Frame repairing

Methods for repairing and or splicing truck frames
Any formulas for calculating the strength of a frame will be located near the end of this summery ( ) notes will be linked to them through out the test for quick reference

There are as many ways to repair truck frames as there are people who perform the repairs.

First off I will discuss the simple repairing of a cracked frame, but in order to determine the best or at least one that will be a safe repair.

A truck frame can crack for many reasons
Just overloading rarely breaks a truck frame on its own you need to introduce other factors like high torque rough terrain, a severe shock from a pot hole in the road things like that.
Another cause of a frame cracking is fatigue. Without getting into all of the causes of stress related fatigue
All metals have a finite number of times they can be stressed. These are called stress cycles. Just to touch on these for a moment.
Stress cycles are accumulative and may be calculated in several ways. Since there is an amalgamated mix of elements in metal to achieve the desired strength, resistance to corrosion, flexibility, hardness, weld ability, machine ability, ware ability and other factors, we will only concentrate on the carbon content. The lower the carbon content the lower the tensile strength the lower number of stress cycles. Consequently when the carbon content is too high the stress cycles can become almost zero as well.
This means there has to be a balance of all of the combined elements that make up the steels aluminum the 2 most commonly used materials for truck frames.
One rule of thumb to reduce the risk of frame cracking is to hold the internal stress levels below 50% of the tensile strength

Repairing a crack in a frame due to induced shock loads the can be done by simply making a “V” in the crack and welding it up it is not a permanent repair without other procedures, there is a process that will be explained later . Then in some cases to reduce the crack from happening again the area needs to be reinforced to disperse the concentration of the stresses.
Once a truck frame has gone past its fatigue life cycle cracks will continuously reappear as long as use continues at the same level of abuse.

When shortening a truck frame it is always better to relocate the suspension components forward when ever possible the same goes if you are extending the wheel base but most of the time this is not an option.
If a frame is to be spliced then care needs to be taken in how this is done .
There are many forces at work against a truck frame some of these are twisting flexing shock and vibration

Truck frames are in a sense similar to an upside down child's sea saw where as they are supported by the suspensions on either end and loaded any where in between.

When truck frames reach a certain length they become very flexible after a point there can be too much flex and the fatigue life cycle is diminished considerably

Some people feel that a frame needs to be completely rigid and say stiffer is better. In practices a frame must have some flex to assist the suspension in smoothing out the jolts and imperfections of the road or other surface the truck is traveling on. To control much of the flex the frames are designed to a specific height or distance between the flanges and a specific thickness plus the shape is tabulated into what is called the section modulus.

The section modulus times the minimum yield strength is the amount of resistance the frame will have to bending. Cross members and their placement contribute significantly to this as well. A poorly designed or poorly placed cross member can even reduce the strength of a truck frame, more on cross members later

At times it becomes necessary to fish plate a frame either as the result of a splice or the addition of equipment being mounted to the truck such as a winch or a dump hoist cylinder. Fish plates are used to increase the section strength of a frame and need to be designed to spread out the additional loading stresses induced when the mounted hardware is being used.

For instance many oilfield and some other trucks have a winch mounted behind the cab some are mounted very high above the frame as well for clearances or operation.

A common mistake in mounting them is they are not made long enough to properly distribute the loads that will be applied. If for instance a winch is to be mounted on a tractor then there is no subsequent bed aiding in the distribution of the loading forces being applied to the frame from the winch. In these cases the frame may need to be doubled with the addition of a pair of rails being mounted inside of the primary rails plus the winch mount needs to be extended along the frame 2 to 2 ½ times the mounting height. Often you may see one that is only as long as necessary to provide a mount wide enough to accommodate the winch this is not the best way to design the mount. As the bending moment is placed directly below the winch it should extend in the direction that the cable will be pulling from by at least the height of the center line of the winch drum.

