Trench, Torque, & Tie

How to Up-Right Your Failing Concrete Retaining Wall

Bernard & Carl Van Wormer (Professional Engineers)

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This document contains procedures, instructions, and examples of a low-cost method to permanently restore your tilting and failing concrete retaining wall. It is designed to allow a single Do-It-Yourself worker to perform the restoration process in an efficient and professional manner, using rental tools and minimal purchased resources.

Contents

GLOSSARY

Chair:	*A seat or support upon which a re-bar sits, spacing it a fixed distance above a form or the earth.*
Daylight:	*(verb) Expose to view by removing the covering earth.*
Dowel:	*Cylindrical piece of hardwood.*
Grid:	*A tack-welded steel mat of re-bars.*
Eyebolt:	*A threaded rod with a circular loop at one end.*
Klein's:	*Wire-cutting pliers for tie-wiring re-bar structures.*
Locate:	*(verb) to place an object in position, or to discover the position of an object.*
Mandrel:	*A spindle or form used to shape sheet metal.*
Mattock:	*A pick-like grubbing tool with a 4" wide hoe-type blade.*
Plate:	*The 4"x 4"x ¼" thick steel bearing plates against the wall and the anchors that distribute the forces onto the concrete.*
Re-bar:	*A ribbed mild steel rod used to reinforce concrete or a tension rod.*
Rodding:	*(verb) Repeatedly plunging a steel rod into freshly-poured concrete to remove air bubbles and to prevent 'rock-pockets'.*
Shim:	*(noun/verb) A block; a filler; a wedge.*
Torque:	*(verb) Twisting action to induce tension by tightening a nut on a threaded rod.*
T.T.T. :	*Trench, Torque, and Tie method of concrete wall resurrection.*
Weldment:	*A unit comprised of two or more welded components.*

LIST OF AND TOOLS, MATERIALS, SUPPLIES, & RENTAL EQUIPMENT

HAND TOOLS

A. Necessary Tools

- Six cubic foot wheelbarrow.
- Skill saw for sawing ground anchor and field splice plywood forms. (And a $4 abrasive wheel for cutting re-bar steel.)
- Shovel.
- 12" crescent wrench.
- Claw hammer.
- 25 ft. tape measure.
- Wire cutting and tying pliers (Klein's).
- Two 8" C-clamps. (cheap at Harbor Freight Store)
- Tri-square.

B. Handy (But not essential)

- 8# sledgehammer.
- 2# stake-hammer.
- Work bench (or a pair of sawhorses) & vice.
- 20# six ft. chisel tipped crowbar.
- Post-hole digger.
- Tin snips.

HARDWARE STORE MATERIALS

The quantities of materials listed herein are based upon a 30 ft. long retaining wall repair installation having three tension rod assemblies and three ground anchors located 12' back from the wall-mounted eyebolts. The lengths of the re-bar rods are intentionally kept short for easy transportation. These quantities may be changed to accommodate the specific needs of your restoration project.

- One bundle of 1"x 2"x 16" wooden stakes for staking-out trenches and ground anchors.

- *One roll of tie-wire (for tying re-bar at the field splices).*
- *Three 36"x ¾" threaded rods for torquing concrete wall at ground anchors.*
- *¼ # No. 4 box nails.*
- *Permatex® Anti-Seize Lubricant (and rust preventative).*
- *Three eyebolts: ¾”-10 Thread (example: www.mcmaster.com Eyebolt with Nut for Lifting, ¾"-10 Thread, 8" Shank, 4" Thread Length part# 3016T64)*
- *Six nuts: ¾”-10*
- *Six washers: 2” O.D., ¾” I.D.*
- *One 10' Roll of Amerimax 20" wide Aluminum Valley Flashing.*
- *One roll of duct tape.*

LUMBER

- *Two 4'x 8' sheets of ½" plywood (One-half sheet for each ground anchor).*
- *One 12 ft. 2”x 4” (for four ground anchor form stakes).*
- *Two 8 ft. 2"x 4" (For wall movement measuring and control).*
- *Two 8 ft. 2"x 4" (For temporary safety knee bracing.)*
- *¾" doweling 3 ft. long. (For preventing liquid concrete from plugging the ground anchor piercing sleeve.)*

MASONRY SUPPLIES

- *One sack of Portland cement.*
- *14- 40# bags of Sakrete concrete mix.*

REINFORCING STEEL

(from Steel Supply Yard)

- *Two 20 ft. lengths of ¾" re-bar (cut into six 40" pieces and three 80" pieces).*
- *Nine 24" pieces of ⅝" re-bar (for three ground anchors).*
- *Six 34” pieces of ½" re-bar (for three ground anchors).*
- *Six 4”x 4”x ¼” bearing plates.*
- *Three 8” pieces of 1” I.D. tubing.*
- *One 36" long ½" re-bar (concrete 'rodding' tool).*

STEEL FABRICATION AT WELDING SHOP

(see Figure 18 - Engineering Drawing No. 4)

- *Drill six 1" holes in six ¼" steel bearing plates.*
- *Tack weld three 1"x 8" tubes to three 4" x 4" x ¼" bearing plates.*
- *Heat and bend three "V" shaped 6" hooks on the ends of three ¾"re-bars 61" long.*
- *Three 6" long lap welds joining 36" threaded rod to 102" ¾" re-bars.*
- *18 tack welds three ground anchor grids of two ½" re-bars spaced 16" and three horizontal ⅝" re-bars spaced 12".*

  (Note: If your tilting wall is less than 3½' in height, see Figure 5 - Truncated Re-Bar Grid for Short Walls, page 21)

RENTAL EQUIPMENT

- *Roto-hammer with ¾" concrete drill bit (for drilling eyebolt holes in concrete wall).*
- *Ditch Witch or Case trencher with 4" wide trenching blades.*

INTRODUCING THE ACTION PACKET BASICS OF THE 'TRENCH, TORQUE AND TIE'™ PROCESS FOR SALVAGING TILTING, CRACKED & FAILING CONRETE RETAINING WALLS

A preponderance of the aging concrete retaining walls of yesteryear were faultily designed and hastily built. Six decades of unrelenting earth pressure have glacially tilted and cracked these yard terracing monoliths into precariously leaning and failing positions. Our new and simple process now enables the enterprising Do-It-Yourself homeowner to permanently up-right, restore and lock into a vertical position his huge home-sight liability.

The 'Trench Torque and Tie'™ method is entirely suitable for poured concrete walls of 2' to about 5½' high. It is not suitable for unit masonry concrete block walls. The key to up-righting a poured concrete wall is to first relieve the earthen pressure behind the structure. But the Ditch Witch and Case trenchers can excavate only a 36" depth. For walls higher than about five and one-half feet, significant additional hand work, or a rubber-tired backhoe is required to excavate sufficiently deep to relieve the earth pressure, permitting the up-righting movement. This factor renders the job more costly and less D.I.Y. doable. The job can still be accomplished, but at the price of more time, more money and more complexity, and is not entirely covered in this presentation.

The 'T.T.T.' process requires that the poured in place, reinforced concrete ground anchors be located behind and beyond the wall's original backfill material and in solid and undisturbed earth. It is these reinforced concrete ground anchors that must provide the necessary anchorage for the tension rods to upright the tilting wall, lock it into place and then, for decades, withstand the horizontal earthen pressure exerted on the wall.

The distance from the wall rearward to a solid earth embedment for the ground anchor determines the length of each tension rod assembly. A minimum of 10 feet is desirable, so the repair of failing walls located close to impediments such as buildings is not easily amenable to our D.I.Y. method.

Four separate components combine herein to achieve this effective resurrection of an otherwise doomed monolith. These factors are:

1. *The rental Ditch Witch or Case trencher to reduce the digging labor.*
2. *A solidly embedded, structurally sound, easy to construct, poured concrete ground anchor.*
3. *A strong, 7-day cured, poured concrete field splice for the 102" re-bar lengths to complete the tension rod assembly.*
4. *A simple mechanical means of transferring the required one ton up-righting force from the ground anchor to the wall. This mechanical means is the threaded nut on the 36" threaded rod shop-welded to the 3/4" re-bar tension rod. A 12" crescent wrench provides the 750 to 1 mechanical advantage to easily re-erect and lock the earth pressure relieved wall into its permanently vertical position.*

These four features comprise the essence of this D.I.Y. concrete wall up-righting method. The homeowner hand mixes his own small batches of concrete in a wheel barrow for the ground anchors and field splices as he needs and installs them. This unique 'wall-saving' resurrection method is solely a D.I.Y. process. The process assumes D.I.Y. difficulty in transporting twenty ft. long lengths of the tension rod assemblies. So, shorter pieces are obtained by having the steel yard chop-saw the re-bars into the exact lengths required. Or, the field splices could more conveniently have been welded instead of poured, but the D.I.Y. handyman homeowner seldom owns an arc welder. The 'bonding concrete' splice method is used to enable the D.I.Y. to readily form, pour, and make in the field those several sturdy, concrete-bonded, spliced connections if and when he needs them.

Note: This treatise is a wall-saving process, not a 'concrete mixing how-to.' So for those D.I.Y.'s who've forgotten how to properly proportion, mix, place and vibrate to obtain high-strength concrete, ---ask your questions of the friendly lumber yard and masonry supply salesmen where you will buy your lumber, Portland cement and Sakrete for the job. You can also find good information (and bad information)

with internet searches. One good source of information is the 56 page document "CONCRETE BASICS - A Guide to Concrete Practice" found at:

http://www.concrete.net.au/publications/pdf/concretebasics.pdf .

PHASE 1: WORKER SAFETY-STRUT - TEMPORARY BRACING

1. WHAT'S THE WORRY?

Your tilting retaining wall has, for decades, been creeping toward its now precarious tilted position. When its center of gravity moves beyond the outer-front edge of the footing, it will collapse! Just as a mountain-top snow avalanche can be set-off by a sonic boom, so can a sudden 'pan-caking' of your wall be triggered by a nearby trencher or even the vibrations of an 8 pound sledgehammer. And when it does fall, anything or anybody within the wall's 'collapse shadow' will be crushed! So, why gamble your life on the instability of that benign-looking, but potentially lethal monolith?

2. SAFETY BRACING INSTALLATION (Short Term)

Should your tilting wall collapse during your up-righting process, it is instantly beyond salvage. Costly demolition and expensive reconstruction then become your dismal, but only option. (See Phase III, 1. WALL SAFETY BRACING. Page 17 for a frightening look at your wall's vulnerability during the 'pressure relief' trenching process.)

