

FLARED STRINGERS

In my 40 plus years as a stair builder, I have seen very few flared stair stringers that have been built correctly. Nearly all were close but only a few were right. Next time you see a flared stringer check and see if the flare is plumb.

One of the first things you are liable to run into is that the builder wants you to flare the circular stair. This is why I am putting this first in this book, because if you do flare your stair, you have to lay out for it before you start the frame.



I built this stair in 1990 in Albuquerque NM. I built it with open stringers, and then they walled it in and put a closet under it. I couldn't believe they did it. It was one of the most

beautiful stairs I have ever built. It had open stringers out of oak, which is now sheetrocked and painted white.

Very few flared stringers are plumb. The risers and flare on this stair are plumb. This stair leaves a straight 60" straight stair and is flared to 96".

You need to know about radial planes, radial movement, and radial gain before you will understand this technique. The thing about a flared stringer is that the radial plane of the flare that you are attaching is the top nose point of the stringers, the rake line of the stringers nose line.

Study these scale model pictures very closely.



If you clamp and nail a flared stringer to a straight stringer and just pull it out and block it and saw the risers and treads out it will be out of plumb like the picture above. No good.

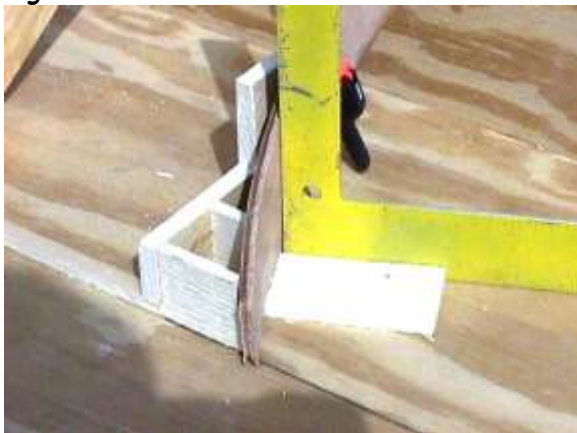
Flared stringers are twisted. Just like a handrail on a circular staircase. Notice in the picture above that there is a gap at the top of the plywood.

You need a radial knee wall or blocking to keep the flare plumb and keep the radius of the flare that you have laid out.



Some carpenters use a circular plate and blocking. This is also a good procedure.

Some carpenters, very few, build a radius knee wall, plumb it and clamp and glue their flared stringer to this. This is a good system.



This is my way, using blocking and blocks for the radius of the flare. I draw a radius line on the floor, cut some blocks the height of the first riser and angle of the flair, nail and glue them, then glue, wedge and nail-staple the flared pieces (3 or 4, .” plywood

rips) plumb. I stagger the pieces of plywood when I start them on the stringer and that way the wood covering or sheetrock will blend the flare into the straight stringer.

Be very careful here when you go to cut and construct your treads and remember in 102 how I explained Radial gain and Radial Movement. You may want to go back and review that section before you cut any material. It is very important that you understand this procedure.

Then I run a straight edge across, mark the flair and cut the risers and treads with a sawsall.

Just make sure it is plumb when you leave it.

Build a small scale as I did and try all of these methods.

For you that are carpenters but have not built many stairs, I suggest strongly that on all of this circular construction that we are about to do, that you take the time and build some scale models. If you never have built a scale model of a project you are going to find that it is almost exactly the same as full scale construction.

I have built I don't know how many hundreds of circular stairs and I still will build a scale model occasionally. You will also find out that it is very enjoyable and will give you a lot of insight as to circular construction.

Later on in 104-107 we are going to do some intense circular construction.

There is maybe less than 100 carpenters in the US that can build a open stringer circular stair, most stairbuilders I know say that the number is far lower than that.

The reason I said that most of the flared stringers I see are not plumb is that all members of the stringers in a circular stair are twisted, there is not a planed surface on any side.

The only planed surface on any circular stringer is the top and bottom of the stringer.

This is absolutely mandatory that you understand this as it explained in detail in Book 102 and the Carpentry Book.

Building an open stringer circular stair is exactly what we are going to do in 107.

FRAMED CIRCULAR STAIR

An open spiral stair is similar to the Loretto stair; the stringers resemble a coil spring, no post, no frame under the stringers. A supported spiral stair has a post in the center and the treads are attached to the post.