This mount should never be welded to the frame it should be bolted with grade 8 bolts an easy way to determine how many bolts are needed is to calculate the total amount of line pull the winch will develop then calculate the amount of shear strength each bolt has divide the shear strength by a minimum of 5 preferably a factor of 10 use that number and divide into the line pull force this will give you the total number of bolts required for each side

The same goes for a dump hoist cylinder however on many of those they will be mounted within the confines of a sub frame that will have the rear pivots for the dump bed in it. On these it is usually nothing more than a few bolts holding everything in place at the mounting tabs made on the sub frame.

For the type that has a separate mount plate for the hoist cylinder and the rear pivot mount is directly mounted to the frame. the better hoist mounts resemble that of a fifth wheel mounting system where there is a reinforced plate with an angle bar extending down both sides of the truck frame.

The rear pivot mount is often times welded directly to the rear of the truck frame. Again the better ones will have an insert or an over sleeve that extends forward along or inside the truck frame for several inches to as much as a couple of feet and may be welded at the rear as well.

Hitches ramps roll of tails and other attachments will be mounted in this manner as well

Splicing a truck frame:

First off let me give you a short history of how I arrived at the way I recommend doing a splice. What seems like 3 lifetimes ago now, I was working in a Blacksmith/ welding & machine shop I was around 12 or 13 years old at the time when I noticed my Mentor MR Ward doing some forge welding, He would heat the metal to white hot then hammer the 2 pieces together. One thing I noticed was that he always did this on the bias to the length of the steel. And if it were very wide he did it in a "V" which looked like this "<<" the 2 pieces would fit together but would be overlapped on top of one another to allow for the hammering together.

Later I helped his son weld up an oilfield Drill Kelly that is the square hollow frill bar that rigs use to turn the drill pipe and bit down hole he was cutting out a section and shortening the Kelly Bar to do this he cut from one corner at an angle across one side to about 60% past center at about a 22 to 30 degree angle then reversed the cut in the opposite direction using the same angle ending at the corner several inches off set from the first corner. He did this all the way around changing his angles slightly so when he was finished no 2 sides of the 4 were cut along any of the same lines. Then he cut the other end in the exact mirror of the first. So they would all fit perfectly together.

William Explained to me that his reasons for doing this was to offset as best he could as much tensional stresses the faces of the Kelly would receive when it was being twisted by the Rotary Table drive.

About a year later a farmer came to the shop one day while William was out in the field and said he needed the frame of his old truck shortened because he was going to make a Semi tractor out of it. Clarence Ward (MR Ward) told him it would be several days before William would return and that he would have to come back. The gentleman replied well then why don't you let the Boy do it I have seen some of his welding and I am sure he can do it.

So Clarence agreed but said he would not be able to warranty the work.

The man said you let him build my horse trailer by him self so I am sure he will do a fine job.

He left the truck and I started laying out my cuts I really had no Idea what I was doing but I knew that if I cut a certain amount and welded it back just right then I would only have to remove one section of the drive shaft and not have to cut the other one.

The layout I used was the one I had watched William use on the Drill Kelly I figured if it was good enough for that then it should work for what I was going to do.

And that is how I came to use the method that I have used many times over the years.

In preparation for cutting a truck frame either adding a section or removing one the process is the same.

First and foremost the frame should be as level as possible both front to rear and side to side and there should be no lateral twist from front to rear.

It is best to block up the front of the truck in 4 places 2 in front and 2 just forward of where you are going to make your cut. The rear of the truck needs to be able to be moved usually by rolling on the tires. To make things easier if it is a tandem axle I like to remove the 4 outside or (inside tires if I need the room) the reason is less tires easier to roll. If a single axle you will need to fabricate a set of dolly wheels or mount 4 heavy steel caster wheels on a steel saw horse to support the frame where you will cut it . A floor jack may be used with blocks to reach up to the frame but there needs to be some way to secure it so the frame cannot fall off.

Next do your lay out then check it 3 times before you make your first cut make sure you have predetermined several check points along both sides of the frame and take written notes or their lengths and placements. There are a lot of holes located on both sides of most frames that can be used as reference points.