A sturdy, quickly installed wall support and workman's safety brace can be as simple as an 8 ft. 2"x 4" and an 8" C-clamp. Here's how. Hand saw a pointed-stake tip on one end of the 2"x 4". Position it flat-side down on the wall at a 45 degree slope, with the sharpened tip on the ground about five feet from the base of the wall. Stand atop the wall and with an 8# sledgehammer drive the 2"x 4" tip firmly into the ground until refusal. Now double cut-off horizontally and vertically, the 2"x 4" top end as ***shown in*** *Figure 1 - Safety Bracing (Short Term), page 12. Connect an 8" C-clamp and an anti-slip block to the wall top, hammer the block down snuggly against the 2"x 4' brace and tighten the clamp. This will halt any further wall movement and safely prevent a wall collapse during your wall repair process.*

3. SAFETY BRACING INSTALLATION (Long Term)

However, if you wish to halt any further wall movement or sudden collapse and also postpone your repair job until fair weather, you can do so. First, install a 'Short Term' brace as shown in Figure 1 - Safety Bracing (Short Term) to permit safely occupying the wall's 'collapse shadow' area. This C-clamped 2" X 4" will allow you to safely install the more substantial 4"x 4" knee braces and footing blocks as shown in Figure 2 - Safety Bracing (Long Term).

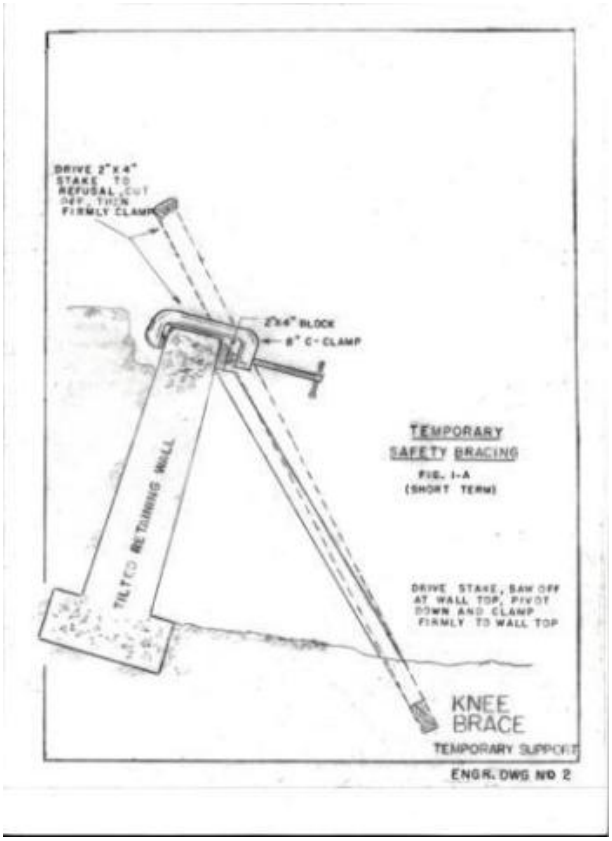

Figure 1 - Safety Bracing (Short Term)

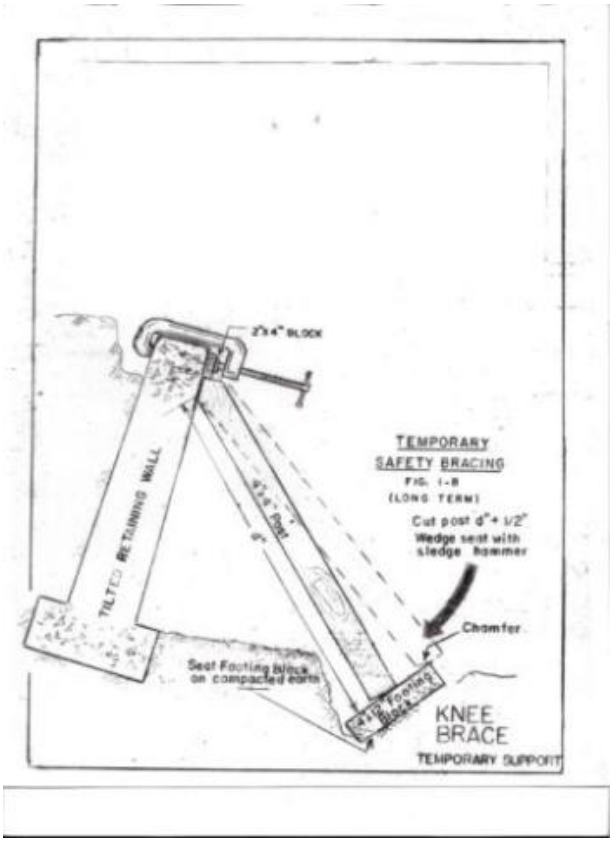

Figure 2 - Safety Bracing (Long Term)

PHASE II: BUILDING THE PROJECT PLAN FOR YOUR PROJECT

The steps for the second phase of the wall resurrection are herein chronologically sequenced. Following this sequence will provide for the DIY a smoother work-flow and minimal conflict between the tasks. Any errors and omissions made during Phase II will morph into additional work and cost later in the job. We believe that this 'task-planning' effort will prevent many problems for the D.I.Y.

*We have noted the three most likely mistakes that could 'fail' the project. (Look for the "**COMMON ERROR**" warnings in **boldface type.**) These mistakes are traps awaiting the unwary builder*

Here then, are the planning, staking and lay-out activities that will smoothen the work flow.

1. UTILITIES LOCATION

We want to avoid unnecessary excitement with this project. Most cities and counties maintain an Underground Facilities Location Council and 24/7 phone-message service. This service provides free underground pipeline or utility line location marking for those intending to excavate. Each utility will mark their own 'underground plant' traversing your property. It is 'self-serving' in that it avoids service interruptions and costly 'dig-ups' for them. Just a phone call gets you this free service within 48 hours. Once all of the location marks have been placed, 'daylight' any utilities that are close to your planned excavation marker stakes, by carefully unearthing all worksite underground utilities; gas line, water service, house sewer, underground power or telephone service line. When you can see the service lines, you reduce the chance of an accidental disruption of that service, electrocution, explosion, or neighbors complaining about missing an HBO special.

2. TENSION ROD TRENCH LOCATING

This document assumes trenching and ground anchor lay-out for a 30 ft. long wall, with three tension rod assemblies. For your project, you must determine the

number and locations of your needed tension rods. Measure the length of your wall. The horizontal spacing along the wall between tension rods should be 8 to 10 feet. This will leave 4 or 5 feet of wall face extending beyond the last tension rod at each end of the wall. Drive a marker stake behind and against the top of the wall at each tension rod location. You may need to adjust the tension rod selection sites if there are other impediments such as tall trees or large tree roots between the wall and your proposed anchor placements. If the large tree roots are shallow, you may be able to tunnel below and pass the rod beneath the root.

3. GROUND ANCHOR LOCATING

Now, select the location of the ground anchors and the trenches for the tension rods. Stand in front of the wall and sight past each wall stake perpendicularly. Look for tree trunks, low limbs, sprinkler controls, gas and water meters or other obstructions that will oblige a lateral shift in the drill holes, trenches or both. Then mark the center of the front face of the ground anchor by driving a stake firmly in undisturbed soil at least 12' from the wall. Add 4 more stakes to mark a 3 ft square for the corners of the ground anchor hole extending beyond this stake. Now re-sight across the two stakes (one at the wall and one at the ground anchor) for a final check on the 'trencher clearances' past any obstruction.

PLEASE TAKE NOTE: (COMMON ERROR No. 1) The ground anchor resistance stability depends entirely upon the transfer of several tons of tension rod force directly onto the earthen face contacting the ground anchor. So, the anchor must lie in solid, undisturbed soil, well beyond any backfill or excavated earth.

4. LOCATING DRILL HOLES IN CONCRETE WALL

With a tri-square draw a chalk line across the wall in a direct line with both stakes, marking the alignment for each of the ¾" drill holes through the wall. At each mark, use a hand level positioned vertically to draw a chalk line down the wall face. For a 3½' to 6' ft. high wall, measure downward 20" and place a mark for the location of each drill hole.

Note: If your wall is less than 3½' in height, see the eight "Special Instructions," appropriately located in the narratives.

Special Instruction No. 1:

NOTE: Measure downward 12" from top of wall to concrete drill holes. (See Figure 12 - Inside View of Ground Anchor Form, page 30.)

5. WALL-PRESSURE RELIEF TRENCH STAKING

This wall pressure relief trenching task is the 'enabler' that makes possible the up-righting and salvaging of tilting and failing concrete retaining walls. And the horizontal up-righting distance that the top of the wall can move is limited by the width of the trench you dig parallel to and behind the wall. So, if the wall has tilted 12," the trench width dug behind the wall must be at least a foot wide at the top! That means three or more 'passes' with the trencher and some hand-shoveling as well.

But, what is the minimum necessary trench width that is sufficient to permit a full up-righting of the wall? To determine it, simply drop a plumb-bob vertically from the outside top edge of the wall to the ground. Now measure the horizontal distance from the plumb-bob to the wall. (See Figure 7 - Wall Pressure Relief Trenching, page 25) This is the number of inches that the wall-top must be free to move rearward to become vertical; ----thence it is also the minimum width of the trench! Remember that you'll be unable to widen, even slightly, the trench width after the rental trencher is returned.

Move back up to the high side of the wall and place a stake at the measured distance 'D' plus 15," plus 4" from the back surface of the wall. (Figure 7) The 15" is the width of the 'un-cut' earthen wedge left by the trencher and lying against the rear face of the wall. The extra 4" should help thwart Murphy's Law and give you a little additional trench width in which to work. Add more stakes at this 'D'

plus 19" distance from the back of the wall every 5' of wall length to mark the distance from the wall of the final trenching pass cut.

Special Instruction No. 2:

NOTE: Do not trench below the depth of the bottom of the wall or its footing. This will undermine the wall's stability. (See Figure 7 - Wall Pressure Relief Trenching, page 25.)

6. PROTECTING YOUR LAWN (OPTIONAL)

Now that you can see the extent of the trenching damage to your yard, you may wish to minimize the effect on your lawn. I avoided decimating my front lawn by vertically slicing, undercutting 2" deep the five 24" wide strips with a mattock, then rolling them up and setting them aside. After filling and compacting the trenched earth, and later unrolling the turf, replacing and tamping it flat, I did no re-seeding. The lawn now appears virtually untouched.

7. YOUR OWN PLAN AND SUPPLIES LIST (SITE SPECIFIC)

After you have read through this document, you will need to draw up your own "master plan" of both the physical layout of your project, along with the supplies list for your specific project. Using the information in this document for your template, double-check all of your calculations before you buy the materials and specify to the steel yard your re-bar numbers, sizes and chop-sawed lengths. The careful, extra planning effort in this part of the project should significantly reduce the number of trips to the stores and wasted materials that accompany most projects.

Now, ---you've done your job planning and stake-out. Let's go to work!

