

Stairbuilding 102

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INTRODUCTION

I have been a carpenter for over 50 years. When I was 9 years old I was helping my dad take down old houses, clean the lumber and build something else. When I was 13 I could actually build a few things.

In the book "50 years as a Carpenter" there are over 150 procedures that relate to stair building, 22 pages on building a straight stair. This set of stair books is a deeper study into the world of stair building. If you haven't read the stair section in the Carpentry Book, you are probably going to be lost on most of the information I am going to put in these stair books, because I am not going to refer you on every line of text. The way I am writing these books is that I am assuming you can build a straight stair and you know the names, terms and procedures.

These stair books 102-105 are going to take you from the basic calculations and construction of a stair (stair book 101 is in the Carpentry Book, and shows the basics to framing and installing a straight stair) to the most diverse formulas and complicated procedures of stair building, "book 105" building an open stringer spiral stair (the stringers look like a coiled spring).

If you are a journeyman carpenter, I hope and pray you

know how to use your equipment safely.

Safety, to me, is priority one, as you will soon find out.

There will not be an introduction and forward in 103-105.

FORWARD

Stair building has intrigued a lot of people, since time began, a little over 6000 years ago. Don't let the liberal scientist fool you.



This is the Loretto Stair in Santa Fe NM. 1880's, no doubt the most famous stair in the U.S and most of the world, and some say it is impossible for a carpenter to build a stair such as this one.

This is not true.

The miracle is not the construction of the stair.

The miracle is how he did it with the tools he had and the

availability of material. Some people say the wood was not grown in New Mexico, but it was, I use it on nearly every job.

The wood to build this stair was spruce and long leaf pine (yellow pine) natural trees of our forests. No plywood, no electricity and no power equipment. This would not be impossible to recreate.

He built it in 6 months. I doubt if I could do it in 16 months with the tools and materials he had. By the way, later on in these books (book 110), I am going to show you how to build a stair like this.

I have always have believed the Mary Jean Cook's version of this stair's history as I have seen some of the drawings that Frank Rochas (superior carpenter in the 1800s) had at his ranch in Alamogordo N.M. (Dog Canyon). He was murdered at his ranch and left quite a history of carpentry tools and drawings of things he had done over the years. The drawings for this stair were in there. I never have thought that St. Joseph built this stair because God doesn't use Spirits to build staircases; he creates carpenters to do these things. Some say it impossible to recreate this stair, it is not.

Although we will need about 3,000 dollars worth of tools and some good lumber suppliers.

There is 22' of rise (264"), 33 risers at exactly 8" each is the way this carpenter designed and built the Loretto Stair.

Absolutely an amazing piece of work.

The stair like this one that I am going to build for you will be $\frac{1}{4}$ or $\frac{1}{2}$ scale of this stair. The skin application at the bottom of the covered stringers is almost perfect, I have never seen anything this old and meticulously built.

He used no metal nails, although they were available, he used mortise and tendon joints and wood pegs and small, almost invisible wood splinters to clamp and hold his parts together.



Rochas did not rail this stair; Phillip Hesch railed it in 1887. You talk about a master carpenters; both of these carpenters were in a class of very few. You will understand this more when we get into spiral (helical) laminated stringers and

rails. If you ever come to New Mexico, you should go and look at this stair. It will humble even the best of carpenters.

I have heard there is a carpenter in the New England states that has built a stair almost identical to this one. I believe it; we have some the best stair builders in the world here in the U.S...

I could go on about this staircase for pages, but we have got a job to do.

My job is to show you what I know about stairs, yours is to take this knowledge that I have accumulated over the past 50 years and use it.

I know very well if you are reading this book and really want to be a stair builder, you have just as much intelligence as I have, and some of you have more.

You are going to invent, and devise different ways to do the procedures of this book. More power to you, this is exactly what I want you to do. Just take what you need of these books and apply it.

I know some of you carpenters noticed the last two pictures of this stair. It was the first thing my Dad and I noticed when I first saw it in 1959. The balusters are not plumb. The stringers have relaxed over the past 100 or so years and the glue has lost it adhesion and strength, hide glue, is what he used.

Bob Johnston, carpenter

CALCULATIONS

I am going to show you how to do many calculations; I showed many times in the *Carpentry Book*.

That is why I told you that you need to read it.

If you don't have it, it is available from me at

<http://carpenterbooks.com>

You are not going to be a NASA aeronautical engineer when you finish these books, but you will know what only less than 1/100th of 1% of the people in the world knows, and that is how to build stairs. All of them.

Stair building without calculations is impossible, building a hog pen without calculations is impossible, if you want it built correctly.

Don't get frustrated and confused by the calculations in this book, they are essential to stair construction. I am not going to give them to you all at once; I am going to give to you as we need them. They are scattered throughout these 5 books. Some are extremely complicated, as in radial rise and radial movement. Radial planes is another thing I am going to cover and it is almost impossible for some carpenters, engineers and architects to grasp the laws of radial planes.

A few things you need to remember are that anytime you have two characters next to each other you multiply; 2r is two times the radius. 3D is three times the diameter. $6/3$ is 6

divided by 3. Basic math and 6 geometry but like me you have probably forgot it.

There will be over 100 calculations and over 300 carpentry procedures in this set of books, but they will all be given to you one calculation and one procedure at a time.

SCHEMATICS

Schematics are drawings, sketches, pictures, soft drawings and or anything else that help you to see and understand what you are going to build.

Many places in this book I am going to have you draw out and cut out paper and cardboard templates and parts of a stair.

