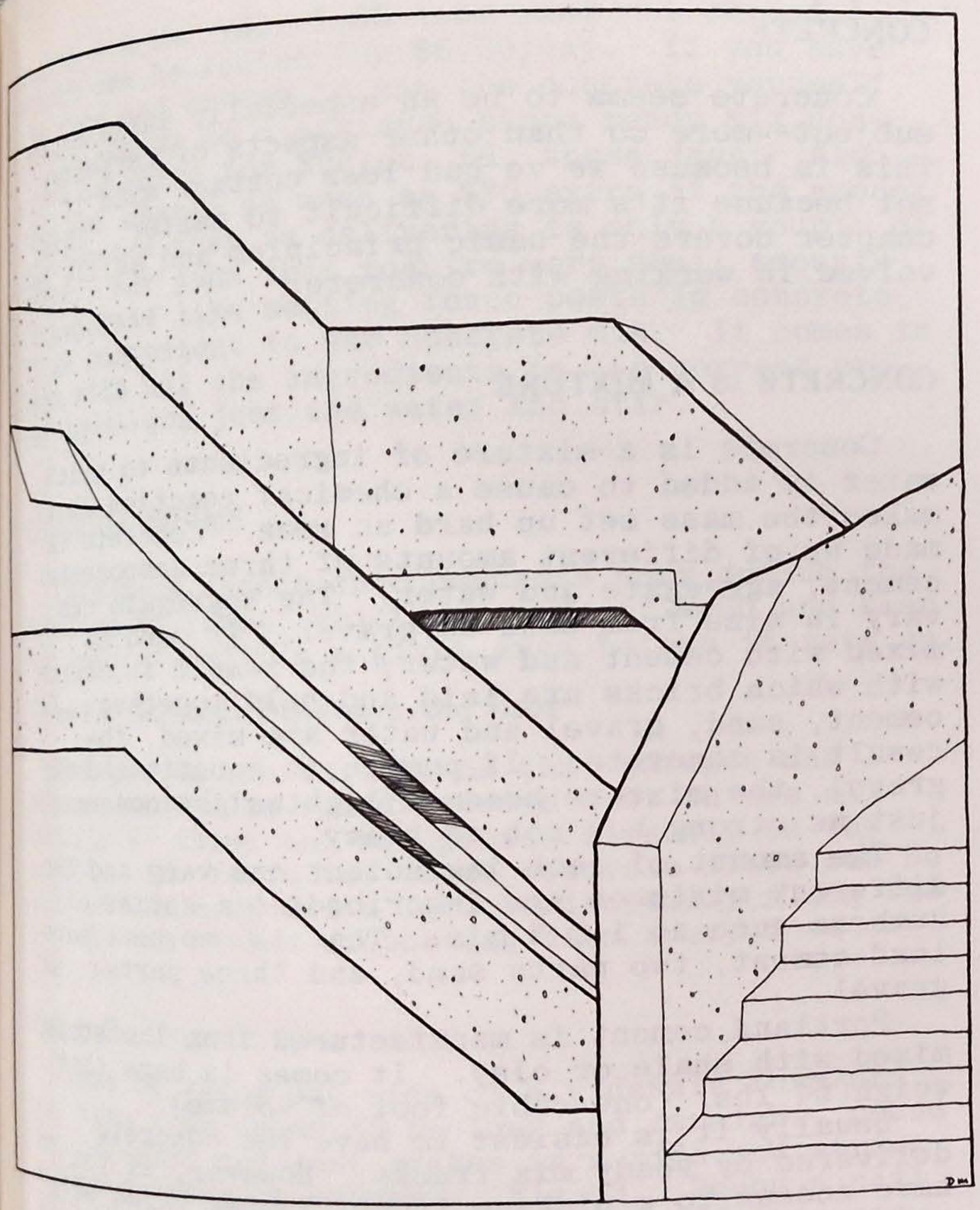


Chapter 10

Concrete

Aggregate

Amount of concrete–See Putting It All Together: Estimating

Pumice

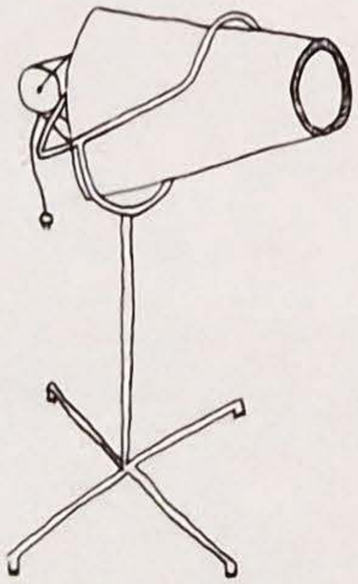


Fig. 1 – A Break down Mixer

CONCRETE

Concrete seems to be an especially intimidating subject--more so than other aspects of carpentry. This is because we've had less contact with it, not because it's more difficult to master. This chapter covers the basic principles and skills involved in working with concrete.

CONCRETE IS A MIXTURE

Concrete is a mixture of ingredients to which water is added to cause a chemical reaction that makes the mass set up hard as rock. Concrete is made up of different amounts of three components: cement, aggregate and water. The aggregate can vary in size from sand to gravel. If sand is mixed with cement and water, the result is mortar, with which bricks are laid and held together. If cement, sand, gravel and water are mixed, the result is concrete. If pumice is substituted for gravel, the mixture becomes lightweight concrete--just as strong but not as heavy.

The amount of each ingredient can vary and the different mixtures are described as a series of numbers such as 1-2-3 mix. That is one part portland cement, two parts sand, and three parts gravel.

Portland cement is manufactured from limestone, mixed with shale or clay. It comes in bags that weigh 94 lbs. (one cubic foot of volume).

Usually it is easiest to have the concrete delivered by ready mix trucks. However, if you have access to a pick-up truck, lumber yards sell gravel and sand by the ½ ton for around $4 each, and bags of portland cement for $2. (1.4 tons