PHASE III: PROJECT SEQUENCE AND DETAILS OF THE WORK

This section of the Action Packet describes in detail the separate construction tasks that comprise the total retaining wall resurrection job. Hence, we have given much thought to the correct and logical sequencing of each of these operations

*For the D.I.Y.'s use in cost estimating, collecting the right tools, scheduling the rentals, buying supplies and hardware, we have assumed a concrete wall 30 foot long, 5 ft. high and 6" thick. This wall length requires **three** ¾"x 12 ft. long tension rod assemblies. For other wall lengths requiring **one**, **two**, **four** or **five** tension rod assemblies, the D.I.Y. can then adjust proportionately his own quantities of steel, lumber, hardware and concrete.*

1. WALL SAFETY BRACING

Before you rent the Roto-Hammer and trencher, here is a thinly veiled warning! Your tilting concrete monolith has been glacially creeping towards its ultimate collapse for perhaps six decades. So, why now does it suddenly warrant a SAFETY WARNING? Here's why. A failing concrete retaining wall collapse can be 'triggered' variously by a sonic boom, an earthquake tremor, by the pull of gravity (when its 'tipping point' is reached) and ---by the added vibration of the Roto-Hammer or the additional weight of a half-ton trencher trundling along its crest!

So, for safety's sake, install two C-clamps and two 2"x 4" knee braces at the one-third length points, to firmly support the wall. (See 2. SAFETY BRACING INSTALLATION (Short Term), page 11) Leave these wall-saving props in place until the wall is tethered to the ground anchors and the hand-mixed concrete has cured for at least a week. This easy-to-build safety measure may well save you a serious injury, a bundle of cash and a ton of grief!

2. DRILLING HOLES IN CONCRETE WALL WITH ROTO-HAMMER

With the rental Roto-hammer drill the ¾" diameter holes in the concrete wall perpendicular to the wall face and at 20" below the wall top as shown in section 4. LOCATING DRILL HOLES IN CONCRETE WALL, page 14. The drilled holes in the tilted wall are located 20" down from the top of the wall, as measured along the face of the wall.

Occasionally, the drill bit will strike a steel reinforcing rod in the wall. If this conflict occurs, you can drill no further. So, move the drill bit horizontally 2 inches and re-drill the hole to miss the steel rod. If you hit it again, move the drill bit vertically 2". This small change in hole position should not affect the trench location.

Special Instruction No. 3:

NOTE: Measure downward only 12" from top of wall to locate the concrete drill holes. (See Figure 14 - Measuring Wall Movement, page 39.)

3. STEEL YARD RE-BARS, PLATES AND TUBING

Now is the time to acquire the re-bars, tubing, and plates from the steel supplier and have them cut into the needed lengths and in the several sizes. This cutting is in accordance with the materials list on page 6. This list is for the three 12 ft. long tension rod assemblies for a 30 ft. long wall. If your wall requires longer, more, or fewer tension rod assemblies, then adjust your steel supply materials list accordingly. (The steel-yard chop-saw cutting will save you and your welder a ton of grunt work and many mistakes!)

4. WELDING AND STEEL COMPONENT FABRICATION

Note: Here now, are the four pre-fabricated steel assemblies and the sequence of D.I.Y. tasks for 'Trench Torque and Tie'™ method of retaining wall up-righting. . (see Figure 18 - Engineering Drawing No. 4, page 45)

The pre-cut rods, tubes, and plates must now be taken to the welding shop of your choice for assembly and fabrication.

This includes all of the steel yard chop-saw cut pieces needed by the welding shop fabricator to make-up the four needed assemblies. (He does not need the three pre-cut 80" re-bar lengths.) The four types of welder-fabricated assemblies for a 30 ft. long wall are:

1. *Three 36" threaded ¾" rods lap-welded (6" lap) to three ¾" re-bars 102" long. One assembly is needed for each ground anchor. (Purchase the 36": threaded rods at a hardware store.)*
2. *Three 4"x 4" square ¼" base plates (with 1" center-drilled hole) are to be tack-welded to three 8"x 1" tubes, with holes in alignment. One assembly is needed for each ground anchor.*
3. *Three 61" long ¾" re-bars are bent to form 6" hooks of 60 degrees bend on one end of each. The hooks engage the eyebolts piercing the wall at each drilled concrete hole.*

Each of the three ground anchors requires a welded re-bar grid of reinforcing steel. The grid contains three ⅝" horizontal rods 24" long, spaced at 12" vertically, and two ½" vertical rods 34" long 16" apart. (See Figure 3 - Tension Rod Assembly, Figure 4 - Re-Bar Grid, and Figure 6- Tube and Bearing Plate, page 21)

Those, then, are the welded hardware assemblies that do the 'heavy lifting' and the concrete reinforcing. The following tasks can now be commenced.

1. *Buy the steel re-bars, tubing, and 4"x ¼" plates from the steel-yard supplier and have him saw-cut them to the correct lengths for your job. (See materials list on page 7.)*
2. *Next, select your 'small shop' arc-welder[1] and deliver to him the three 102" and three 61" pre-cut re-bar pieces, 36" threaded steel rods, 4" sq. bearing plates, and 8" steel tubing pieces. He can now fabricate the four types of assemblies required for your job.*

[1] [1] *Note: We recommend selecting a 'small-shop' type welder with whom you can speak directly. With a large commercial steel fabrication company, you will find higher 'overhead' costs and you must deal not with the actual welder, but through a third-party, the 'office manager.'*

Special Instruction No. 4:

Note: If your wall is less than 3½' in height, fabricate the truncated re-bar grid. (See Figure 5 - Truncated Re-Bar Grid for Short Walls, page 21, and Figure 18 - Engineering Drawing No. 4, page 45.)

We have provided a steel fabrication 'shop drawing' for your welder's *information and guidance (see Figure 18 - Engineering Drawing No. 4, page 45). It contains the arc-welding assembly details drawn with the American Welding Society's standard welding symbols. Shop welders are familiar with A.W.S. symbols and standard practices.*

The welder/fabricator at his shop can now assemble, heat, bend and weld for you the three assembly units for your job. These units will link your tilting wall to the ground anchor through the intervening pre-cut 102" tension re-bar rods. He will also drill, align, and tack weld the bearing plates to the 1"x 8" steel tubes.

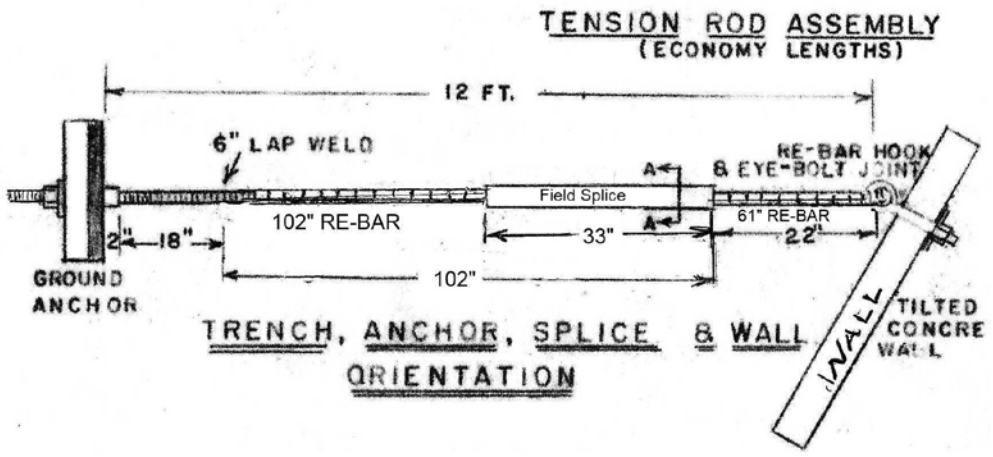

Figure 3 - Tension Rod Assembly

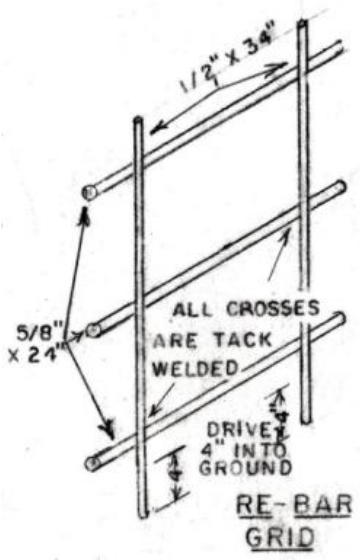

Figure 4 - Re-Bar Grid

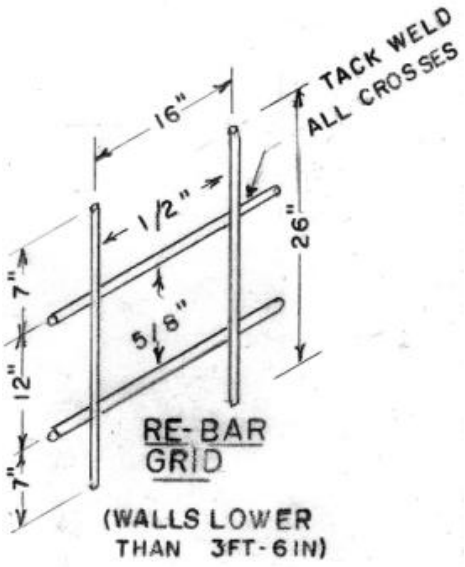

Figure 5 - Truncated Re-Bar Grid for Short Walls

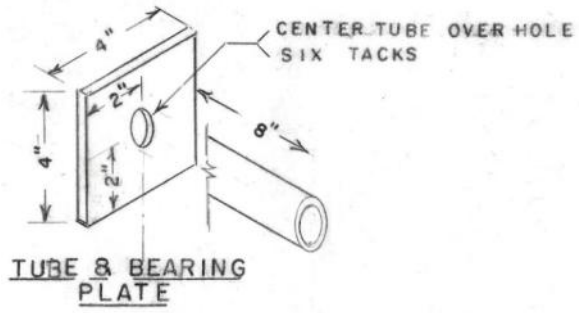

Figure 6- Tube and Bearing Plate

5. RENTAL TRENCHER MACHINES (GENERAL INFORMATION)

TOOL RENTAL SUGGESTION: Trencher rental time is the most expensive cost element of the job, so don't rent the roto-hammer and drill any holes until all o the trenching is completed and the trencher is returned. You may find that you need to relocate some of the trenches to avoid trees, meters or other obstructions. Any such trench re-alignment will affect the location of the holes to be drilled through the concrete wall. So leave the hole-drilling until after all trenching is completed.

If your wall is more than 30 feet long, and has more than three tension rods, then a half-day, 4 hours ($100) is probably insufficient trenching time. However, for less than twice the rental fee you can use the machine for a full day, 24 hours ($185). I found that with my own failing 50 foot wall, trenches and five ground anchor pits, I needed the full 24 hours and had to hustle to return the trencher on time!