A circular stair is a circle, or an arc; it can have open stringers or a have a wall under the stringers, or can have no stringers and built with frames for risers and treads. This is the stair for this section.

This framed circular stair will have frames for the risers, no stringers. The next stair we build in book 108 will be an open stringer circular stair. It takes twice as long to build. This framed circular stair is the easiest of all the circular stairs to build.



Study this picture closely, and look at the frame I built and attached to the plates, on the inside of the circle. Everything I told you in the Carpentry Book and Book 102 about stair

construction, you are going to use every part of it on this simple little stair.

That is why I am showing you how to build this stair first and it will probably be the first circular stair that you will build.

About 95% of the circular stairs built are framed circular stairs and there are a hundred different ways to build it, but this procedure I am showing you is by far the easiest, simple and strongest way that I and many other stairbuilders know to build it.

It is built of 2x12 headers and 2x4 king studs, trimmers and tread cleats.

As always, the layout of the stair is the most important and unforgiving part of the procedure, as you will learn.

I do not like to build a stair that is not to code unless I have instructions from an architect and he will have to sign the plans and be responsible for the inspection of the stair. They usually back off when I tell them this.

I have turned down quite a few stair jobs, because they were not only out of the code requirements, but the structure would be dangerous to anyone using the stair.

The stair I am explaining to you is 105 degrees of a 360 degree circle. We are going to have 8 risers and 7 treads (FFR). Go to the Carpenter Book and make sure you know and learn the FFR and FFE procedures.

As you will find out, most circular stairs are not to code, they have a 6" inside tread run and usually the travel line is about 8". They don't have an 11" travel line (**slot line** is the **safe line of travel** of the "bodies center" closest to the rail) as should be the IBC code, **it is not. Slot line** for me is 11" of tread where the foot closest to handrail lands 12" from the rail. This is the way it should be, but it's not even mention in the code book. This is a real gray area in all code books.

The line of travel is the center of your feet as you walk up the stair, much more important than this useless code of a 6" inside tread run.

The office person that came up with this code has probably never built a stair, and may have never walked on one.

A stair that has treads that are over 16" in the line of travel can also be dangerous. I have seen some that are 20" and they are very uncomfortable to climb or descend.

Safety is the most important thing you can install on a staircase. You can go up a circular stair with an 8" deep travel line with ease. Going down could get someone killed, or disabled for the rest of their life. Read Fools Stair in the Carpentry Book, it is very interesting.

Neither I nor you want this to happen on a staircase that we

build and leave for someone else to trust and use.

The only 2 known factors in this stair layout is that we want an 11" tread depth where your inside foot (the one closest to the handrail) lands and a 7" rise, not much, but that's enough for us. We have Magic Circles.

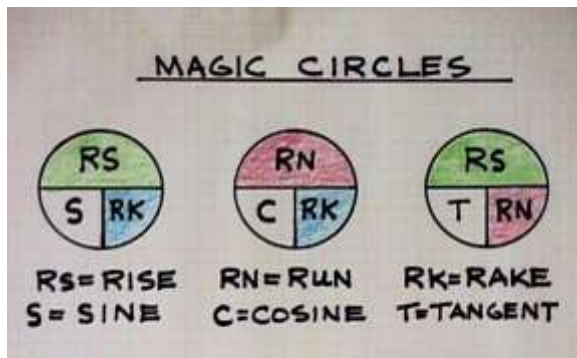
USING MAGIC CIRCLES IN CIRCULAR STAIR CONSTRUCTION

"Magic circles" is carpentry talk for trigonometry. I substituted the 3 Trigonometry names (opposite, hypotenuse and adjacent) of a right triangle with carpenter/construction talk, rise, run and rake.

I told an architect-engineer in Denver Co. one time that "most stairbuilders cannot spell or pronounce the correct names of a right triangle, but we can build the staircases for those who can".

He did not find that very humorous, he is one of the few architect-engineers that think they are better than carpenters. Spherical trigonometry is the functions and applications of a triangle inside of a sphere or a circle. R-P.

about using them and the formulas for construction. You don't have to use them. There are many different ways to get the measurements and parts list of this stair. If you have another way, use it.