I am teacher, I love to teach, and I love to see someone that wants to learn. All teachers want what I want from a student, complete attention to the issue at hand.

After saying this I hope that you at least give the explanations of procedures I have instituted in this book a try. Some of you will and some won't.

I am 62 years old and every time I go to a stair job and work with any carpenter, I usually learn something. You will too if you pay attention and keep your mind open.

I need for you to go to an office supply and get a engineers rule, architects rule, 2mm lead holder and some lead refills, eraser, some card stock (2 sheets, 24x36), a 6" compass, 6" protractor (8" if they have it), some ¼" grid paper and a scientific calculator, Casio fx 260 is the cheapest and the best. With these tools, we will begin our trip into the world of stair building, a trip few carpenters have made, and few that ever will.

MEMORY OF MATERIALS

If you are one of the majority of builders and carpenters that believes concrete does not have a memory, you probably can quit this book now, because there is no one that tell you about the memory of material or how to use it.

The memory of material is the qualities that a material is made with or that it is created with, that gives it an ability to return to its original shape after it has been bent, twisted or moved.

Memory.

Engineers and geologist say that a fired brick or a rock, such as granite has hardly any memory. True.

Glass has about a 10% memory before it breaks, about the same as concrete.

If you break a piece of material, no one can evaluate the memory. Dry Spruce wood (this is the wood that the Loretto Stair was built of, and some other woods) is very stiff, will hardly bend, but spruce soaked in hot water (or steam it) makes any wood flexible; you can also use molds and glue and capture and retain the shape of the part you are wanting. When a part is pulled from a mold, it will usually not be exactly like the mold when you pull it.

This is called spring-back, the material wants to go back to its original shape.

On a lot of these bending rails you have to wet the rail or steam it, put it in the mold and clamp it (dry, no glue) then pull the rail and glue, then reclamp it in the mold and let it set overnight. It still will have some springback left in it.

LUMBER

Lumber is trees that have been fell, bucked and sawn into useable stock.

Mills take this rough lumber and mill it into finished products that we use to build stairs.

Engineered lumber is Microlams (laminated veneer lumber) lvs.

Plywood is an engineered product. All of these are explained in the book 101.

Hem-Fir refers to a mix of Hemlock and Fir trees.

A very strong and available wood. The tensile strength of lumber is readily available to anyone with a computer or in a library. I do not reference any books in these books and if I went into this tensile strength stuff, that is exactly what I would be doing, because I don't know all about these things. I do know this; yellow pine is a strong wood, so is oak and both are heavy. Pine is a weaker wood and lighter to pick up.

I have just about depleted my knowledge about the aspects of wood, but I know how to use them and manipulate them to get their maximum strength and usefulness. I know about pitch tension and the headaches it can cause a stair builder when cutting it and implementing it into a staircase assembly.

The Carpentry Book explains pitch tension in a very detailed manner.

FLOORS, WALLS AND SUBSTRUCTURES

You may be thinking that we are never going to cut a board, we will, but this section, the ones before it and the following sections are things you have got to know before starting any stair job, this one especially. Before building any stair you should inspect the floors, wall and substructures of absolutely any structure you build anything to.

I have seen great stairs built on 2x6 floor joists on 24" centers and spanned 15' and more.

They got the stair built and they had a depression in the floor. I have seen this many times. I have seen stairs built and the landing wall bows and deflects because of the force that the hanger boards distributes when a stair is used for a while.

Any stair you build should have the load capacity to hold and support about 200 pounds per tread. 16 treads=3200 pounds. Most of this will be on the anchor plate but some, about 30% will be forcing the hanger board wall to go away from the stringers.

Can you imagine 2240 (70% of 3200) pounds of pressure on a floor that is designed to support 105 pounds in an area 10"x42" (area at the bottom of the stringers where the anchor plate is). Now we are into this Memory of Material stuff. With no memory, the floor joist (code

built floor) would go down about 1/16" every time someone walked up or down the stair and in a short few times of use and this stair would be down one story. I-beams and solid floor joist have a memory and they will sustain tremendous loads and recover to their original shape because of the way they are designed. This 3200# is an imaginary load.

Probably never will happen, you think, 16-200 pound people on a small staircase, but it happened about 8 years ago in a disco up in the northern U.S. The steel stair and the landing collapsed and killed some people. Engineers and architects know that this is unlikely.

Another case, a catwalk collapsed a couple of years ago because no one inspected the cable connecting plates that were holding the catwalk up. Look up "Stair disasters" on the internet.

It will strongly reinforce what I am trying to teach you. There is no way that we could afford to build all stairs to carry such a load. We could but we would go out of business, because no one would hire us. Our prices would be astounding for such a stair and balustrade. This is the same as the Food and Drug administration does, it gives the OK for drug companies to sell some drugs and they know a few are going to die from taking them. Sad but true.

Back to stair building.

We have a stair, that we know could have a 3200# load and we have a floor area of 3 square feet that 70% of the load is going to be distributed to. Well, what are we going to do?

I'll tell you what we will do, we'll build it to code, exactly to code, and as I do, go a little or lot beyond the code. Install a beam in the floor, if needed. The IBC code is what I was taught to build stairs to and I have always tried to do this. IBC says that a 4" ball shall not pass through any opening in a balustrade, some local codes will let a 6" ball pass through.