Tool rental stores carry several brands of trenchers, each with models for different types of trenching and at various maximum trench depths. Some are suitable for shallow lawn sprinkler systems of only 18" depth. So be certain that your trencher will dig at least 36' deep. Even at this maximum depth, you will need to do additional hand-shovel trench deepening for sufficient earth pressure-relief behind your wall.

Now, here's a useful caveat you'll want to recognize. Tool rental stores now provide the D.I.Y. the trailer needed for hauling the trencher, but they now require a 'frame-mounted' trailer-hitch on the towing car or pick-up truck. So, no more 'clamp-on-the-rear bumper' type hitches! Home Depot stores may also rent their trucks for transportation of large purchased or rented items.

6. TRENCHING FOR 'WALL-PRESSURE' RELIEF AT BACK OF WALL

The retaining wall 'pressure-relieving' trench is the most crucial; the most difficult and also should be the first trench to be dug. Here is why. The wall trench runs perpendicularly to the several tension rod trenches which will later intersect it. And this wall trenching task will demand a smooth, flat surface upon which the

trencher wheels must roll to make multiple consecutive 4" wide 36" deep cuts. So, digging first the wall pressure relieving trench, then the tension rod trenches, avoids creating mounds of excavated earth across the needed flat area behind the wall.

Special Instruction No. 5:

NOTE: Do not trench below the depth of the bottom of the wall or its footing. This will undermine the wall's stability. (See Figure 7 - Wall Pressure Relief Trenching, page 25.)

Since 36" is the maximum 'Ditch Witch' or Case trenching depth, some additional-hand shoveling must be done behind walls of five feet height. The D.I.Y.er may also loosen the deeper earth enough to permit up-righting, by using a 20# six-foot long chisel-tipped crowbar, and repeatedly plunging and prying back the loosened earth behind the wall at its base. Alternatively, a post-hole digger may also be used to lift out soil deeper than 36".

PLEASE TAKE NOTE: (COMMON ERROR NO. 2) The failure to remove a sufficient width and depth of earth behind the full length of the wall can prevent the wall's full vertical up-righting.

There are two consequential risks involved in wall-torquing with an excess of solid earth remaining low in the trench against the base of the wall. This earthen plug can act as a 'fulcrum,' restraining the wall from fully up-righting.

Then, the huge horizontal pulling force exerted by tightening the threaded rod, rather than moving the wall-top rearward, may cause the wall to actually pivot upon the earthen fulcrum. The resultant prying action could push and move the wall footing forward, rather than pulling the wall top rearward as intended.

Alternatively, continued torquing against this low-lying earthen fulcrum could open a horizontal crack along the front face, low on the wall. This is particularly a risk if the wall contains little or no vertical steel reinforcement. So, the D.I.Y

certainly must apply the tensioning force sparingly, and carefully control the wall movement. (See Figure 14 - Measuring Wall Movement, page 39) It is these kinds of technical problems that we envisioned when we provided for E-mail and telephone consultation services for those clients who chose the option granting additional guidance and advice. These problems are site-specific and complicated. Thus, the generalized information in this packet may be inadequate for complex solutions. Such inquiries may require considerable additional information exchanges to enable a competent response to the D.I.Y client.

Trenching parallel to and behind the rear face of your tilting concrete wall is the crucial element in relieving the earthen pressure behind the wall. But great care must be taken to safely position the trencher's rear single left side wheel along the top edge of the narrow concrete wall. The ejection auger casts the excavated earth from the left 'single wheel' side of the trencher. This trencher positioning, on the first of several passes, will eject and cast the surplus earth directly over the wall. The discharged earth will thereby not interfere with the trencher's back and forth travel as it excavates the remaining 4" wide, 36" deep 'pressure-relief' cuts.

With the single left rear wheel riding atop the wall, the first cut will be made as closely as feasible; about 15" from the rear face of the wall. After each cut, back the trencher rearward the full length of the wall, then move it to the right laterally 4" further away from the wall and repeat the several cuts until the needed width of pressure-relief trench is acquired.

There is a distance of about 8 ft. from the trencher's cutting blades to the operator's position. So, depending upon end-of-the-wall conditions, there may remain an un-excavated plug of earth after the required several 4" wide cutting passes. If so, turn the trencher around 180 degrees and carefully make a series of 4" wide cutting passes to remove this remaining 8 ft. long earthen plug.

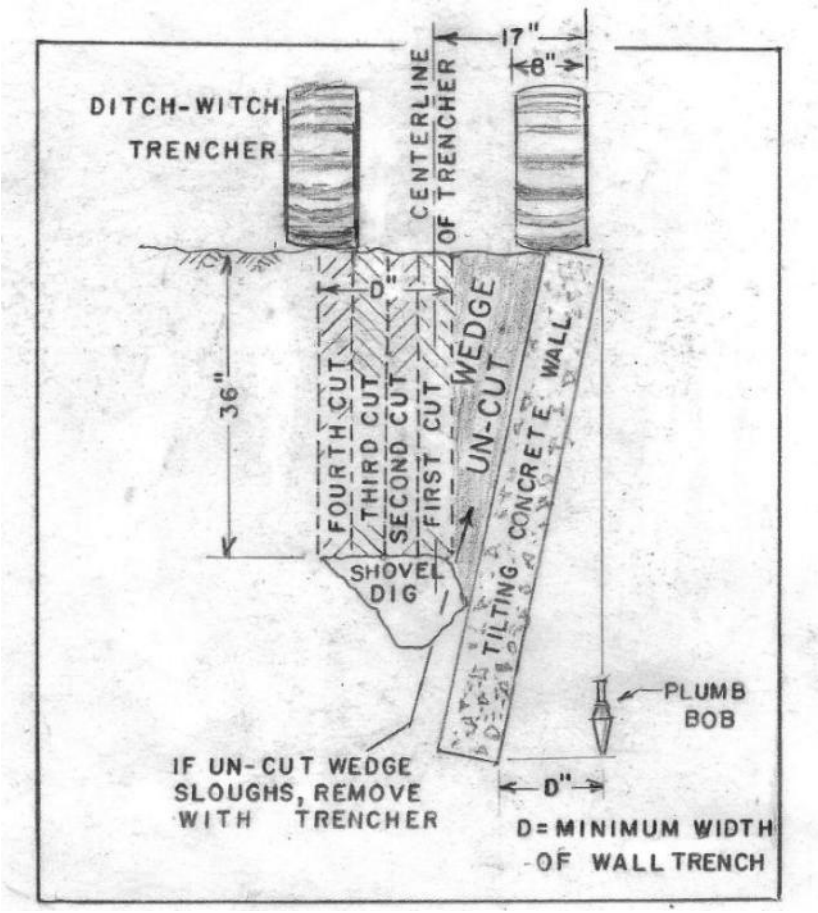

Figure 7 - Wall Pressure Relief Trenching

7. TRENCHING FOR THE TENSION ROD

Now you are prepared to excavate the trenches for the tension rods and anchors. Since the operator walks backwards, but ahead of the following trencher, start digging the tension rod trench at the wall and finish excavating at the stake marking the ground anchor location.

For our example, we are assuming that the wall top has tilted laterally (horizontally) 12". Dig the tension rod trenches 22" deep. This trench depth is needed at both the eyebolt (beginning) and at the ground anchor (end) of the tension rod assembly. The tilted wall geometry has effectively 'lowered' the eyebolt elevation about 4," hence a deeper trench depth must accommodate the

lowered re-bar hook elevation. And the threaded rod connection depth at the ground anchor must remain low enough to provide the required load bearing capacity. These two factors combine to necessitate this 22' tension rod trenching depth.

Special Instruction No. 6:

Note: If your wall is less than 3½' in height, dig the tension rod trenches only 14" deep.

8. TRENCHING FOR THE GROUND ANCHOR INSTALLTION

The tension rod trench excavation was completed when the ground anchor location stake was reached. Now rotate the trencher 90 degrees CCW, perpendicular to the trench, and excavate the 3 ft. square (at the bottom), 34" deep ground anchor pit. The 34" excavation depth places the ground anchor top 4" below ground surface to allow for topsoil cover, turf and plantings.

It is from this pit, behind the ground anchor that all of the wall up-righting torquing action will be done. The 36" long ¾" threaded rod will be withdrawn rearward through the 1"x 8" tubular sleeve (in the ground anchor) using a 12" crescent wrench. The back side of the ground anchor pit must have enough room for installation and the subsequent stripping of the form, along with sufficient working space for manipulating the 12" wrench for the upraising process.

The pressure face of each ground anchor pit must have a smooth wall of undisturbed earth to resist about a ton of up-righting wall resistance force. As the trencher is now cutting parallel with the wall, the resultant earthen pressure face should be flat and smooth, ready to receive the 28" x 30" plywood form.

Finish the pit excavation by using 4" wide sharpened mattock blade or a small spade to 'square' up the rounded trencher-cut ends at the pit base.

Special Instruction No. 7:

Note: If your wall is less than 3½' in height, dig ground anchor pit only 22" deep.

9. FABRICATION AND INSTALLATION OF THE GROUND ANCHOR FORMS

FORMING: We've found that the plywood form 'box' for the ground anchor concrete pourings can best be built on a work-table.

First build the complete box-form upon a work-bench. For a 'make-shift' work table, place a scrap plywood sheet on a pair sawhorses. Then lay-out, saw and assemble the trapezoidal box containing three long wooden stakes, a steel tube and base-plate and a re-bar mat. (See Figure 8 thru Figure 12, starting at page 29)

Each anchor form contains three plywood panels, three 34" long wooden stakes and two steel weldments from the welding shop. The assembled form box is then installed as a unit in the three ft. square earthen pit merely by driving three wooden stakes and two steel re-bars 4" into the earthen floor.

Here are the steps for building, assembling, and installing the ground anchor forms:

9A. Building The Front And Rear Panels:

1. *For each of the three ground anchors, lay out the three panels on a sheet of ½" plywood. Then saw-out the three panels; two 14½”x 30", and one 28"x 30". (See Figure 8 & Figure 12, starting at page 29)*
    1. *Rip-saw-cut two 34" long 2”x 2” pieces from a 34" long 2"x 4", and then sharpen one end of each. These are the two end stakes for the ground anchor*
    2. *box form. Alternatively, you can use 2”x 2” lumber to make the stakes.*
    3. *Rip-saw cut the two 34" long 2" x 2" pieces from a 34" long 2" x 4" and then sharpen one end. These are the two end stakes for the ground anchor box form.*

Special Instruction No. 8:

Note: If your wall is less than 3½' in height, cut the three plywood panels 8" shorter at the top; that is 22," rather than 30" high. Leave all other horizontal dimensions 'as is.' (See Figure 9 - Truncated Anchor Form, page 29.)