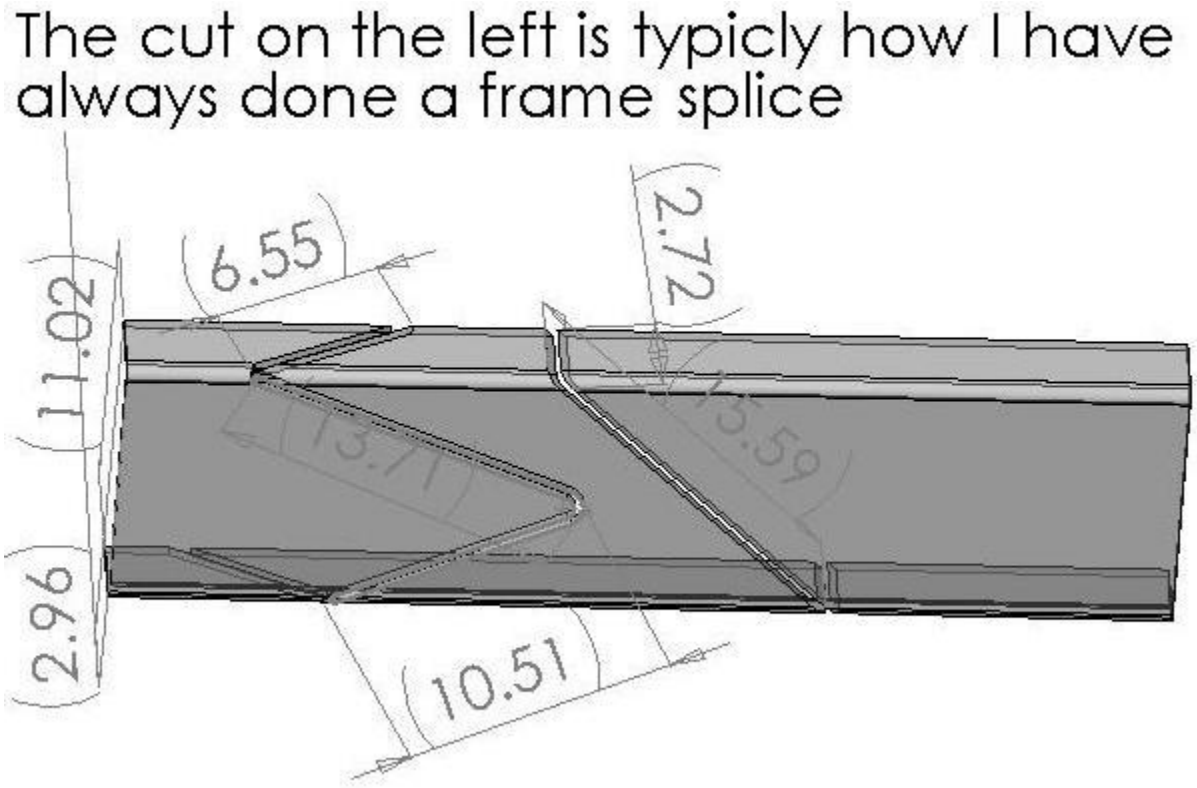
I also usually make 2 or 3 sets of Trammel points out of bolts that fit tightly in the holes To do this take a bolt of the proper diameter and machine the threaded end to a point on a lathe it is important that it be in the exact center. Leave enough threads so that you can still get a nut on the bolt to tighten it up on the frame. These make a great way to always have your references in place through out the procedure. Another way to mark your references is to Scribe them on the frame using a good machinist square and a scribe or Awl. Again make triply sure your measurements are correct. Then check them again.

Another thing that I like to have is a set of references wider than the frame about 30 to 35 inches out on each side for these if you use them you can take 2 pieces of very rigid steel with a set points or holes or what ever your preferences are marked exactly the same distance apart from the center you can then mount the 2 steel bars somewhere that they will be out of your way and will not have to be moved through out the build. You can use these to give you a more accurate way of determining the straightness and can get a diagonal cross measurement from them as well.