This is engineering talk, that one day; some of you may get familiar with. Above are the magic circles if you don't know how to use them they are in the Carpentry Book, four pages

FORMULAS OF CIRCULAR CONSTRUCTION

Now for you that you know the Magic Circles, I am going to show you something else that will work. It is called a reverse formula.

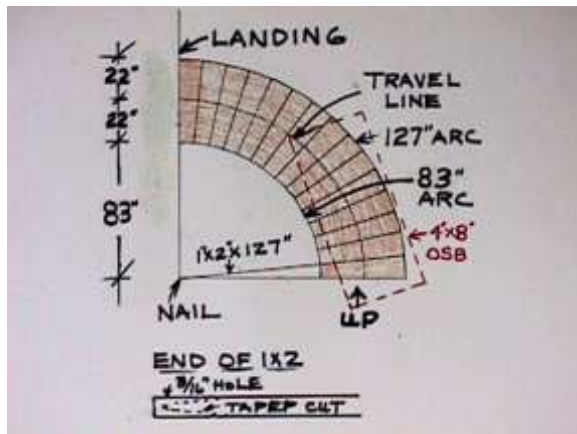
You may have had this in high school, but if you're like me, that may have been a while ago.

We know that 105" is our radius and that 210" would be the diameter if we went ahead and made a big circle (added 3 quarter circles) out of the quarter circle layout we are using.

The formula to check this would be 210 (diameter) x 3.14 (pi) divided by 4 (4 quarter circles) divided by 15 (treads) = 10.99 (11").

Good, Magic Circles work.

But say we don't have a scientific calculator handy. We only have a math calculator to calculate a ¼ bend stair.



You multiply 11 (inches of slot run you want) x 15 (the number of treads you need) x 4 (number

of 90° quarter circles in a 360° circle) divided by pi (3.14) + 2 (half of the diameter [radius])

= 105" radius and you have the radius of the safe line of travel.

Slot line.

This is absolutely the first thing you do when you build a circular stair, I usually use 12" for the slot line, just to make sure I have a good and safe line of travel.

I have read many stair articles and books. I have absolutely never seen this formula in print. This is the most important formula you will ever use in circular stair construction to get a safe slot line.

You had better write this one down and learn it, front to back.

One more time, **11" tread x 15 treads x 4 (.circles) + 3.14 + 2 = 105" radius.**

I call this the "slot line", it is the "safe line of travel".

You need to sit down and calculate some stairs using different measurements than I am using.

You are going to have to practice and practice these formulas to learn them.

Very few carpenters know how to calculate the radius of an arc. Even fewer know how to calculate the angle of a triangle. But you will know after we rail.

If you have never framed a circular stair, this next chapter is for you. You need to take heed to every word and especially every one of the drawings and pictures. Study them and build a scale model.

STAIR LAYOUT

I am not an architect but I am the one they call when they need a stair built and they have not left enough room in the area to build the stair with a safe slot line.

If you don't understand what I am explaining to you, you have probably not read all of my books about tread depth. This is the most important part of laying out a safe stair.

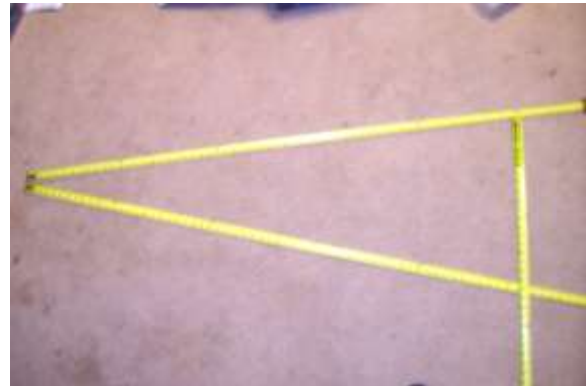
The architect drew a line on the floor and told me the stair had to stop HERE, and walked off.

When you build a house or stair, it is best to get a stair builder to calculate your stairs on paper.



This is what he gave me. I built it and the slot line will be 33." from the radius point. They gave me a 59" radius (where my tape is sitting). Let's calculate this slot line, carpenter style, no calculator. The long osb arc you see is 97" long, it was 79". I took a flexible steel tape and measured it. Then I divided it by 5 and marked 19.4" increments on the osb plate. I measured for one

point to another and came up with 19½" for each of the outside tread arc (about 18½ straight). I also marked the small circular plate in 5 equal arc increments using a rule, (flexible steel ruler).