4. *In the 28"x 30" (and the truncated 28" x 22") front face panels bore a 1-¼" hole on centerline and exactly 10" above the bottom of the panel. Here is how to bore a large hole with a small bit. Scribe a 1-¼" diameter circle centered 10" above the bottom of the 24"x 30" panel. Then rough-cut it out with a series of ¼" holes drilled along the perimeter. This hole will receive the 1"x 8" long tubular sleeve tack welded to the bearing plate (See Figure 11) mounted on the two rear panels.*
5. *Lay the pointed 34" long 2"x 2 stakes along the edges and beneath 28"x 30" panel. Drive four nails through the plywood panel and into each of the 2"x 2"s. This is the front half of the concrete anchor box form. Flip it over and set it aside.*
6. *Now prepare the rear half of the box form. Mark a centerline on a 34" long 2"x 4" piece, and then sharpen one end to form a stake. Firmly fasten the two rear 14½"x 30" plywood panels to the 2"x 4" stake and abutting that centerline using No. 4 box nails. Slope the panels upward at 4½" in 14½" (18 degrees) adjusting the 2"x 4" temporary support shims to achieve the proper angle as shown in Figure 10 - Plywood Shim Detail.*
7. *Now bore a 1" hole through the two rear plywood panels and the 2"x 4" stake, centered 10" above the bottom edge of the panels. This 1" hole in the rear of the form aligns with the front 1-½" hole and receives the 1" tubular sleeve, and later, the 36"x ¾" threaded rod. (See Figure 8 & Figure 11)*
8. *The rear panels remain positioned with the 2"x 4" stake side down. Now place the 4" square steel plate and tube centered over the 1" hole. Using two No. 4 box nails for each edge of the steel plate, drive the nails half way into the plywood and 2"x 4", and then bend them over to firmly affix the 4"*

square steel bearing plate and protruding 8" long tube. This completes the rear panel of the concrete anchor box form

9. *Cut a pair of 2"x 8" rectangles from scrap ½" plywood. Position these shims as indicated in Figure 12 - Inside View of Ground Anchor Form, page 30. Tack-nail the shim in place, bending the protruding nail over for safety. Set the rear panel aside.*

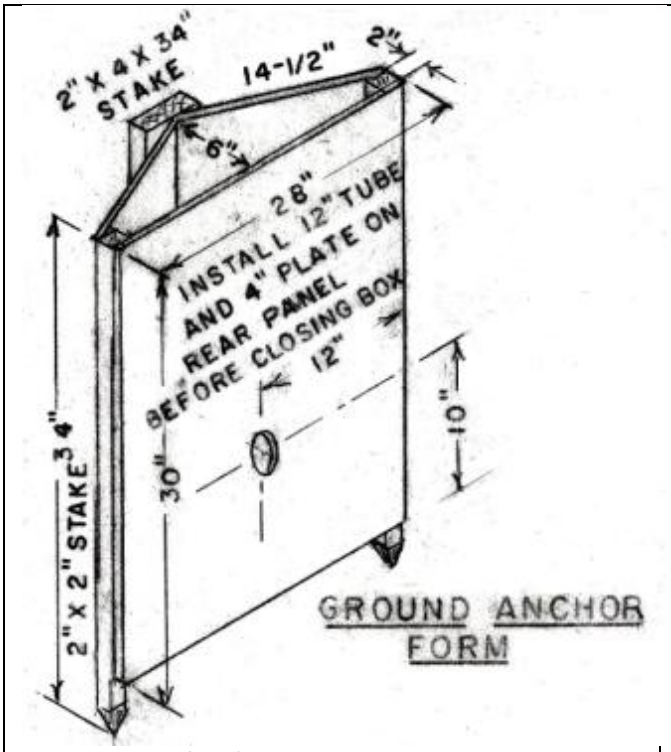

Figure 8 - ***Ground Anchor Form***

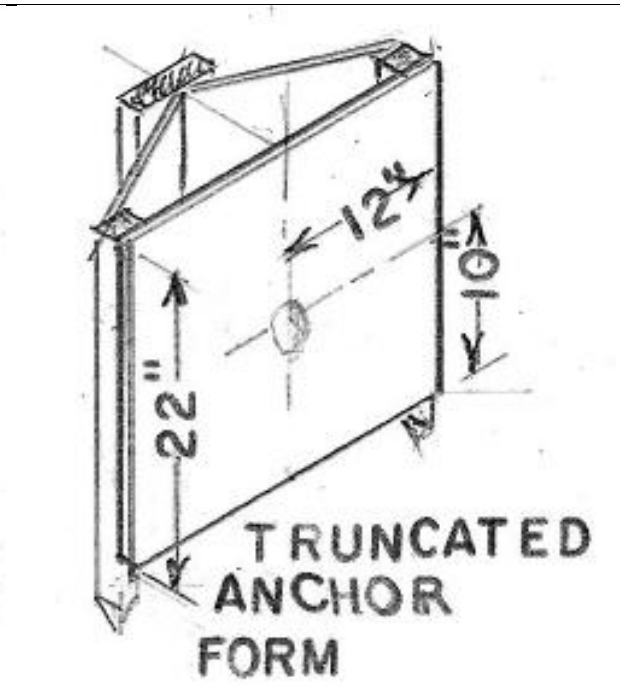

Figure 9 - Truncated Anchor Form

Note: The two weldments (Figure 4 and Figure 11) must be enclosed before attaching the back half of the form to the front face..

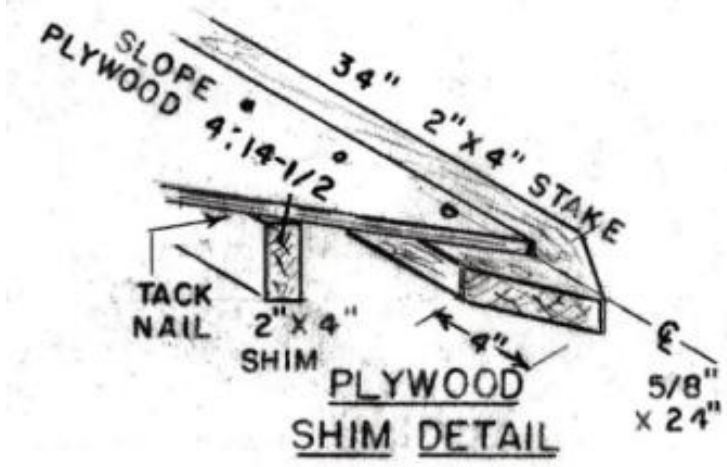

Figure 10 - Plywood Shim Detail

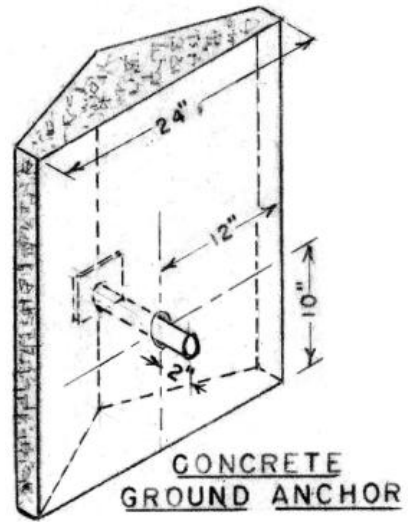

Figure 11 - Tube and Bearing Plate Position

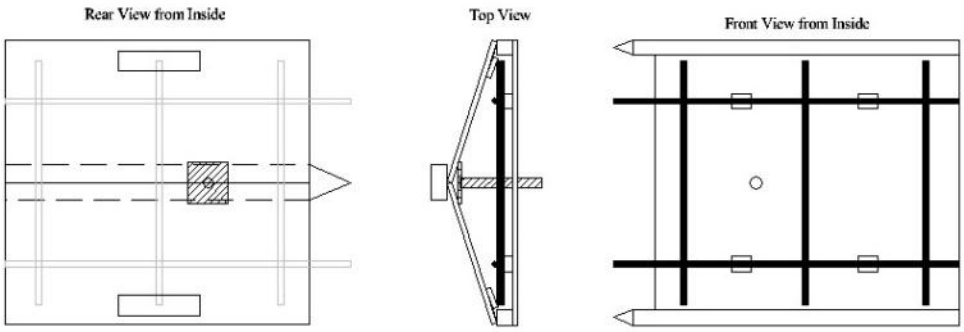

Figure 12 - Inside View of Ground Anchor Form

9B. Assembly:

1. *Now place the front panel of the form box face down, and then set the steel re-bar grid on front panel, with the 2 vertical bars towards the plywood.*
2. *Position the lower 12"x 16" central re-bar opening over the 1¼" hole in the front panel piece, with the long ends of the ½" re-bars centered midway between the points of the 2"x 2" stakes.*

3. *Saw cut four 2" long 2"x 2" wooden chairs from your left-over 2"x 2" stock. Place them under the vertical re-bars as shown in Figure 12 - Inside View of Ground Anchor Form, page 30. Drive 3 or 4 nails into each chair, and then bend them over the re-bar. Lightly nail them into place on the front form. This will position the steel re-bar mat with the horizontal bars parallel with and properly spaced about 1" from the front face of the panel*
4. *Place a pair of 2"x 4" scraps under the sides of the front assembly to provide space for the protruding pipe, and then fit the rear assembly onto the front unit. Allow the bearing plate's 1" diameter tubular sleeve to pass downward through the 1¼" hole in the front assembly.*
5. *Align the edges the rear panels with the edges of the two 2"x 2" front panel stakes, and then fasten with 4 nails along each side, completing the forming job and the assembly.*

9C. Installation:

1. *The complete plywood form assembly is now perched upon three wooden stakes. Position the flat side of the form against the "pressure face" (wall side) of the anchor hole. With a heavy hammer gently pound the three stakes down four inches to seat the three plywood forms firmly onto the trench floor. Alternate the hammer strikes among the three stakes to avoid twisting the form.*
2. *Drive the Re-Bar grid legs approximately 4" into the earthen floor until flush with the top of the plywood box form.*
3. *Before pouring concrete into the ground anchor form, insert the three ft. long ¾" wooden dowel through the tube and form. This precaution step will assure that liquid concrete, during the ground anchor pour, does not enter and plug up the 8" tubular sleeve.*

Now, -----If you think this assemblage was a bit tricky, just try assembling and nailing together this eight-piece form while bending over in a 34" deep earthen pit!

These sturdy anchors are the foundation upon which success of the remaining work depends. Care in their construction for adequate strength is crucial. Adhere closely to the engineering drawing and construction details for their dimensions, steel reinforcing and positioning. The front side of the anchor is the 'Pressure face.' This anchor face transfers several tons of tension rod force from the wall directly onto the vertically cut earthen surface.