gravel = 1 cu. yd.; 1.35 tons sand = 1 cu. yd.) Mixers can be rented for $6.50/day. If you have the time and energy to mix the concrete yourself, it can add up to a savings, since ready mix concrete is going for $28/cu. yd. these days. Also they can charge as much as $30 extra if the amount of concrete they're delivering is only a couple of yards. For jobs that require very small amounts of concrete like setting fence posts in concrete, it is convenient to use concrete mix. It comes in bags with all the ingredients in the correct proportions--you just add water and stir.

CONCRETE FORMS

Carpentry enters into concrete work during the building of forms, which are made of wood and keep the concrete within a given area before it sets up.

Forms For Sidewalks, Driveways And Slabs

The poured concrete slabs that garages and houses, sidewalks and driveways rest on are all usually 4" thick and are poured directly on the ground. The forms for these concrete slabs can be made of 1x4's or 2x4's laid horizontally along the ground with stakes supporting them every 2'-4'. Fig. 2.

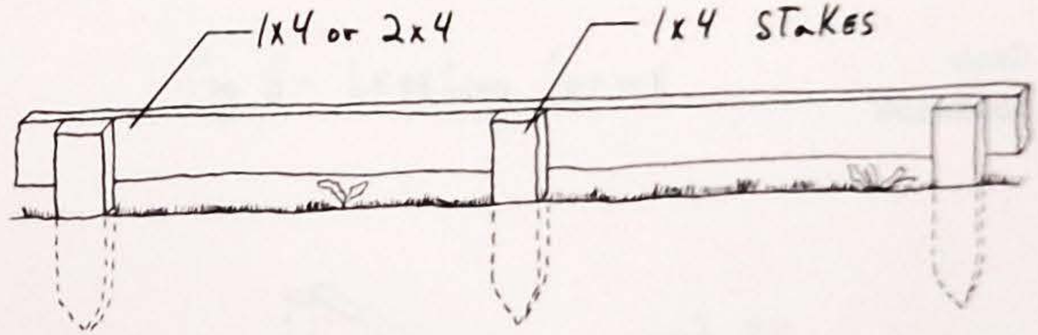


Fig. 2 - Sidewalk form

Making The Forms Straight

When building one side of a sidewalk form or any form that needs to be long and straight, pound in the first and last stakes in a side and string a line tightly in between. Fig. 3. Pound a nail into the far edge of the last stake and loop one end of the string around it. Stretch the line