Some local codes will let you do anything. Learn and use the IBC (International Building Code). Any time you use and abuse materials and structures, in a way that they were not designed for, you or someone else is going to pay for it, in money or lives. New Mexico adopted the IBC code in January of 2005. I can go show you some commercial staircases that are not to code, not just a little bit out of code, there is some that are so far out I would be afraid to walk on them. The contractors, inspectors and carpenters that built these suicide structures are probably proud of themselves, but I'm not. This book follows the IBC code, as you should do, all of the time.

HEADROOM

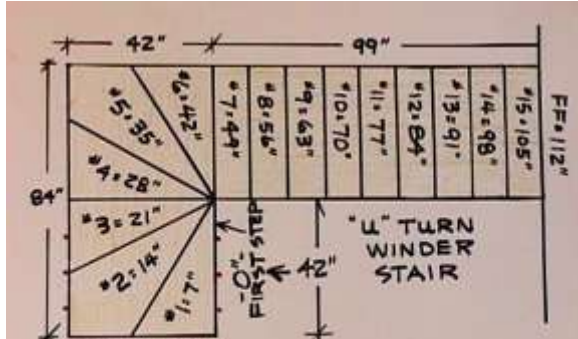
I could show you a picture here and explain headroom. Fast and easy.

The best way for you to really learn this and remember it, is for you to do it. Take your grid paper and draw a stair stringer, one grid up is a riser and two grids long is a tread, draw about 8 steps. Now draw a line connecting all of the points whereas the risers and treads meet (nose line is what you are drawing) Now take your architect scale and use the $\frac{1}{4}$ " scale and draw a vertical line 7' high off of the nose line. Now draw a line at the top of the 7' line parallel to the nose line. This is how you draw a staircase plan. This is how you measure headroom, 84", not 80" as most codes read. The extra 4" is for sheetrock, wood trim on the corner and many other things that can bring an 80" rough opening headroom area down to 76 or 77".

You have just completed your first stair lesson/procedure, and I will guarantee you that you will remember it, since you drew it and thought about it. If you will notice the headroom is measured off of a rake line (nose line to stair builders) and not off of the center of the tread nor at the back of the tread, and that is a vertical, plumb line off of the nose line to anything that is above it. It doesn't lean, it is plumb.

WINDERS

Pronounced (whyn ders) not (when ders).



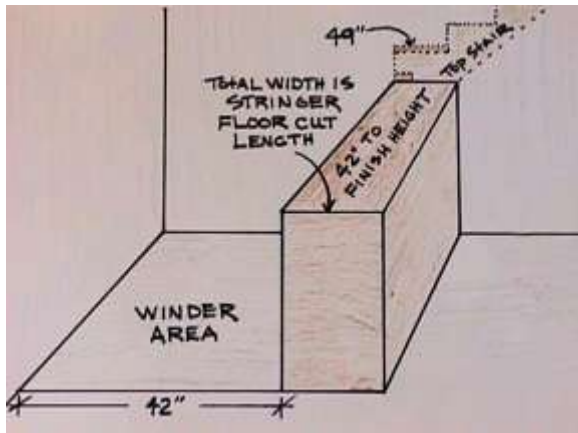
Expand these pictures to 200% and read the details.

This U shaped winder does not save a lot of floor space (5 sq. ft.) but the main thing it does is change the approach and reduces the stair area. Some say that winders are dangerous.

All stairs are dangerous.

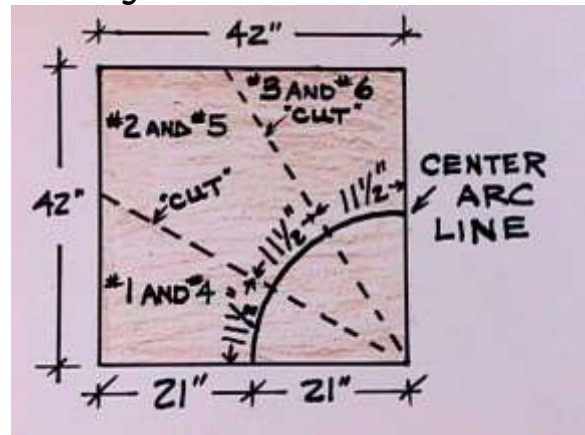
Just about anything you build 1" high or higher that you walk on is dangerous.

The first thing you do is calculate the total stair, for simplicity of calculations and since 7" rise and 11" run is IBC code, I am using 11 1/2" to the top finish floor.



Second is to build a base for the top stringers to attach to. Frame it out of 2x4's and cover it with 3/4" osb. Attach the frame to the wall. If there is no stud behind the rock, cut an opening and install a 2x block to attach the base.

The finished floor of this base is the same elevation as the 6th tread, 42". It goes 42" from the landing wall and is 42" wide.

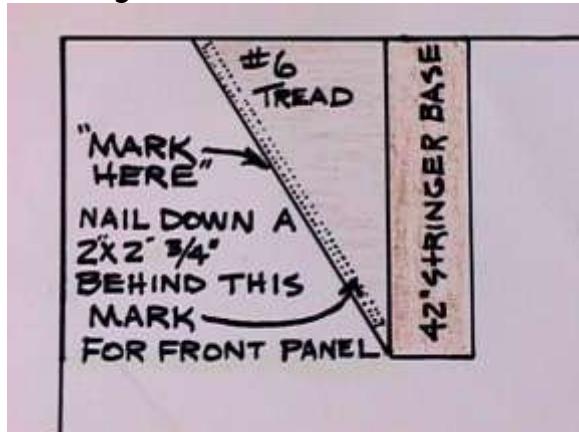


Cut a piece of 3/4" osb. 42x42", then mark the winders on the osb. They are 30 degrees each (90 divided by 3=30).