The steel reinforcing tack-welded grid for the ground anchor consists of three ⅝" re-bars placed horizontally, spaced 12" apart vertically. These horizontal re-bars are the principal concrete anchor reinforcement and must be carefully positioned 1-½" from the plywood front face. This horizontal steel prevents the two tapered wings of the anchor from 'breaking off' as the tension rods are torqued and stressed to their design limits.

The two vertical ½" 'support rods' are spaced 16" apart and held together by tack-welding. These two ½"x 34" rods have 4" of extra length at the bottom that is to be driven into the earthen floor to hold the grid firmly in position 1-1/2" from the front face while concrete is poured and rodded. The anchor will achieve adequate strength, about 70% after 7 days of curing.

10. EYEBOLT CONNECTION AT THE WALL

Install the eyebolts, bearing plates, washers and nut as shown on Figure 15 - Engineering Drawing No. 1, page 42. This will allow the tension rods to be properly positioned for the field splices. Run the eyebolt nut, washer and bearing plate fully up against the front face of the wall, drawing the eyebolt loop against the rear face of the wall. This will provide four more inches of length if needed later. If not then needed, the bolt length protruding from the face of the up-righted wall can be sawed off.

11. CONSTRUCTING THE FIELD SPLICES

There is a maximum of only one field splice in each tension rod assembly. It employs the 100 psi bonding strength of concrete-to-reinforcing steel to link together the two ¾" re-bars (102" and the61" long, 6" 'hook ended'). These three

¾" re-bar rods, once combined, connect the sturdy ground anchor to the, soon to be up-righted, tilting concrete wall. (see Figure 3 - Tension Rod Assembly, page 21)

But, there is a downside to the necessity of using a 22' deep trench, as discussed earlier in "7. TRENCHING FOR THE TENSION ROD, page 25" It is impractical to properly 'pour,' or assemble the several field splice components while working in a 22" deep narrow trench So, to 'simplify the complex,' we are advising, ---merely assemble, 'pour,' or weld the splice on the ground surface, then simply lower the completed splice assembly into its final position on the trench floor.

There are perhaps as many ways to form a poured concrete field splice as there are D.I.Y's to do it. But since you'll need to cast six of these units, it's well worth doing it as effortlessly as possible. So here is how this pair of engineers prefer to form the field splice.

But, before accepting our solution, browse through Ace Hardware or your favorite lumber yard's rain gutter and downspout display looking for a suitable 'U'-shaped sheet metal cross section. Plastic isn't much good because you can't alter its shape by bending it. Select a shape at least 3" wide but 4" is maximum. The sides can be 3" or more in height and you'll need six to eight lineal feet of sheet-metal for six 33" long splice forms.

Should you be unable to find a suitable or adaptable sheet metal gutter or downspout shape, here is our preferred solution to your 'form-building' task. All you need is a mallet, a pair of tin-snips, a mandrel, some duct tape and six slices of sheet aluminum. A make-shift mandrel upon which to bend and shape the aluminum plate into a 'U' - shaped aluminum concrete form can be as simple as a 2" X 4" firmly clamped in a vice leaving about 16" protruding.

Ace Hardware sells a 10 ft. roll of Amerimax Aluminum valley flashing in 20" width. Each 33" long metal splice form can be cut and shaped from a 33" X 13" piece of aluminum flashing. Cut and bend it into form as shown in Fig. 9.

11A. Poured Concrete Field Splice:

1. *Place on the ground at the splice location a small piece of scrap plywood for a work-surface beneath the field splice. Lay out a 16" wooden support stake across the trench near the ground anchor form, and another support stake across the end of the trench near the wall.*
2. *Now position the tension rod elements on the two stakes and plywood work surfaces. Lay the two re-bars in the 33" long sheet metal form plywood work surface. Using a carpenter's level or plumb-bob, carefully position the 'bent elbow' of the hook exactly above the loop in the eyebolt.*
3. *Moving to the ground anchor plywood form, and again using the level or plumb-bob, position the threaded rod to overhang and extend about 4" beyond the rear form. This precision positioning of the two weldments is crucial because it rigidly 'fixes' the length of the tension rod assembly between the immoveable anchor and the implanted eyebolt. And if the assembly is just 2" too short, we cannot later, after hooking up the eyebolt, engage the torquing nut onto the 36" wall up-righting threaded rod.*
4. *Before pouring the field splice re-check both the hook positioning over the eyebolt loop and the 4" to 6" protrusion distance of the threaded rod extending beyond the rear anchor form.*
5. *Firmly tie-wire the pair of re-bars at both butt-ends. You can cut about 2' of wire, and then fold it in half. Wrap this double wire 2 or 3 times around the re-bar, about an inch from the butt-end. Hand twist, and then grab the twist with the Klein's to tighten up the wrap.*
6. *Slide a 33" long aluminum sheet metal form beneath each tied re-bar splice. Saw cut four 1"x 2" by 3" long wooden support chairs from a 16" stake. Lay them flat-wise across the bottom ends of both forms to support the re-bars. Center the forms on the tied re-bar butt ends.*
7. *Using duct tape, close up both ends of the aluminum forms to prevent concrete leakage, as shown in Figure 13. First tape a 1" wide by 16" long strip circumferentially around each end. This provides a support strip across the top upon which to bond the ensuing 8" long by 1" wide duct tape strips*

that close up the openings at the box ends. This taped sheet metal concrete-filled form can be buried and abandoned after the 7 day curing period.

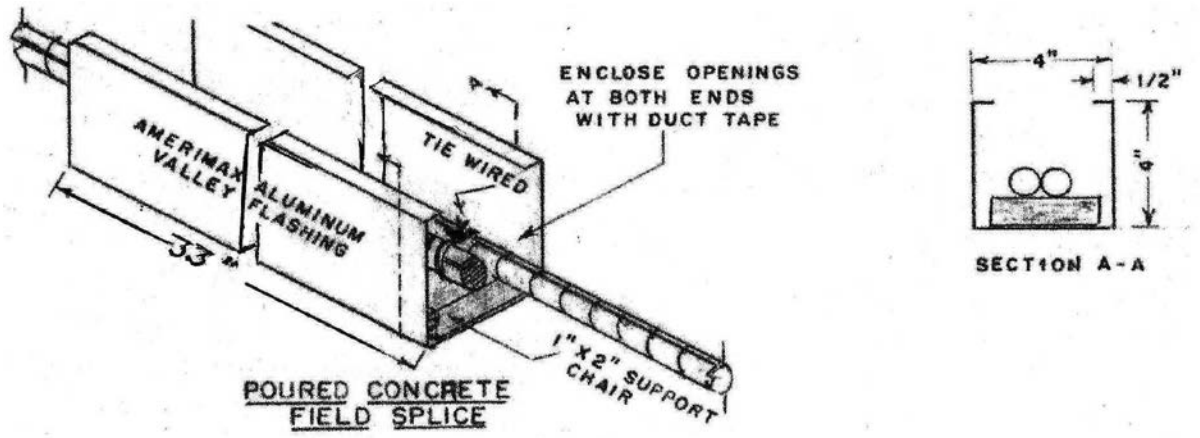

Figure 13 - Field Splice Detail

11B. Welded Re-Bar Splice

However: If you happen to have access to an arc welder, the entire field splicing process becomes much simpler.

1. *Follow steps 1 through 5 for proper positioning and tie-wiring of the steel pieces. There should be an overlap for welding of about 12" at each splice. (It is here at the splice that we can absorb any shortage or surplus of the pre-cut re-bar lengths.)*
2. *Run two pairs of 12" lap welds along both the top and the bottom of the two pairs of overlapping side-by-side re-bars. The permanent connection and the length is now 'fixed.'*

12. MIXING AND POURING CONCRETE

Now you're ready to mix the 'mud,' and to cast-in-concrete the anchors and splices that truly comprise the structural heart of the D.I.Y. wall salvage process! The concrete for the anchors and splices is to be hand-mixed in a 6 cu. ft. wheelbarrow with a shovel, hoe and a garden hose. Both the anchor (for strength) and the rod splice (for bonding) are dependent upon high quality concrete and careful

placement. Use Sakrete with a minimum of water, low slump and also add an extra pint of Portland cement for each 40# bag of Sakrete for additional concrete strength and workability. Hammer-tap vibrate the plywood forms and reinforcing steel and rod-plunge the concrete with the 3 ft. x ½" re-bar rod to prevent rock pockets and to thoroughly coat the re-bar grills.

Concrete acquires about 70% of its full term strength during the first week of curing. Let the finished anchors and splices cure for at least 7 days to insure the necessary bonding strength for the next phase of the T.T.T. process. After the 7 days curing, you can strip off the rear portions of the concrete anchor forms, but you'll be unable to remove the 28"x 30" front face of the form, so, just abandon it. You can leave the forms on the field splices, too.

13. ATTACHING TENSION ROD HOOKS

After the required 7 day curing period has elapsed, the finished tension rod assemblies can be moved into position for the final stage of the project. This is the one part of the project where a second set of hands can come in handy, so invite a neighbor over to enlist his help and to show him the progress on your project.

Liberally apply a coating of Permatex Anti-Seize lubricant to the full 30" length of exposed rod threads in the ground anchor. This will greatly reduce the mechanical torquing friction when up-righting and protect the threads from rusting.

Carefully lift the poured or welded spliced tension rod assembly at its mid-point and insert the threaded rod partway into the ground anchor's protruding 1" diameter tube. Then hook the other end of the tension rod assembly downward onto the eyebolt loop at the wall. Now lower the entire tension rod assembly onto the trench floor. The threaded rod should now protrude 2" to 3" beyond the anchor form to permit the washer and nut installation. Install the washer and nut on each of the threaded ends, spinning them on "finger tight". This completes the installation of the field-spliced tension rod assembly

14. BACKFILLING THE TENSION ROD TRENCHES -- (But NOT YET)

After completing the concrete pouring for the ground anchors and field splices, the tidy D.I.Y.er may be tempted to then immediately backfill the 22' deep 'Verdun-looking' trenches plowing-up this front yard. ***Do NOT do it!*** *---and here's why.*

Until the concrete retaining wall is finally 'torqued' into its upright position, this ready access to the ground anchors, rods and field splices should remain open. A poorly bonded re-bar rod might pull apart from the splice. A tension rod could snap under the torquing stress. Or a ground anchor could fail under pressure.

Following any such event, visual inspection and instant access for repair of the entrenched elements is essential. Also, during the up-righting process, the field splices must slide rearward in the trench and move backward the same longitudinal distance as does the top of the wall. Only an open trench affords this needed visual observation and repair access.

You've already returned the rental trencher. So, a hand re-excavation of a backfilled trench could be an overwhelming task!

PHASE IV: UP-RIGHTING THE WALL (This is the easy part.)