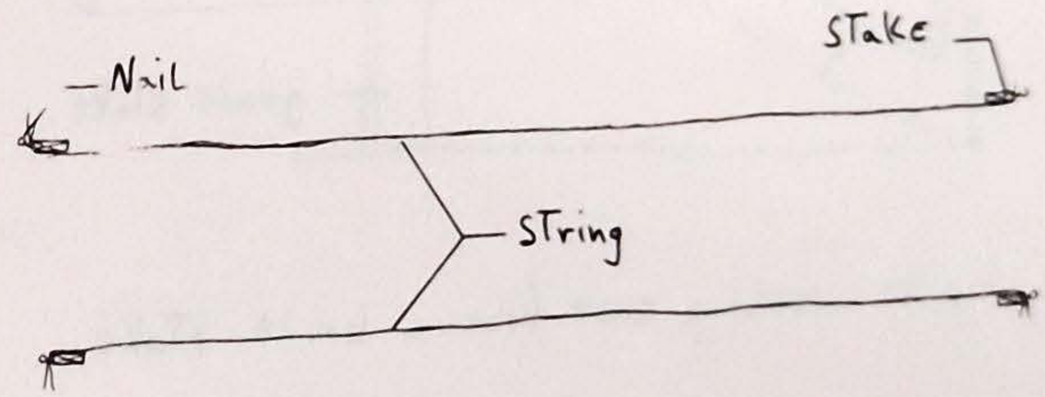


Fig. 3- STringing a Line

Grade

Benchmark

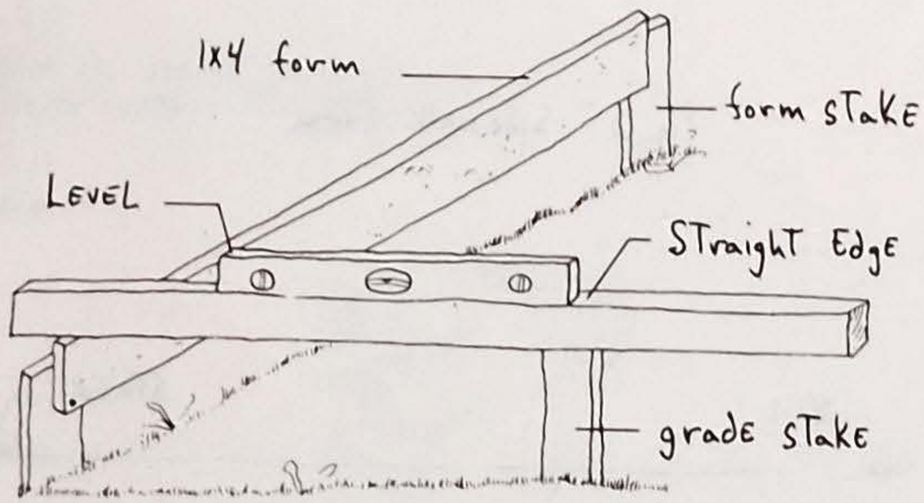


Fig. 4- Leveling over from a grade stake

Builder's level--See This Chapt.: Water Level

back to the first stake and tie it around a nail in the edge of the stake. The string should run along the side of the stakes that will face the concrete. The other stakes that go in between can be pounded in along the non-concrete side of this straight line, allowing their broad sides to barely graze the string (not distort its line) as you hammer them in. The tops of the stakes, when pounded in, should be slightly below grade.