With this 42x42" winder area we will have about 12" of tread area in the travel line, code is 11". The reason we use 42 on nearly all of our stairs, is so that we will be certain and have a full 36" clear when we finish, another reason is that if we go to 43" we have to install another handrail on the wall (IBC code). Cut the winder templates, and mark them, 1&4, 2&5, 3&6, just like I did on the drawing. I want you to really study these drawings; I am not putting them in the book to show you how good

of an artist I am. They all tell a story.

Missing one small detail and you could get lost.



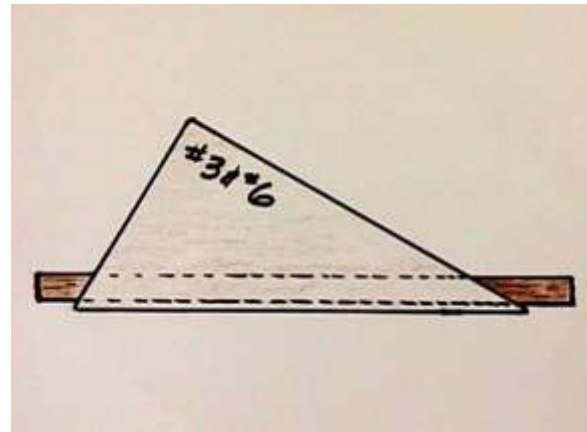
Now lay the 1#6 template on the floor and mark the floor by the template, remove it and nail or screw (construction adhesive goes on **ALL** parts of a stair, I am leaving out the adhesive part from now on, because I said all parts of a stair get adhesive, either carpenters glue or a flexible construction caulk, adhesive) a 2x2 onto the floor for the front panel to be nailed to, it goes $\frac{3}{4}$ " behind the 21 line you drew.

By the way, when you apply construction adhesive to wood I-beams to install $\frac{3}{4}$ " T&G flooring on, the glue is not used to hold the flooring to the I-beams, it is applied to hold fill the gaps and hold the flooring up. Same as mortar and blocks. The mortar holds the block apart. Gravity holds them together.

You need to cut 3 more treads each of these 3 templates out of $\frac{3}{4}$ " osb. Be very sure you mark

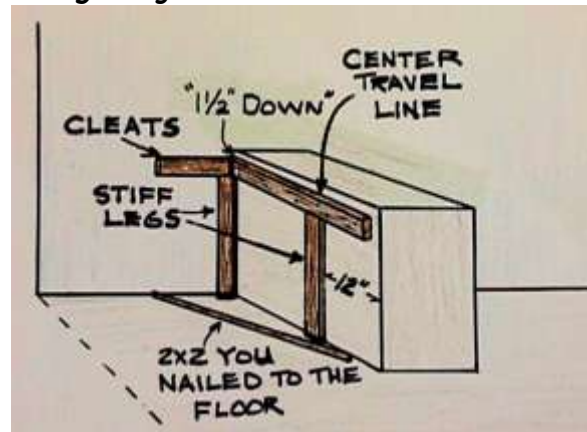
the pieces, on the top, always on the top.

I don't how many times I have seen carpenters build these and have to tear them apart and rebuild them. Mark them all.



Now lay the tread on a 2x2 and attach it to the 2x2 and cut the excess 2x2 off flush with the tread. It is not a template any more, as I hope you have cut all the treads. It goes on like the other 2x2 did, back $\frac{3}{4}$ " from the mitered edge.

Now you can cut the front panel. The panel will not go all the way into the mitered point; you will have to cut it shorter than your tread. It is $40\frac{1}{2}$ " tall (+ $1\frac{1}{2}$ " tread will give you 42" finish).



Now you can attach the cleats as shown. These cleats have to be cut where that they don't hit the 2x that you attached to the tread. Now you can install the front panel, then the tread. If you don't have a stud behind the wall cleat, put a couple of stifflegs under it.

Remember what the construction adhesive does, it holds the parts apart, fills the gaps, and makes a tight joint.

Glue will make the structure all one piece and it won't squeak.

Carpenter's glue holds parts together.

Go ahead and install the other cleats, front panels and the treads using exactly the same procedure. Build your stair to the top (book 101) and you have just got a taste of circular stair building.

Winders are not circular stairs but they are close, it will get far more complicated as we go on.

*One procedure in this book you want to remember and that is when you are building winders, lay out all of the treads and mark them.

This is the first thing you do and keep the templates for marking and cutting out the other treads. This is by far the most important part of this book.

There is a hundred ways to frame a winder stair. Only one way to properly lay out the treads and build it correctly.

ALTERNATOR STAIRS

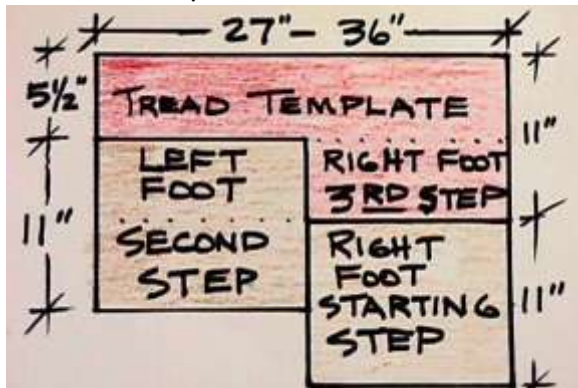
Before we get any further into stairs, I want to explain alternator stairs.