The wall up-righting phase of the job is perhaps the single most enjoyable and gratifying task in the retaining wall salvage project. This is because the D.I.Y. homeowner gets to witness in about sixty minutes the full reversal of the wall's glacial tilting that has occurred during the last sixty years!

You have completed the final concrete pour more than a week ago. The anchors and splices are cured, and the tension rods are ready for tightening. The bearing plates, washers and nuts are in place on the threaded rods.

Now that the wall is tethered to the anchor, and will not collapse, you can safely remove the temporary safety bracing. Concrete reaches about 70% of its ultimate strength in 7 days. Full strength requires 28 days curing to be attained.

PLEASE TAKE NOTE: (COMMON ERROR No. 3) The temptation is to rapidly 'crank-up' the tilting wall and quickly raise it to a plumb position. Resist this impulse! The torquing of the nuts, even alternatively, puts a slight longitudinal twist on the wall. So, tighten the nuts only in small increments. This will minimize the wall-twisting and lessen any vertical cracking occurring between the eyebolt connections.

1. THE LOGISTICS OF WALL UP-RIGHTING

It is crucial to raise the entire length of the wall uniformly to avoid vertical cracking of the concrete. Ideally, all of the tension rods would be tightened simultaneously and at equal rates during the up-righting process. But with three tension rods that would mean the coordination of three people on three rods with three wrenches. This is not very practical. So instead, the up-righting D.I.Y. alone can tighten the nuts in rotation and in small but equal increments.

2. TORQUING WITHOUT CRACKING

The rod's threads are 10 threads per inch (t.p.i.), so three full rotations of the nut moves the wall 3/10ths of an inch. That's quite a bit of 'wall twist.' But a single full turn revolution moves the wall only 1/10th of an inch. So, begin by taking the

slack out of each tension rod by tightening each nut until the hook and eyebolt make firm contact and do not slide with gentle hand motion. Then, begin the wall moving at one end of the wall and tighten each nut only one full rotation of the crescent wrench. Then return to the same end of the wall and repeat the tightening process sequence.

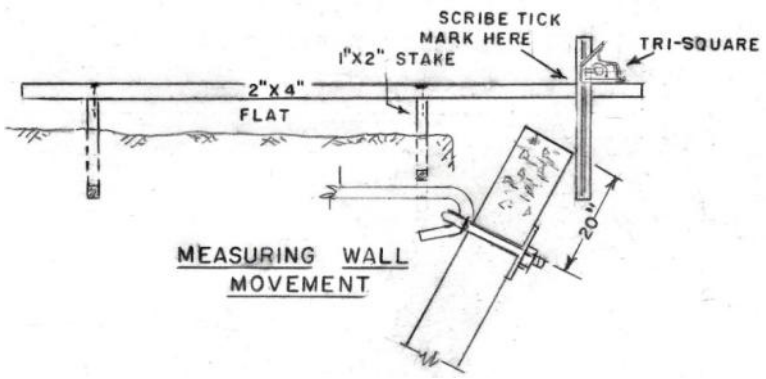

Figure 14 - Measuring Wall Movement

3. MEASURING THE WALL MOVEMENT

The concrete wall up-righting process, with its 750 to 1 mechanical advantage (neglecting friction), produces a tremendous horizontal pulling force. Since the wall moves in small increments, you'll need a method of measurement to indicate your progress. Here is an effective, accurate means of monitoring, measuring and controlling your wall's movement.

Position flat a six to eight foot 2"x 4" alongside the tension rod trench, and protruding slightly beyond the wall (Figure 14 - Measuring Wall Movement, page 39). Drive two 1"x 2" stakes, one near the wall and one at the other end of the 2'x 2"x 4", with 4" exposed above ground level. Place the 2"x 4" on the stakes, positioned to overhang the wall about 6" and nail it fast onto the two stakes.

Now lay your tri-square on the 2"x 4" with the blade extending downward and against the front face of the tilting wall. Scribe the 'zero' tick mark on the 2"x 4" edge. Now, by 'tick-marking' the 2" x 4" after each successive wall movement your can monitor the progress of the nut-turning cycles.

NOTE: *WALL MISALIGNMENT: Your wall may be tilted at varying angles throughout its length. Vertical cracks along the wall face are evidence of this differential tilting. A quick means of checking and rectifying these deflections is with a chalk line tightly strung the full length of the wall. (Place a short ½" piece of wood doweling beneath the string at each end so that the string does not touch the wall at any point.)*

Why is this so important? It is because you must align and 'true-up' the wall by torquing the points of greatest deflection first. Then, after your chalk-line gage shows the wall to be in straight alignment, proceed with the uniform rate of up-righting.

It should take about an hour to move the top of a 'three tension-rod' wall 12", horizontally. When the wall appears to approach the vertical position, check with a level for plumb at each tension rod location. You can adjust the rates of wall movement at each rod location to bring the entire wall to "plumb" by turning the nuts less than full turns on the "more vertical" locations.

4. COMPLETING THE JOB

After backfilling and compacting (use an eight ft. 2" x 4", plunging it *vertically 'endo,' compacting the earth into the trenches. Replace the rolls of lawn, sprinkle with water, and lightly tamp down the strips at any high spots. You will still have leftover, surplus earth about equal to the volume of concrete you mixed and poured for the ground anchors and field splices.*

(A suggestion) If there exist below the wall no impediments, such as a sidewalk to preclude it, you can now again dump the surplus earth over the wall onto that already ejected during the wall trenching. Rake it out smoothly, and you're done!

A personal note to you, our enterprising D.I.Y. client:

You are pioneering a startlingly new do-it-yourself retaining wall salvage method that will save many otherwise doomed tilting monoliths. We are learning new things, along with you, about your project, problems and our process. But, we'd like to learn even more from your experience with what we hope is a resounding success.

We value your ideas, comments and criticisms. Have you any guidance or cogent ideas for changes or improvements in our text, instructions, drawings, materials list, hand tools needed, narrative or our tool rental information? If you have any useful and useable ideas and suggestions that may help other D.I.Y.'s with problems that you have already experienced, studied and resolved, please send to us your E-mail comments.