Grade

The grade or bench mark is a point fixed at a certain level and is continually referred to when building a structure or pouring concrete. For sidewalk or slab forms, the grade can be represented by the top of a stake driven into the ground. The top of the stake should be at the level desired for the surface of the slab after it is poured. The stake should be located outside of but near to the area to be excavated.

Leveling The Forms With A Carpenter's Level

1. Once the grade has been determined and the stakes pounded in, to a little below grade, the 1x4" forms can be leveled and nailed to the stakes. Start at one end and nail one end of a 1x4" to the first stake with one nail so that the top edge of the 1x4" is at grade. One nail is used at the first end of each piece of 1x4" so that the other end can be moved up and down as the form is being leveled. The top edge of the first piece of 1x4" is set at grade by leveling over from the grade stake to the top edge of the first 1x4" by using a level, a level and straight edge, a water level, or a builder's level. Fig. 4.
2. Level the 1x4" and nail the other end to a

stake. The 1x4" can be leveled by placing a level on the top edge of the board and moving the non-nailed end up and down until the form is level. Mark on the stake along the bottom edge of the 1x4", remove the level, and nail the end of the 1x4" to the stake. Fig. 5.

Fig. 5- LEVELing forms

DO NOT nail the board to the stake while holding the level against the board as it will damage the accuracy of the level.

3. The next 1x4" is nailed to the other half of the same stake that the end of the first 1x4" was nailed to. The top edge of the second 1x4" is held even with the top edge of the first 1x4" and the second section of form is nailed to the stake. Level the other end of the second 1x4" as you did the first and nail it to the near half of a stake. Nail the 1x4's to stakes that support them in the middle. Continue in this manner until all the 1x4's are leveled in. The 1x4's should always break at the middle of a stake.

3-4-5 METHOD OF SQUARING

The principles of right triangles can be used to lay out corners when there isn't a transit available. The method is called the 3-4-5 method of laying out or checking right angles.

Pythagorean theorem–
See Roofs: Fig. 4

A triangle with sides of 3', 4' and 5' is a right triangle because the sum of the squares of 3 and 4 equal the square of 5. According to the Pythagorean theorem, $A^2 + B^2 = C^2$, this means it is a right triangle.

$$3^2 + 4^2 = 5^2$$
$$9 + 16 = 25$$
$$25 = 25$$

Any triangles whose sides are even multiples of 3, 4 and 5 are also right triangles. For example: 6-8-10, 9-12-15, 12-16-20, etc..