Begin the lay out on 1 side then if at all possible off set the cut on the opposite side by at least 2 times the height of the frame. One note the longer the frame is going to be the more important the offset. Particularly if no insert sleeve is to be used.

But if your cut is to be directly across from the other side make sure that you cuts are reversed in the direction you do them.

Start your layout on the top flange from your scribed reference mark make the cut line at least 2 times as long as the flange is wide note a 3 inch flange would have a 6 inch cut minimum. Continue around the corner radius reversing the direction as you do so then draw your line down the side of the web of the frame to about 60% down from the top make this line roughly 2 times in length as the height of the frame is, radius your end and reverse the direction and continue to the corner radius this time continue in the same direction to the edge of the flange. When you are finished your marks should be well offset to each other the top and bottom cuts will be in opposite directions from each other. Grind all cuts to a bevel from both sides leaving approximately 1/16” thickness in the center. When you fit the 2 pieces together leave a 1/16” gap as well

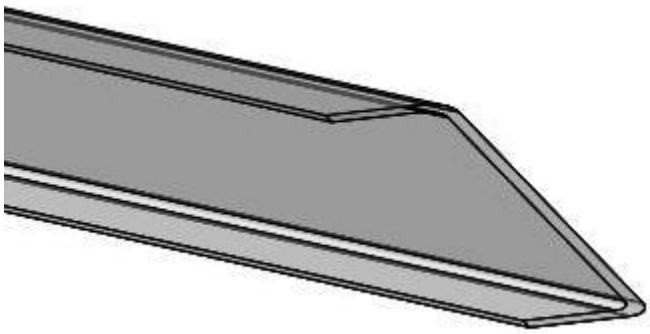


Here is an example of what I have explained the cut you see on the left is my method the one on the right is the one that most body builders use as you should be able to see any stress lines from flex or twist will be distributed over a large area. Another thing I have done when it was important that a splice not be found was to locate them in such a manner as to fall where a cross member was to be located. After welding and sanding was completed, few times on a long enough frame I was able to do this over the span of 4 cross members, 2 forward on one side and 2 to the rear on the other. I don't feel that there was any advantage to this other than it made it much harder to detect the extension in the frame.

A few important things to remember when it comes to making a weld on a truck frame longer is better for the cuts. The more your offset is the better you do not want to reduce the stiffness below the minimum that the truck manufacture has engineered.

For instance if a truck manufacture uses the same frame section for 2 different length trucks that is to be used in the same situation you can rest assured that you should be able to lengthen your truck to the longer length that they have used a like frame on. But if you are going to go much beyond this then you must increase the section area of the frame a

good way to do this is to add an insert that fits tightly inside of your frame. At least 2 ½ times longer each direction for the splice as the height of the frame you are working on
Example if you are adding a 4 ft section to a frame and the frame is 11inches tall you need (11x 2.5) x2 + 48" = 103" or long enough to end behind the center of the next cross member the sleeve should be cut on an angle this may be from top to bottom on both ends like the following picture.



I prefer to use only the bolts that were previously used and to fill any additional holes that may have been in the frame with bolts as well.

For the filler metal IE Welding rods or mig wire

They should always be selected based on the type of steel or aluminum frame to be welded

Since we are talking about welding a steel frame you need to use a low hydrogen electrode this should have a high but not brittle tensile strength. Rods such as E7018 is the most popular rod for structural steels but a frame normally has quite a bit higher tensile rating than the 7018 rods will yield however if E10016D2 or E11018 are used there are other properties that for me at least don't fair well for a long lived repair, those being too low % of elongation and reduced Charpy.

I prefer to use an 8018 or 9018 DC electrode with at least a 21% elongation and a -30 Charpy with between 88,000 and 95,000 PSI tensile. Or my main preference would be a duel shielded Mig wire .045" diameter using Co2 as the shield gas with a flux core the Hobart excel 550 or Tri-Mark 771 or Lincoln E71T1 work well they pretty much equate to a low hydrogen DC electrode but have slightly higher tensile strengths while maintaining a better % of elongation and Charpy with out and increased reduction of area, all will have around 90 to 95,000 PSI tensile. I would rather have the weld material be slightly more elastic than the base metal.