I know a few people that you would have to explain which foot to start with.

Altered (close), offset, staggered, single-foot, half step. I have heard these stairs called everything you can imagine. Alternator is their name. They are fine for homeowners, but not for the public.

Some public places get by installing these but access is restrained, or should be.



The red part is the template. Get you some 2x12's for stringers and clamp two 1x12's with

Titebond Glue for the treads. Use 2x2 cleats to attach to the stringer for the treads. No 2x12 treads, they will break.

You need to build a 4 stepper some time, just to say you have. Some manufacturers sell these stairs and say they cut the run in half. Theirs will, but not the ones that I have built. Alternators only cut the run by about 35 to 40%, if you build them the way they should be built.

An alternator stair should not exceed 55 degrees.

Some of the ones that are sold go up to 65 degrees and I saw one that was 72 degrees, the same as a ship ladder.

How they do this? They build a fools stair, it is explained in the stair book 101. You can go up with ease, going down is a whole different can of worms. I have seen some alternators have an 8" treads and have a 9" rise. This is how they get these high degree stringers.

Don't get talked into building one of these suicide contraptions. If you are going to build an alternator, build it right.

11" treads and never install over an 8" rise, even for a homeowner that says "they will be the only ones that ever use it". I've heard this hundreds of times; some homeowners will promise you anything to get you to build an unsafe stair.

Don't do it. Most of them will never remember any part of the conversation.

In construction "if it ain't written down, it never happened". A very true statement. I got these out of the way, now we can go back to stair building. A 7-11 alternator is 53 degrees.

*Same thing as the winders, pop lines on the floor and lay out all of the treads before you start.

You will get your run and then you can calculate your stringers.

25

ANGLES

If you are wondering how I came up with 53 degrees in that last statement, I will tell you.

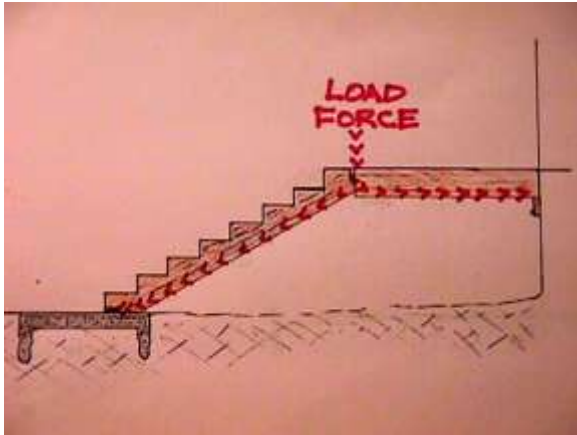
I remembered it.

But the way I calculated it is that I drew $5\frac{1}{2}$ (run) ($\frac{1}{2}$ of 11) grid marks over on my grid paper and 7 (rise) grids up, drew a line at the ends, then put a protractor on it and read 53 degrees. You had better memorize this procedure, we are about to get into some serious calculations and if you want to learn the stair business you have got to know everything about angles, rise-run-rake and about the relationship of a circle drawn inside of a square. This is called Radial/Polar.

Another thing, if I had drew an L and used a half a grid across and one grid up, it would be the same angle, but almost impossible to draw an accurate line so as to use the protractor to read the angle. But if I had marked over 11 grids and up 22 grids, it would be more accurate than the $5\frac{1}{2} \times 11$ that I marked. All the same angle. With this small and simple procedure I am preparing you for some of the most complicated calculations and procedures of the carpentry profession.

When you read and learn this book, you won't be afraid to tackle anything.

ANCHOR PLATE



to attach the anchor plate with bolts. I guess they figured it out on their own.

I have stressed throughout the first part of this book, and I really cover it in 101, the importance of the anchor and hanger plates. This landing and stair carries it to the extreme, but I have built some of these, railed them and did not install any post to support the landing. If you have a solid pad and a solid wall, bolt the plates (both), you do not need any posts.

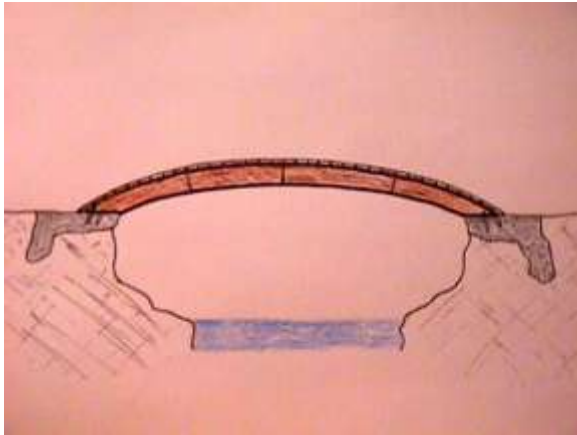
You have built a bridge. Try one. One thing though, you had better attach the anchor plate exactly as I have shown you. Carriage bolts in the hanger plate.

A major magazine had an article in 2000 about framing a straight stair.

He said "all you need to attach the anchor plate is 3 or 4 16p nails". I was astounded. I wrote the Carpentry Book in 2003 and explained the anchor plate in detail, all of the engineering aspects of it. I sent them a copy of the book, no answer.

Now they have come out with an article telling how important it is

WOOD BRIDGE



compression and tension. A law you do not want to break.

This bridge has the same engineering aspects as the stair and landing in the previous page.

The frame for the bridge is doubled 2x12s mitered and glued together, then sawn into an arc. You would think that it would collapse under a load, but the force is not on the joints of the 2x12s. The built up 2x12s have only compression force. The force of the load is diverted through the 2x12s and down to the concrete footings.