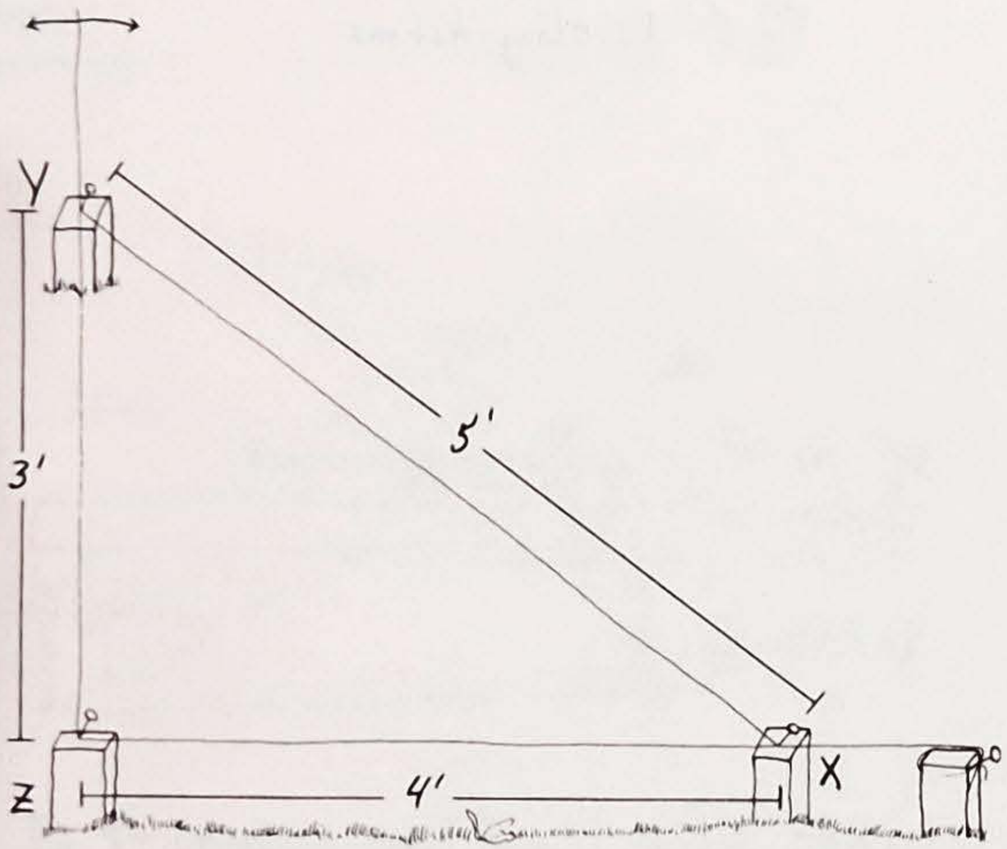


Fig. 6 - The 3-4-5 Method of Squaring

Measure back from the corner stake along the string line 4' and pound a stake in. Drive a nail into the top edge of the corner stake. Measure more exactly along the string line, from the nail in the corner stake back 4' to the stake recently put there, and drive a nail into the top of the stake 4' from the nail in the corner stake. (The nails mark the distance in a more precise way.) Now take two measuring tapes; hook one over the nail at X and hook the other over the nail in the top of the corner stake. Stretch the tapes tightly and move them until the 3' mark on the YZ tape intersects with the 5' mark on the YX tape. Pound in a stake at this point and mark the exact spot with a nail in the top of the stake. Stretch a line from the corner stake over this point (Y) to lay out the 90^{o} angle. Construct the forms for the other side of the corner along this line.

THE DIAGONALS METHOD OF SQUARING

Another way of checking to see if a layout or structure is square is the diagonal method.

Diagonals of a rectangle or square will be equal if all corners are square (90°).

Measure the diagonals of a wall, layout, form, etc., to see if they are equal. If they are, the assembly is square. If they aren't, move the parts of the assembly until the diagonals are equal. The diagonal method of squaring works best with two women--one on each end of the tape. This method is used to square up walls built horizontally before they are braced and raised. Fig. 7.

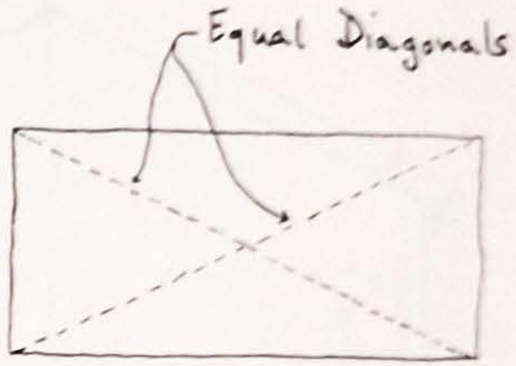


Fig. 7 - Diagonal Method of Squaring

THE WATER LEVEL

A water level is a simple inexpensive tool that can take the place of a builder's level in many situations. It consists of 1/4"-1/2" flexible transparent tubing (which can be any length) filled with colored water. It works on the principle that a body of water is everywhere level with itself. At any given point on its surface, a body of water is parallel with the horizon. A water level is a small body of water whose surface has been particularized into two points--the water levels at the two ends of the tube. (A meniscus is the curved shape the surface of water tends to