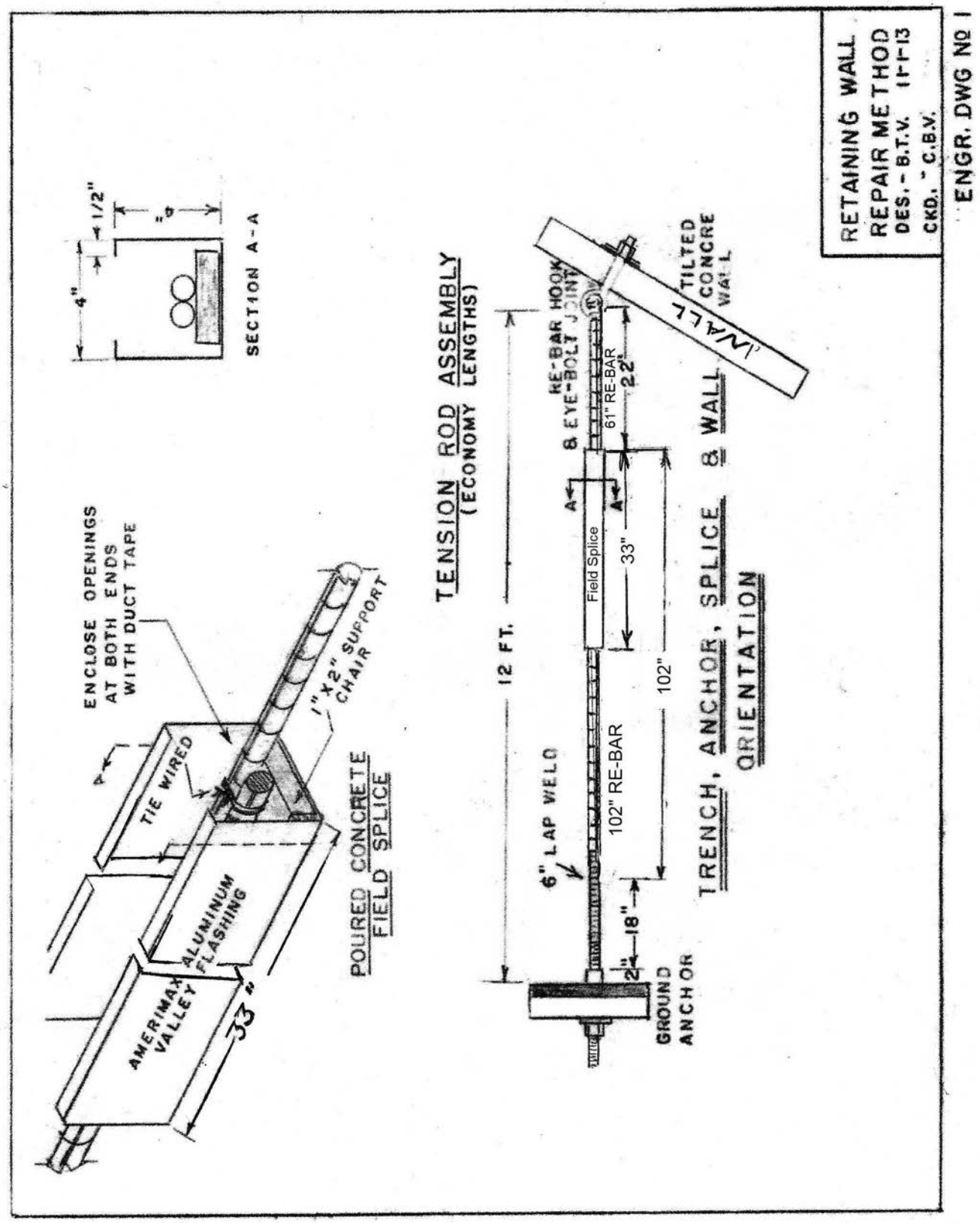

Figure 15 - Engineering Drawing No. 1

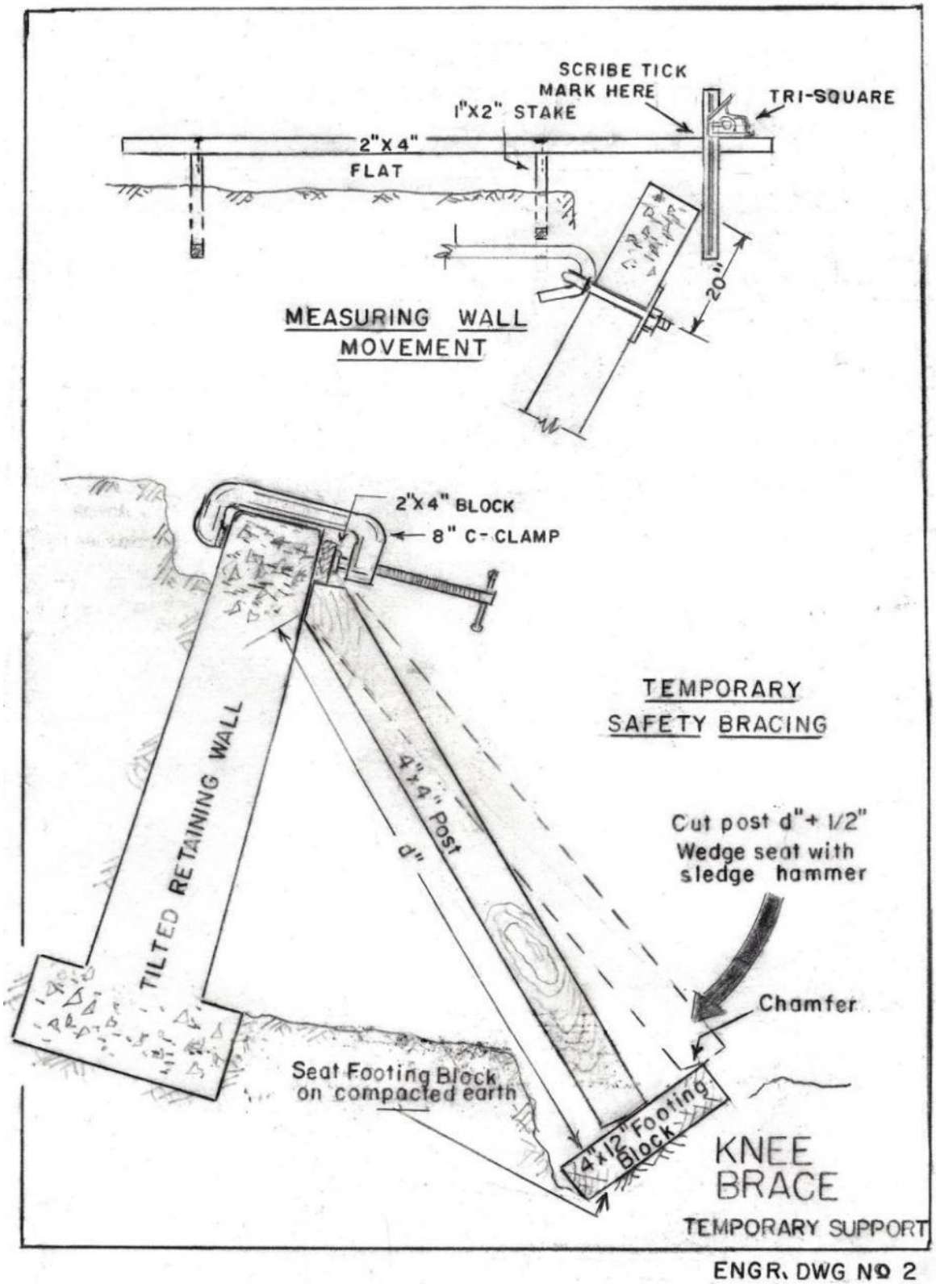

Figure 16 - Engineering Drawing No. 2

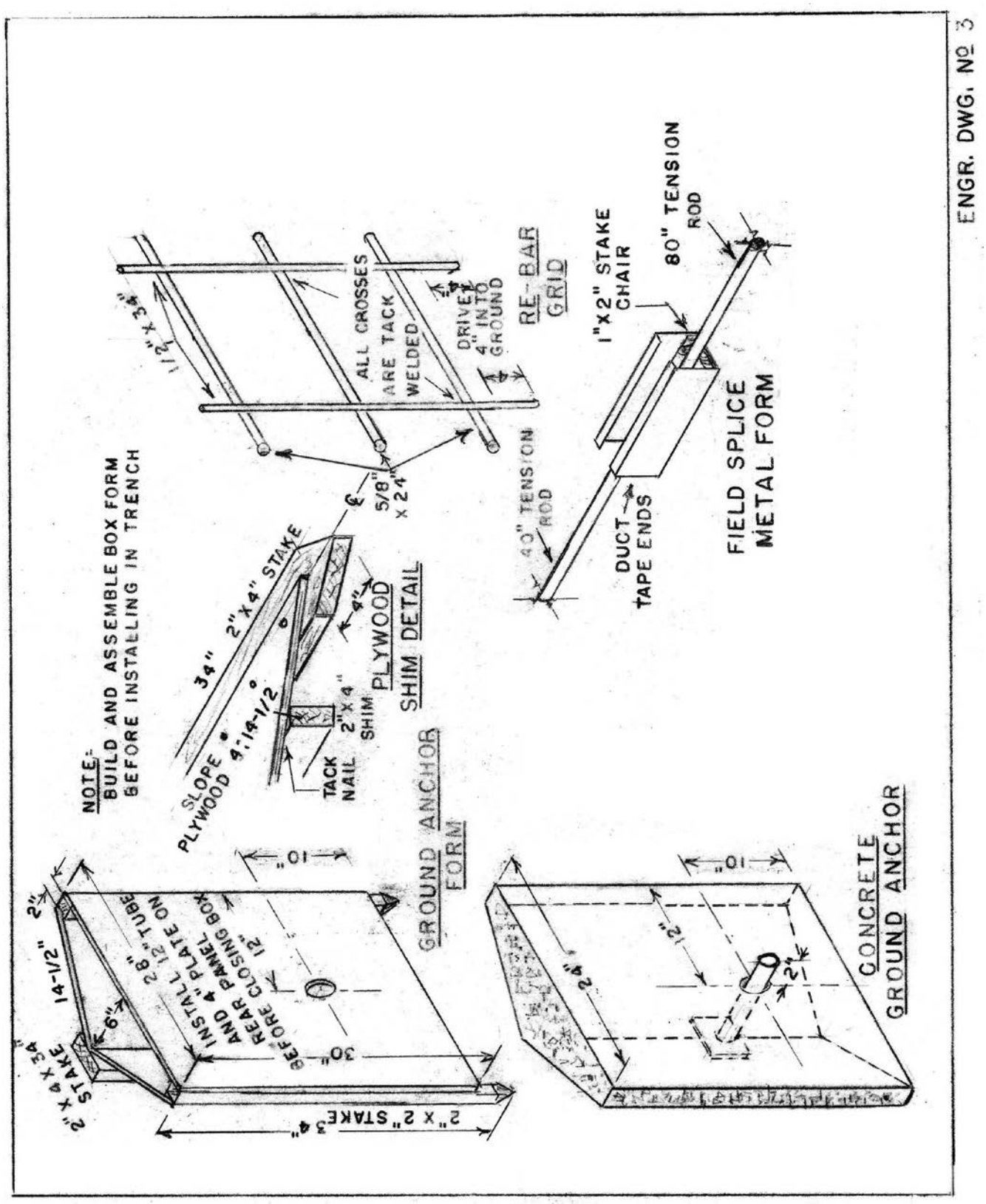

Figure 17 - Engineering Drawing No. 3

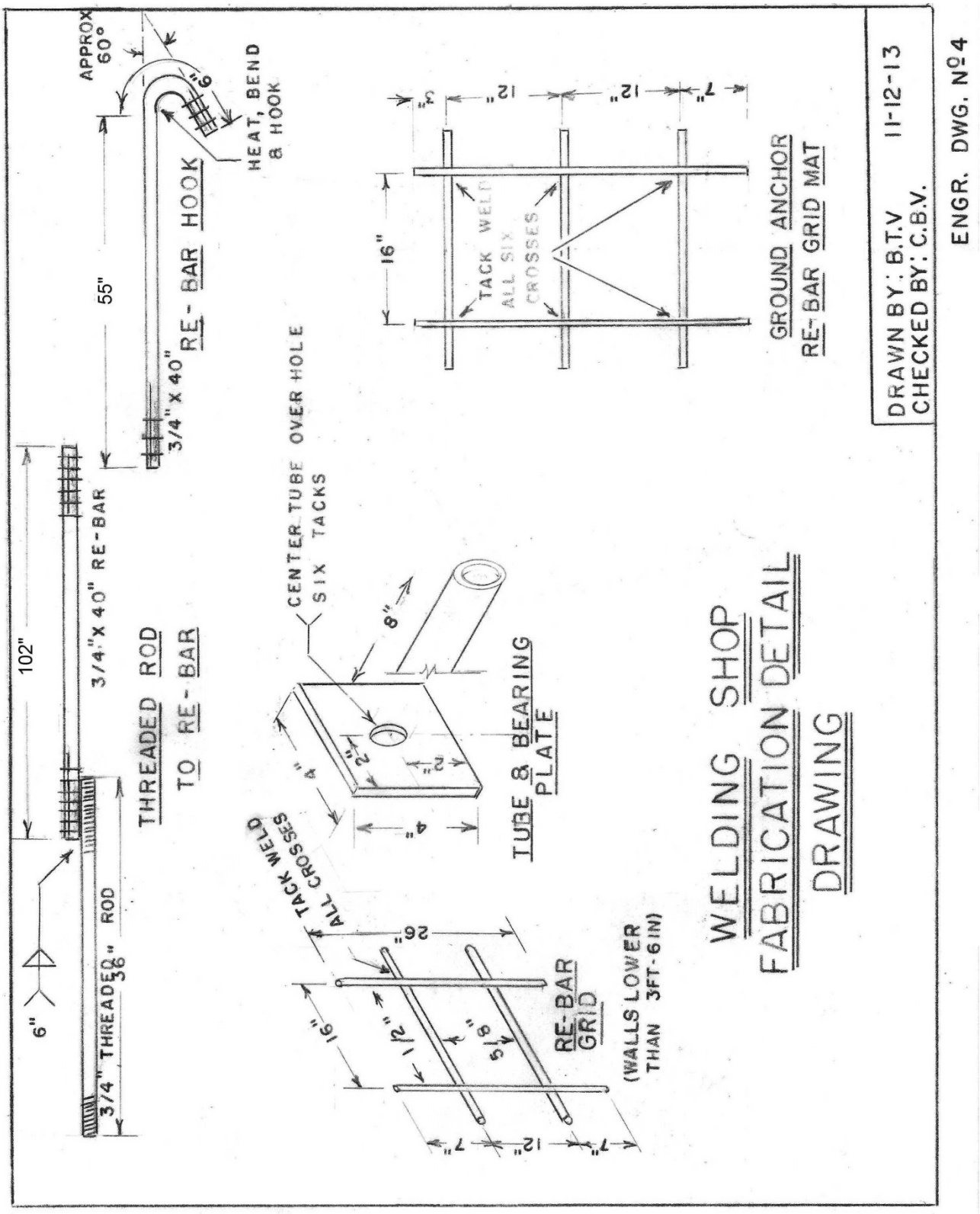

Figure 18 - Engineering Drawing No. 4