I know of a few engineers that don't agree with this, but I know a whole bunch more that do. Some engineers say that you cannot take the tension out of a member and replace it with compression. This is not true. Remember the bowed 2x4 that I had you nail on the wall and floor. No tension. With proper anchoring and construction you can move the neutral line out to the edge and do away with tension. We are about to get very deep into this law of

PLYWOOD BRIDGE

can prove any part or procedure that is in this book.

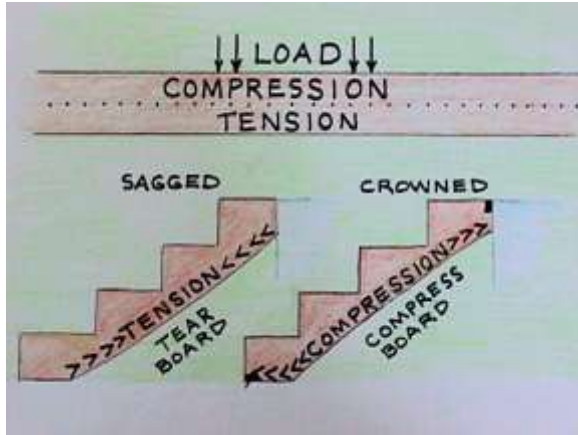


This is a piece of 12"x $\frac{3}{4}$ "x8' CDX plywood spanned 8' and has a 32# block set in the center of it. It sagged 3". Tension.



No tricks here. This is the same piece of plywood, I took an 8' pipe clamp and clamped a 3" crown into the plywood and set 10 blocks in the center, 320#, it never went down even 1/8". When I compressed the plywood with the clamp, I removed the tension aspect of the plywood and converted it to compression, all of it; there is no tension in the second picture, compression only. I could have put 20 blocks on it and it would not have sagged. Some people will try and trick you into believing their theories, I won't. Get you a piece of plywood, pipe clamp and blocks and try this. I

Engineering



This is a schematic out of book 101, the picture shows the 2x12 on top being supported at each end, load in the center. The top half of the board has compression, the bottom half has tension in it caused by the load. The dotted line is the neutral line. The stringer on the left has no anchor or hanger plate, the crown is down, the compression area of the 2x12 has been cut out (treads and risers). If you stood on this stringer it would break or split in half and you would fall.

The stringer on the right, you can compare to the piece of plywood in clamp on the last page, it has an anchor and hanger plate and the crown is up, the total stringer has compression when you load it. Very little tension, if any at all.

In these last four pages I have shown you the importance of proper construction of stairs and the mandatory construction of a solid anchor plate and

hanger plate, solid floor and landing wall. The plywood, pipe clamp and the 32 blocks should tell you all you need to know about how important anchor plates and solid landing are. Most stairs are built without using these procedures; this is how "Stair Disasters" came to be a popular website.

DEFLECTION

Deflection is the sideways movement of a framing member that is stood up and installed in a structure to carry a load.

If you have a 16' wall, a nailed stud at each end and only one nailed in the middle and you drop a 200# load on the center stud, the 2x4 stud will deflect; it will vibrate when you drop the load.

You can see it.

If you have someone jump on a floor in the center of the span of a wood I-beam floor and you are under the floor, you can actually see the I-beams moving, you can feel them moving from side to side.

This is why we install bridging in a floor.

Anytime, any joist, of any frame deflects, it means that is going down. Not much, but it went down some. If you nail or screw a 1x4 to the bottom of your floor joist, you have diverted the load, and the bottom deflection of the joist, to the entire joist system, instead of just one or two. A 1x4 stapled to the bottom of your wood I-beams on 4' centers will completely stop deflection, instead of installing bridging.

The same law applies to stairs, especially circular, open stringer stairs. The law also applies to straight stairs. The glued riser boards in a straight stair keeps them from deflecting, to a degree.

All of this engineering stuff will come to light when we build an open stringer spiral stair.

RADIAL GAIN

In the next book, 103, we are going to cover the construction of a supported framed circular staircase.

First you have to know the terminology and aspects of radial gain.

We are going to cut some 3½" osb sole plates for the next stair. Well over half the carpenters that I have seen trying to cut these use radial movement to try to mark these plates. Radial movement is the wrong procedure.

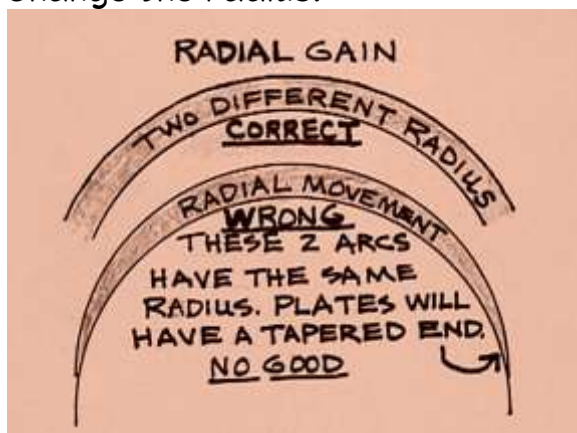
Radial gain is when you mark an arc (semicircle) with a compass, then extend the compass, increasing the radius, the width you want and make another arc, different radius, and you are gaining radius as you extend the compass.

Radial movement is when you move the compass and do not change the radius.

the radius (the width of the plate you want to cut out).