Builder's level

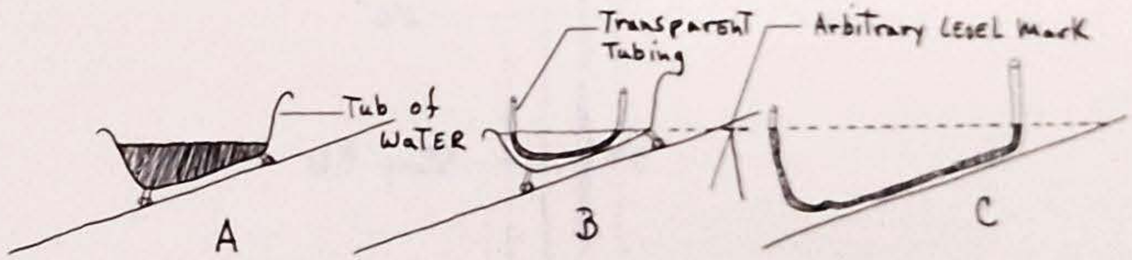


Fig. 8 - The Principle of a Water Level

Meniscus

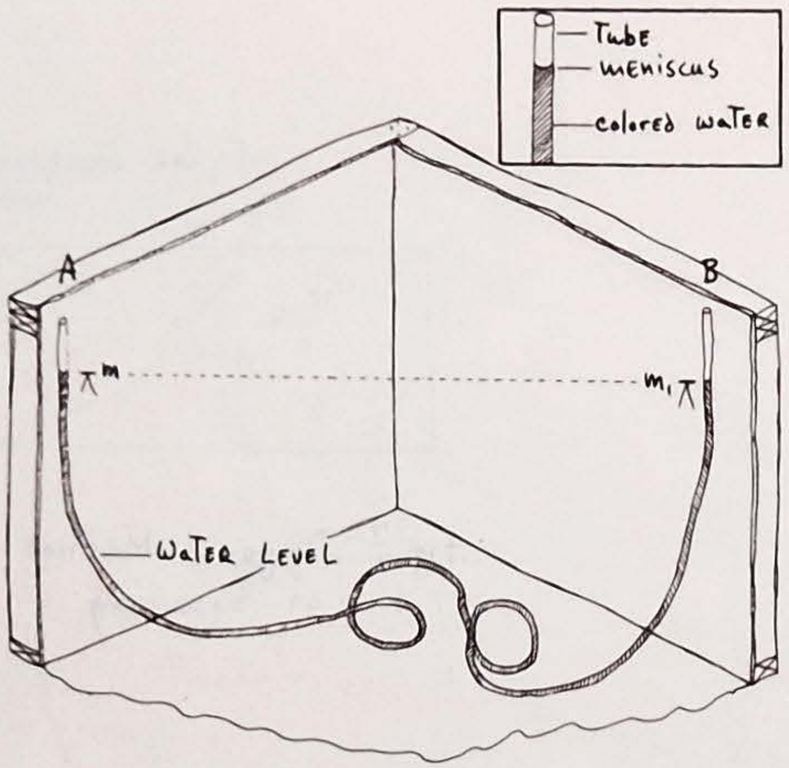


Fig. 9- Using a water level

take in a tube.) If the bottom of the miniscus at end A of the tube in Fig. 9 is held against mark M on one wall in a room and the end B of the water level is held against another wall in the room, a mark M_1 made at the level of the miniscus in end B of the water level will be level with the original mark M. Fig. 9.

Leveling Forms With A Water Level

The easiest and most accurate way to level in forms is to use a builder's level, which can be rented from rental stores. The techniques and how to's of using a builder's level are explained very well in Modern Carpentry, by Willis Wagner; space will not allow me to include an explanation here as I would wish. However, using a water level to level in forms is a cheap, accessible method and involves the same basic principle that underlies the use of the builder's level and transit: An arbitrary level line parallel to the horizon that is constantly held by the builder's level or water level and translated to the forms on the ground via a story pole or leveling rod.

A story pole as it's used in leveling is a straight piece of 1x2" or 1x3", the function of which is to hold a constant arbitrary level line. For leveling a sidewalk form it should be between 2' and 6' long.