You can't read these tapes unless you expand to about 300% on your table above, doesn't matter.



This is a procedure I use all of the time, no calculator, no nothing, just 3 measuring tapes. I laid the tapes out and at 59" I spread them out to 19½" and then found the slot line at 33½", look at the picture above.

From the radial point he gave me the inside plate was 11" from the radial point of the stair.

Where I have my tape in his picture is the safe line of travel.

This is where it is safe to go down the stair. You can go up a stair with a slot line that has a 7" slot line tread, but going down your foot will break over the short nose of the tread and you will most likely fall or injure your ankle or your neck.

For this stair to have a safe 1 1" slot line you would have to install the railing 10" from the inside radius of the tread, about half way from where my tape is to the right edge of the tread. It won't happen; they will put the rail at 3".



This puts the slot line at 23½" from the inside radius of the stair. If they put the railing center (center of handrail) at 3" (this is where we will be putting the center of our rails in "Stairbuilding 104") this will put the slot line at about 20" from the rail, it should be 16" from the rail center. I will show you in Book 104 that I put the rail in more than they told me and not one person noticed.

This 3 tape procedure is something you can do quickly and show an architect, engineer, contractor or homeowner the

stair they are going to have and some of them will understand it, some won't, and that includes some engineers and some architects.

I have shown you 3 ways to calculate the slot line. Now let's build the out of code stair that will pass the frame inspection.

This is a perfect stair for you to follow, because it will give you the correct procedures besides giving you the "out of code" stair procedures that are passed every single day in the US by building inspectors that we are paying to protect us from illegal building construction.

I am going to be nicer in these books about the building inspectors than I was in "50 years as a Carpenter".

I hurt a lot of their feelings in that book.

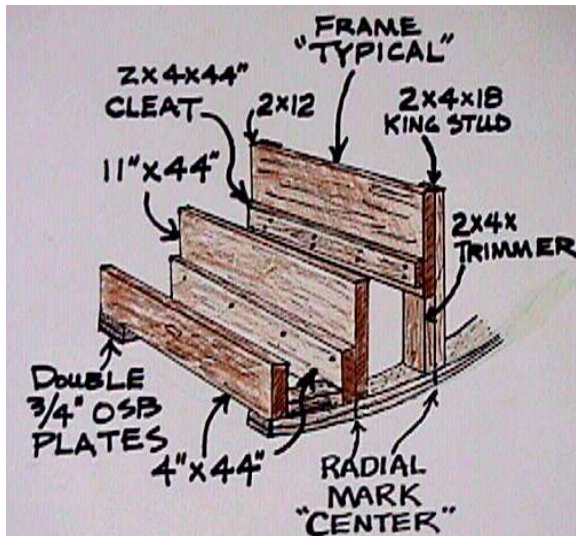
One of my best friends is a state building inspector and he encouraged me to write a lot of things I said in the Carpenter Book, and like he said, "The truth hurts when you're wrong".

Stairs are dangerous, even when they are built to my building code, which exceeds the IBC code.

CIRCULAR STAIR FRAMING

I reviewed the past pages and could not single out one procedure (especially that last one) that was not important to bringing you to where you are now in stair knowledge.

If you see one, mark it out and don't use it.



This is typical of the frames I use on circular stairs, expand and study this drawing closely, as it names all the parts of the stair frames and gives you an idea of what we are doing.

This stair I am going to show you how to build will give you a lot of knowledge as to building any circular stair.

I decided to use single $\frac{3}{4}$ " osb for the frame plates, I do this on most stairs. I glued them down one evening with weights on them and then the next morning they were solid but I still shot a few $1\frac{1}{2}$ " Pan (powder actuated nail

gun) nails in to be sure they didn't move.



On the picture above I took a piece of osb and marked an 59" radial mark and a 55 $\frac{1}{2}$ " radial mark.



I used a circular saw to cut out radial plates if they are over 4' radius. No trick to it, but you had better know what you are doing or you could get a turning saw blade in your belly. You take it very slow when cutting a radial line using a circular saw, the depth of the blade is absolutely no more than $\frac{1}{8}$ " more than the thickness of your material, no more than one piece at a time.



The smaller radial plates I cut with a 1584 Bosch "barrel grip" jigsaw, the only jigsaw manufactured to cut lumber, as far as I am concerned.