Radial movement is when you move the compass and use the same radius to make another arc mark.

You want to remember these two different procedures with a compass, there will be many more to come. This will especially be true when we get into radial rise and radial plane.



Radial gain is when you gain radius; you add more length to

RADIAL RISE-RUN-RAKE

I am going to simplify the most misunderstood aspect of building circular structures, the simple procedure of calculating a circular stringer. I am going to do it with a piece of your cardboard you bought.

If you look at an open circular stair in awe and wonder how in the world they build it, let me tell you something. Look at a curved wood barrel (larger diameter in the middle than the ends are) and think about building one of those, with no electricity, as they did 150 years ago. Or calculate the circular locations for spokes in a wagon wheel with no calculator, then forge a **premade** steel band to go around the wheel that fits perfectly.

These things are just as intriguing to me as the Loretto Staircase. In our electronic age, we have it easy.

I need for you to get a coffee can or a can that has the same diameter from top to bottom, no cone shaped cans.

I hope you know some geometry, trig and math; you are going to need it to be a stair builder. If you don't the Carpenter Book will teach you all you need to know,

I have seen many AGC, Carpenters Union, and other organizations competency reports and I can tell you truthfully that only about 2% of

the carpenters in the USA can build a circular stair.

They can lay out the circle, cut the plates, build their tread and riser frames, nail them up and tread the stair (this is what we are going to do in the next stair section) and do a really good job.

But here they stop, by all means not all of them, but most of them stop and learn no more about circular and spiral stairs.

I am going to take you into the inner world of stair calculations and construction.

As I said before, few have been here and few will ever come here. There are many thousands of stair builders that you could not pay them enough to read and learn this book.

They know all they want to about the stair business. I hope you are not one of those. A mind is a terrible thing to block off.

This is very complex and complicated material, I am going to explain it as though you know nothing, as I was about 40 years ago.

Pi (3.14) is the ratio of the circumference of a circle and the diameter.

If you have a circle and the diameter is 6" and the circumference is 18.84" and you want to know how to calculate this and not have to measure it with a cloth tape. You take the 18.84, (13 7/8") circumference and divide it by the diameter, 6", and this will give you Pi, (3.14).

Knowing this, all we need to calculate the circumference of a circle is Pi, 3.14. Pi actually has 51 decimals in it. Some use 3.1415 and it goes on for 47 more numbers.

We're carpenters, we'll use 3.14. I am going to use a large Folgers coffee can, 6" diameter and 6 1/4" high.

Figure the circumference; $3.14 \times 6 = 18.84$, now draw a radial point line (vertical) on the side of the can. Take your card stock and measure from one corner and mark 18 and 13/16ths". Now measure up from the same corner and mark 6 1/4" height.



Now cut the triangle out.



Tape the big end onto the radial point line, pull it tight and tape the other end, you can draw some little steps on it if you

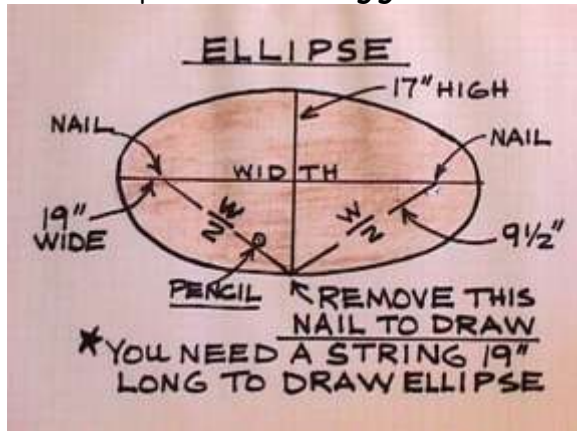
want to see the stair 16 treads and 16 risers. Can you calculate the rise-run on this can? (You take the run 18.84 and divide it by 16 = 1.18, then divide 6.25 by 16 = .39. The risers are about 3/8" and the treads are about 1 1/8".) This would be the outside stringer of a circular stair, do the same thing and calculate, mark and cut out the inside stringer with a 3" diameter.

This little project should take away your fear of calculating a circular stair.

Everything in a spiral stair is calculated as straight, and then we transform the material into a spiral or circle with clamps and frames.

ELLIPSE

To build stairs you have to be able to understand and draw an ellipse, an elliptical shape. It is shaped like an egg.



As the drawing shows, draw a line 19" wide and another line 17" high, perpendicular to the 19" line.

I explain this fully in the Carpenter Book. I have a whole chapter on Elliptical drawings and construction.

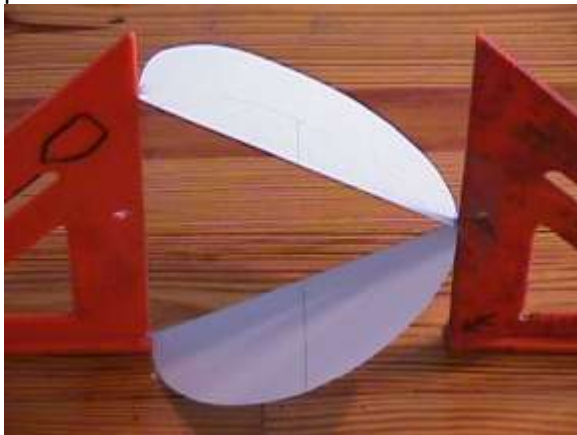
You need to learn this procedure and learn how to draw and calculate an ellipse.

RADIAL PLANE

This is the section that I told you in the start of the book that is hard for carpenters, some engineers and architects to comprehend, but the way I am going to explain it, I know very well that you will understand it.