Measure from the bottom of the story pole an arbitrary distance--say 2'0". Square a line across the story pole at this point. Fig. 10. Measure up from this 2'0" mark a distance equal to the width of the 1x4" form material (approx. 3½"), make another mark and square it across the story pole. Fig. 10. Acquire another story pole and transfer the marks from the first to the second so

Transit

Story Pole

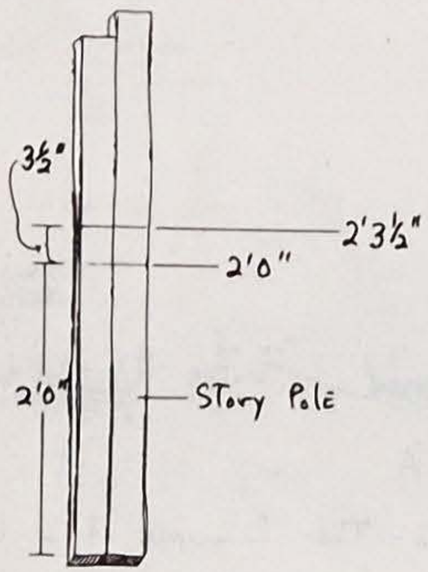


Fig. 10- Making Story Poles

that there are two identical story poles.

Hold one story pole with its bottom end resting on the top of the grade stake. (Remember the top of the grade stake will be level with the top of the slab and therefore the top edges of the forms should be level with the top of the grade stake.) Story poles should be held as plumb as possible; a level can be held against the pole to check for plumb. Hold one end of the water level against the story pole at the grade stake so that the meniscus is even with the 2'0" mark. Another woman should hold the other story pole against the inside width dimension of the first stake. This woman is also holding the other end of the water level, which should be held against the story pole so that the meniscus is even with the 2' 3½" mark on the pole. Fig. 11. The woman at the first form stake moves the story pole up and down, while holding the water level tube stationary, until the meniscus in the tubing is even with the 2' 3½" mark on the story pole. During this process the woman at the grade stake may have to move her end of the tube up and down in order to keep the meniscus on the 2'0" benchmark. When at last the meniscus at the grade stake is on 2'0" and the meniscus at the first form stake is at 2' 3½", it means that the bottom of the story pole at the first form stake is exactly 3½" below the level of the grade stake, or 3½" below the level of the surface of the concrete to be poured. Make a mark on the stake along the bottom of the story pole. If the bottom edge of the 1x4" form is placed even with this mark, the top edge of the form will be at grade.