If you build circular stairs, if you are right handed you will own one or both of these, a 423 mag 7¼" FC saw and a 345 6" Porter Cable saw.



Use this cutout for a template.

To mark the smaller plate which has an 11" inside radius and a 14½" outside radius, I simply laid out a piece of osb and cut an 11" and a 14." stick and drove a nail in my frame table and marked the plate.



Now I want to show you something I had to do and that is to cut the tread cleat short because the layout of the small plate was every 3½". The smallest radial marks I like to make on an inside plate is 4.8". 4.8 "is ¼ of one of those little mystery marks that are on your Stanley tape measure every 19.2". 2x4.8"-9.6 and that is the measurement that you rip osb for a 9½" I-beam rim, 20x4.8" is 8', the most common length in American Construction. Interesting article in the Carpenter's Book.

The frames I build are 3" thick, plus the tread cleat makes it 4½" thick, code for ¾" top balusters, center to center, is 4.75", which means when I install balusters on 4.8" centers, I am one of "half of one of those little bitty marks" (as some building inspectors say) out of code, but with the finish on and the gradual taper of the baluster, a 4" ball will not go through the opening unless

the inspector drives it through with a 8# sledge hammer.

I take a lot of shots at the building inspectors in "50 years as a Carpenter" and I will be taking a few more shots in these books.

As I say in the Carpenter Book "if they want to debate staircases with me, they had better bring their Kleenex, but I won't need any".

That statement was made because of some of the dangerous stairs they have passed with flying colors and inspected by a New Mexico state building inspector.

Read Stairbuilding 101-103 in the Carpenter Book.



My first finished tread height was 37" so I need a frame 35." high. I cut two 35." king studs, a 43" cleat for this 48" frame, a 48" 2x12, and I used the burn measurement procedure to cut the trimmer, 24.". Read "[Burn Measurement and Draw Knot](#)" in Carpenters Corner.

This is the frame I built; the frame is leaning some but will be plumb when I attach the treads.



As you can see, the tread cleat is held to the frame by nails and adhesive, I don't use trimmers under these cleats, (if you have room) but you can if you want to. I shoot two 10p nails in straight at each end to hold the cleat to the marks I made on the 2x12, then I angle the other 5 or 6 nails down at about 10 degrees. A drove nail angled up at 10-15% towards the force will support almost twice the weight of a straight nail.

I have never had one single failure using this process.

I marked lines on these plates every 1 9/16" on the outside plate and every 3 1/2" on the inside plate and then took a 4' straightedge and made radial marks on both plates. The joint of the king stud and trimmer go exactly on this radial mark.

[This mark is the front of this tread and the back of the next tread.](#)

I installed all of the king frames and then installed the ripper frames.

This is the ripper frame below; you would need to add a

2x4x37" under this 4x4" ripper frame for this stair.



The bottom arrow is where you need the 2x for support. The 4" ripper frame will not hold up to load it will have to carry with support from the floor.



The next step was to cut the treads. Notice the grain of the plywood. I laid out the first tread on a sheet of $\frac{3}{4}$ " cdx plywood a $3\frac{1}{2}$ " mark on one edge and a $19\frac{1}{2}$ " mark at the other edge. I did this by marking $9\frac{3}{4}$ " from each end of the plywood, (this is the center of the $3\frac{1}{2}$ " end and the center of the $19\frac{1}{2}$ " end, then off of this center mark).

I marked $3\frac{1}{2}$ " on one end and $19\frac{1}{2}$ " on the other end using the $9\frac{3}{4}$ " center as the center of the marks.

This kept the grain perpendicular to the tread depth and gives it more strength for the 16" span on the outside edge. This is

called the material axis strength, this is why you absolutely never install osb siding standing up on the frame of a house. Always lay it down, just like sheetrock.

Then I took this tread (template), of which I carefully cut exactly to the line and flipped it over and mark the other 9 treads. Mark this first tread "TEMP" and use it to mark the others, don't use the second or fifth one for a template.

You could get off by $\frac{1}{4}$ or a $\frac{1}{2}$ " by the time you got to the tenth tread. Always use the laid out template to mark your parts.



Here I am installing the treads with plenty of adhesive. Then I shot them down with 2" deck staples ($\frac{7}{16}$ " crown).