When welding the frame you should preheat the weld area in hot climates or when ambient temps are above 90f the first or root pass may be sufficient to accomplish this but I normally will bring the frame temp up to spit fry temps around 220f to 300f for at least the first 6 inches away from the weld joint

Care should be taken to not over heat the metal while welding the core temp should remain below 500to 550F. Normalizing each pass by peening the weld also helps to reduce the heat effect of the welding.

Welding can induce internal stresses that will remain in the material after the welding is completed. In stainless steels, such as type 304, the crystal lattice is face-centered cubic (austenite). During high temperature welding, some surrounding metal may be elevated to between 500°F and 1000°F. In this temperature region, the austenite is transformed into a bodycentered cubic lattice structure (bainite). When the metal has cooled, regions surrounding the weld contain some original austenite and some newly formed bainite. A problem arises because the "packing factor" (PF = volume of atoms/volume of unit cell) is not the same for FCC crystals as for BCC crystal

The bainite that has been formed occupies more space than the original austenite lattice. This elongation of the material causes residual compressive and tensile stresses in the material. Welding stresses can be minimized by using heat sink welding, which results in lower metal temperatures, and by annealing.

Annealing is another common heat treating process for carbon steel components. During annealing, the component is heated slowly to an elevated temperature and held there for a long period of time, then cooled. The annealing process is done to obtain the following effects.

a. to soften the steel and improve ductility

b. to relieve internal stresses caused by previous processes such as heat treatment, welding, or machining

c. to refine the grain structure

Remember when welding a truck frame distortion is one thing you need to avoid

Prior to making the first bead you should place several ½" long tack welds at key points on the flanges you need 3 the first right in the middle then at each end of the cut do the flanges then the web check your work for straightness preheat slightly then make the first bead on the bottom flange from the inside of the frame. Weld from the edge towards the corner about half way. Then weld the top flange the same way. Next from the inside of the frame weld the transition corner of the "V" in the web. From this point you may alternate welding inside outside top and bottom. You should make as small a bead as possible for your root pass. Remember half of your root or stringer pass will be from the inside and the other half will be from the outside. Overlap your beads past the opposite stringer about ½" if you own a needle scaling gun you may use this to peen the stringer pass. Then use your grinder and carefully grind the stringer to leave a nice even "V" for your next passes.

Frames are not all that thick in most cases they will be 3/8” or less so often times there will only be a need for 1 pass inside and 1 pass outside. Be sure and clean the ends of the welds before adding the next bead. A few other things to remember never scratch start your arc anywhere on the frame use a piece of donor metal like a short piece of flat bar either hand held or clamped close to the weld joint area.

Lastly a few things to remember

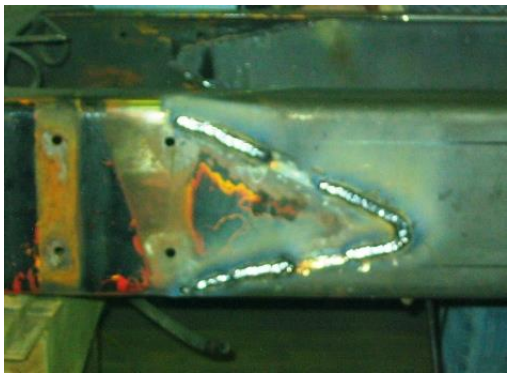
1 control your heat (DO NOT over heat your welds.

2 take care about distortions. Making too long of a weld on one side before applying the same amount on the inside and the frame will warp or creep.

3 watch you’re grinding use light pressure and short grinding period’s Heavy pressure and grinding for extended periods of time creates heat and hardens the area.

4 care should be taken to the directions your are grinding, deep long grind marks can act as a focus point for future cracks. Personally I never use a hard grinding wheel on my grinder after I have finished welding. I use a 36 grit soft sanding disc.

I have included a few photos of a frame splice job recently done by a friend of mine using the principals I have laid out.



I hope some of these instructions are helpful

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