A radial plane is a flat circular surface, like the outside and inside of a piece of pvc pipe. It can be an ellipse or it can be a circle. If you take a level (instrument) and shoot elevations every 5' in a circle with a 20' radius the stakes you set are in a radial plane, they are all the same elevation.

A full circular stair, with no center post has two radial planes in it.



If you bend over and look directly down on these two pieces of paper semi-circles, they will look elliptical; they are, from the overhead view.

There are also two radial point lines, one is the point on the floor where the stair starts and the other one is exactly

opposite (180 degrees off the starting point, center of the rise) (where the two pieces of paper are touching).

The last place these plane areas connect is the top of the landing. The center of a circular stair is the half way point of the radial point line opposite the starting radial point line.

Mark a center point on the rake line of the triangular card stock that you taped on the can, this is the point. 3 1/8" off the bottom, exactly opposite the meeting points of the card stock on the other side. Now we need to calculate the rake of the triangle that would be inside of the can. The run is 6" and the rise is 3 1/8". $6 \times 6 + 3.125 \times 3.125 = 45.77$ and the square root of this is the rake length, 6.77. Not many.

Most carpenters think that the profile of a stringer is a circle. The layout is a circle, why isn't the stringer a circle, as I have heard many times.

This is the first lesson in radial planes. Not as simple as it sounds.

This section, if you noticed uses the radial gain/movement, all of the radial procedures that I've talked about.

These two pages are very important to learning to build circular stairs.

SCALE MODELS

As you probably noticed I speak a lot about scale models. The scaled down models saves money and gives you confidence. If you are not familiar about scale models you will not be able to understand plans and schematics that architects give you. This is a major hindrance to a carpenter. If you are building a scale model and you want to use a one fourth scale you divide all the full measurements by 4. If you are using a $\frac{1}{4}'' = 1'$ (as most plans are scaled) scale, you use an architects rule. Don't confuse a $\frac{1}{4}''$ scale on an architect's rule with a one-fourth scale model.

Scale models are interesting to build and they serve a very important role in construction. The first circular open stringer stair I built was a $\frac{1}{4}$ scale model. I built in my mind a great deal of confidence by building it. It was 21" wide and 33 $\frac{1}{2}$ " high. Full scale would be 84"x 133 $\frac{3}{4}$ ".

A $\frac{1}{2}$ scale you divide by 2, a $\frac{1}{8}$ scale you divide by 8. Study your architects rule.

Don't confuse these scale reductions with the $\frac{1}{4}''$ scale on your architects rule. The $\frac{1}{4}'' = 1'$ on your architects rule tells us that the scaled drawing of the building plan is reduced to one-forty eighth of the actual size.

There is 48 quarter of inches in one foot and the drawing represents one of these equals one foot. In other words it is a $\frac{1}{48}$ scale model drawing.

I use many full scale models in these books and

I use many drawings and scaled models. In the spiral, open stringer (no post) section you and I are going to build a $\frac{1}{2}$ scale model, my cuts will be your cuts; my parts will be identical to your parts.

This will be a challenge, from start to finish.

Read the label on some model cars and trucks in a toy store, they will have one twentieth scale or one fifteenth scale written on them. I have built many scale models of commercial buildings. I first buy the autos to go in the parking lot and then scale the building to these models. Try it.

A $\frac{1}{4}$ scale of a 100'x100' building would be 25'x25'. This is 25% of the building.

On your architect's rule it is only 25". This is .25%. Confusing.

It won't be after you read the next chapter.

PERCENTAGE OF GRADE

While we are on the subject of scales and percentages I want to cover something you are going to be presented with. Probably sooner than you think.

I was building a handicap ramp for a commercial building and the architect gave me a drawing of a ramp 12' long and a .0834% grade.

Sounds confusing doesn't it, that is exactly what his and her intentions were.

Well it's not as confusing as he meant it to be. If they give you a % of grade, simply multiply the % of grade times the distance $.0834 \times 12' = 1.008'$ or 1" per foot of rise to 1' of run. One foot of rise in 12'.

If you have a road 16 miles long and a 6% grade and you want to know what the rise is, you simply multiply $16 \times 5280' \times .06$ and this gives you 5068.8' of elevation, or .96 of a mile elevation (about 1 mile) of increase from where you started. This is the hill we climb from Alamogordo to Cloudcroft N.M.

Some architects/engineers, not many, like to remind carpenters that they are not as smart as an architect/engineer, but we build their houses and stairs.

CONCLUSION

This concludes this first, Book 102, of stairbuilding. I wrote far more than I intended in this book, but to learn stairs you have to have this information.

In the next ebook we are going to build a circular stair. You will be using a lot of the information that you have gained in this book.

To be a stair builder you have to know everything that I am telling you in these books. I learned it by building stairs, a lot of stairs.

You are not going to learn all of this over night or by reading this book, you are going to learn by building some stairs.

The next book, 103, gets more intense in the calculations and relation of a circle and a square, **shift R-P (the plus button)** on your Casio calculator.

There were some boring pages in this book, they probably didn't relate to your idea of stair building, but they will later on.

The circular stair book that is coming next will not have all of the calculations and explanations of the engineering aspects of a stair, but I will guarantee you when we get to the last stair, the open stringer helical stair, you will need every one of them to build one.

The circular stair that is coming up will prepare you for this stair that some say no one can build with using metal fasteners.

<http://carpenterbooks.com>

Bob Johnston