Point to point is all you have to remember on this procedure.

Notice the gap (void of support) that will be under the underside of the inside of the tread, between the cleat and the king stud. If we could have put these on 4.8" centers we would not

have had this gap, all three members (frame/king stud/tread cleat) would have came to the inside radius and been a lot more solid.

Now we are going to get into the correct calculation of the riser height of a circular stair. I am not going to completely go over this again, I have already given to you once, but is very hard for some carpenters to understand and you cannot build a stair correctly if you don't know this procedure. Read Stairbuilding in the Carpenter's Books and read "Unequal floor finish" in Carpenters Corner" if you are having trouble with this.

The formula is: height from finish floor on bottom to the finish floor height of the landing divided by the number of risers you need to make the stair legal, then subtract the thickness of your tread $1\frac{1}{2}$ " and the thickness of you $1\frac{1}{2}$ " plate, 3". You have the height of your first ripper frame, 4". Then you add your riser height to each of the next frame.



These are parts for some circular stair frames.

Example: We have a FF to FF of 49". $49" \div 7 = 7"$. $7" - 3" = 4"$. We rip our first ripper frame 4". The next frame we rip an $1\frac{1}{4}"$ $2 \times 12'$ to $1\frac{1}{4}"$, our second ripper frame. Then we cut 2-18" king studs, lay them on the floor and nail on a $1\frac{1}{4}"$ $2 \times 12 \times 44"$ (or whatever your stair is wide) the measure and install the $6\frac{3}{4}"$ trimmers. Add seven inches and build the next one and then the next one and so on. When you get to the top your frame is going to be $8\frac{1}{2}"$ from frame to top of landing, when you get the treads on, it will be 7".

I said I was not going to give that to you again, but I did.

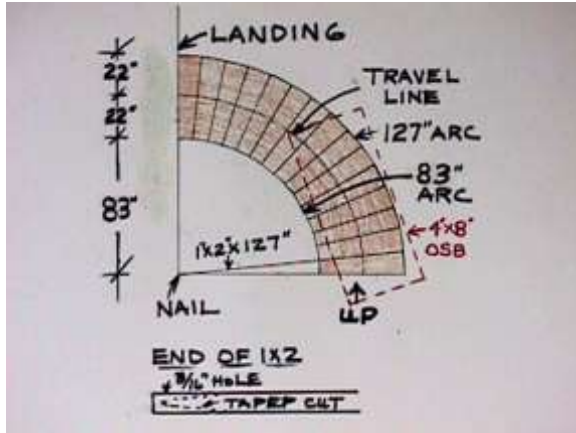
You have got to learn this, it is mandatory to calculating stair member heights/lengths and elevations.

Now I am going to show you something I hope that you understand and learn to apply the procedure when you get to a stair job and have to draw and calculate a stair in an area that the person who drew the plans gave you.

We have a stair here in Cloudcroft, in a new home, that has a $9\frac{1}{2}"$ starting step, the sixteen 8" steps and a $6\frac{1}{2}"$ step at the top.

It passed inspection.....

Reason for this: The carpenter forgot to do what I just explained to you, he did not subtract the 3" that we had in our example, which gave him a $9\frac{1}{2}"$ starting step instead of $7\frac{1}{2}"$.



This is a plan of a stair I drew, trying to explain to the homeowners and architect what they would need to build to have a safe line of travel. I did not get this job. They got another carpenter to build it with a 48" inside radius instead of the 83" inside radius that I calculated. He did a really good job on it and later told me that the stair he was building might not pass inspection.

It passed with flying colors, and it had $7\frac{1}{2}$ " slot line. $9\frac{1}{2}$ " rise for the starting step, top step rise was $6\frac{1}{2}$ ".....

Hard to believe, go measure some winders or circular stairs now that you know how to calculate circular stairs and a safe line of travel, you will be amazed at what you will find.

I turn down as many stairs as I build, some of them I turn down because I don't have the time, but a lot of them are not framed for a safe stair. I build some that are a little out of code, but I see that the architect or homeowner is responsible, in writing.



This is the finish frame and here I have rail ripper, $\frac{1}{4}$ "x $2\frac{1}{4}$ "x8' long, and I am starting the bending rail. This is what we are going to do in stairbuilding 104. Look at how the ripper is twisted.

If you have never built a circular stair frame, get you some 1x2 to use for 2x4's and some 1x4 to use for 2x12's and some $7/16$ " osb for plates and build a $\frac{1}{2}$ scale of this stair. Email me and tell me how it went.

This book has a lot of information in it, but 104 has a whole lot more, we are going to make our own stair parts and rails and connect some parts with rail bolts. I will be interesting. I am the only stairbuilder in NM that makes rail parts for resale.

If you need help Email me. Bob



This is something extra I am going to show you.

The picture above is a circular stair I built and when it was finished, including the stair, balustrade, curved beams and landings the cost was about \$175,000. The most expensive stair/balustrade that I have ever have built.

You know how to calculate and cut the round plates, calculate and the riser height, calculate and build the frames for the stair, calculate and cut out the treads, you know a lot more about this \$175,000 stair than you probably are thinking right now. As I say "these stair books are not a one-time read".

I doubt if I ever build something this elaborate again. Money was no object on this job. It was a show home.

This is what you are going to get into if you become a stair builder. You need to read "Laminating Curved Plywood Beams" in Carpenters Corner, it will show you how we built these curved laminated beams and shows some of the stair.

We built this massive structure with the same knowledge that I am showing you in these books.

I was hired for this job because the general contractor knew I could build this structure. He and I ran the frame crew to frame and finish on this architectural dinosaur. The total cost of the house was about \$1.8 million.

I thought this would be a good break and give me a chance to show you what you can do with the knowledge I am showing you in these stair building books.



If you read and learn "Laminating Curved Plywood Beams" you have the knowledge to this frame you are looking at. You build it one piece of material at a time.

This is not a job that you will do very often, but it could come up, I help lots of carpenters on jobs like this via Email, and I will be glad to help you if you get in a situation and need some advice or help.

<http://carpenterbooks.com>

Bob Johnston

CONCLUSION

If you have noticed in Stairbuilding 102 and 103, I have given you some complicated calculations for circular stairs, but I always think of the carpenter that built the Loretto Stair in Santa Fe, NM. How did he do it?

Well, when we put those 3 tapes down on the floor to measure the treads and measure the slot line, we were probably do in exactly what he did. To pop a line he stirred his horse hair or hemp stringline in some cinnamon or ground up ground up dried flower petals.

I want to tell you something else that this carpenter knew. If you take two plumb bobs and hang them 10' apart and get them to rest (lines are absolutely not turning and the plumb bob is not turning or moving) the two lines of the plumb bobs are not parallel, they are at an angle to each other.

Read "[Gravity and Leveling](#)" in the Carpenter Book.

It will humble the best of carpenters as to what we deal with getting a building plumb and level.

We will be getting into this in more detail in

books 105, 106 and 107.

We will be doing some procedures that many architects have never even thought of, I know, when I was in college and would ask one of my professors of architecture or

engineering a question about stairs, most of them, would go to giving some theory that someone came up with 3000 years ago and in no way answered my question.

I am going to do more than answer your questions; I am going to show you how to lay out, cut and build staircases, all of them.

I have shown you how you can do a lot of carpentry work on a stair without a calculator. You need to learn to use the Magic Circles and a calculator, but you also need to learn how to do a procedure without a calculator.

The next two books will be on shop made stair parts, gluing, cutting, profiling, sanding and assembly to the stair, very complicated and intense carpentry work.

There will be over 50 projects and procedures in Stairbuilding 104.

You probably got bored in 102, but not in 104, guaranteed. These books will get more complicated and be doing some of the most precise woodworking that there is. There is not any carpenter that is more respected on a construction job than a stair builder. I always looked up to them with envy. I was taught how to cut out a stair at the age of 15, but I learned how to build stairs when I was about 25, when I started building stairs on my own and that has been in profession for over 30 years.

Stairbuilding is a challenging job, a never ending learning process. Once you built a few hundred stairs you may think you have seen it all, and then some little simple stair will fool you.

The worst case that you will run into is when there are no plans, not enough room to build a safe stair and they want you to figure it out.

Read and learn these books, if you want to build stairs, for every one of these books you read, learn and apply the procedures will put you in a class of carpenters that are very few in number, and the list will get smaller as we go.

Bob Johnston, carpenter

<http://carpenterbooks.com>