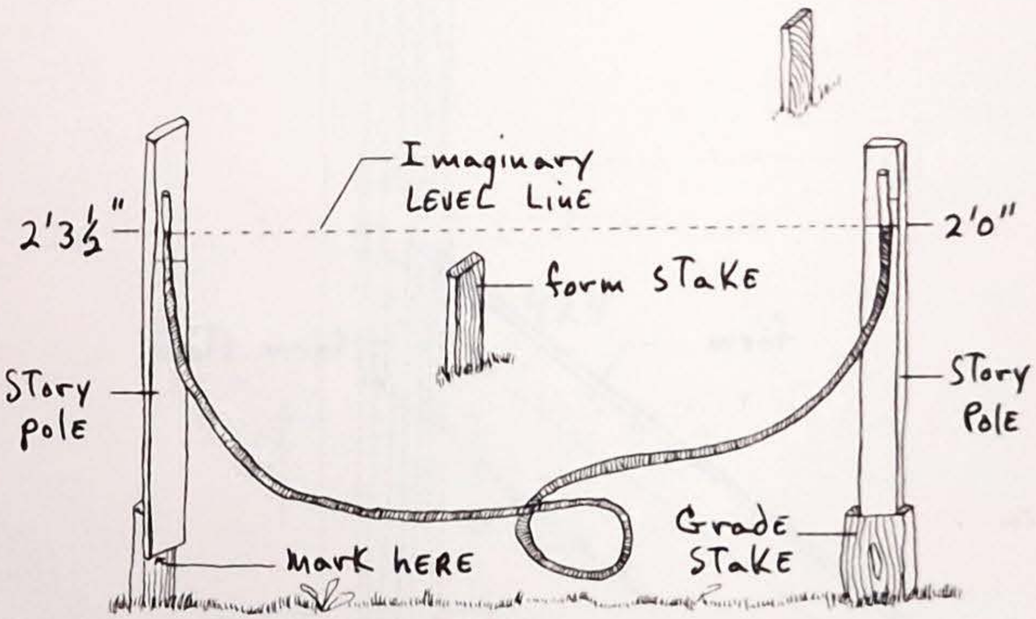


Fig. 11- Marking Grade on form STakes

The principle behind all this is that the two menisci (plural of meniscus) of the water level are always level with each other. So if one meniscus is held 2'0" above grade and the other meniscus is even with the 2' 3 1/2" mark on the other story pole, then because the menisci must be level with each other, the bottom of the second story pole is 3 1/2" below grade.

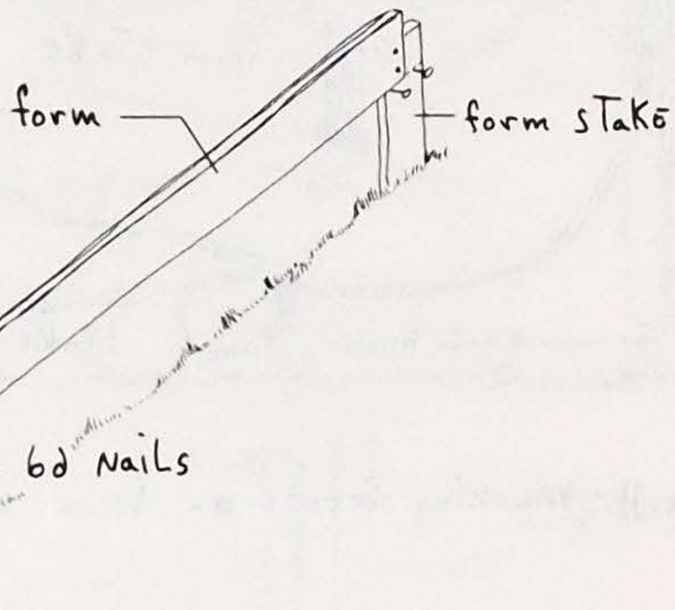


Fig. 12 - Ledger Nails

Two women can continue in this way to mark the level of the bottom edge of the 1x4's on all the stakes that the 1x4's will break on. The stakes in between do not need to be leveled in. Next go around to the stakes that have been leveled in and start two 6d nails even with the level marks on width dimension side that will face the concrete. These nails are to support the 1x4's as they are nailed. The level marks are so low to the ground that it would be impossible to watch and make sure the 1x4" is even with the mark and nail at the same time. After the 6d ledger nails have been started and are about one-quarter of the way home, set the 1x4's so that they break on a stake and their bottom edges are resting on the ledger nails. Nail them to the stakes with two 6d common nails at each end of a 1x4" and two nails per each middle stake. The ledger nails can be left in (or taken out after the 1x4's are nailed and reused). Fig. 12.

Making A Water Level

50' water levels can be purchased for around $12 but can be made for around $8. Obtain 50' of transparent or translucent flexible tubing with a

1/4"-1/2" inside diameter. (Translucent surgical hose is twice as expensive as transparent plastic hose that can be bought at farm supply stores, etc.)

Fill a bucket or half-gallon jar with water and add enough food coloring so that the color is dark enough to see. (This is a good use for all left over red dye No. 2.) Put one end of the tube in the bucket of water and hold the bucket higher than the other end of the tube. Suck on the low end of the tube until the water begins to siphon through the tube. When the colored water has totally filled and there are no bubbles, the water level is finished. Drain a little water out of each end of the tube so that the menisci are about a foot from the ends of the tube. Now there is room for the menisci to move during leveling.

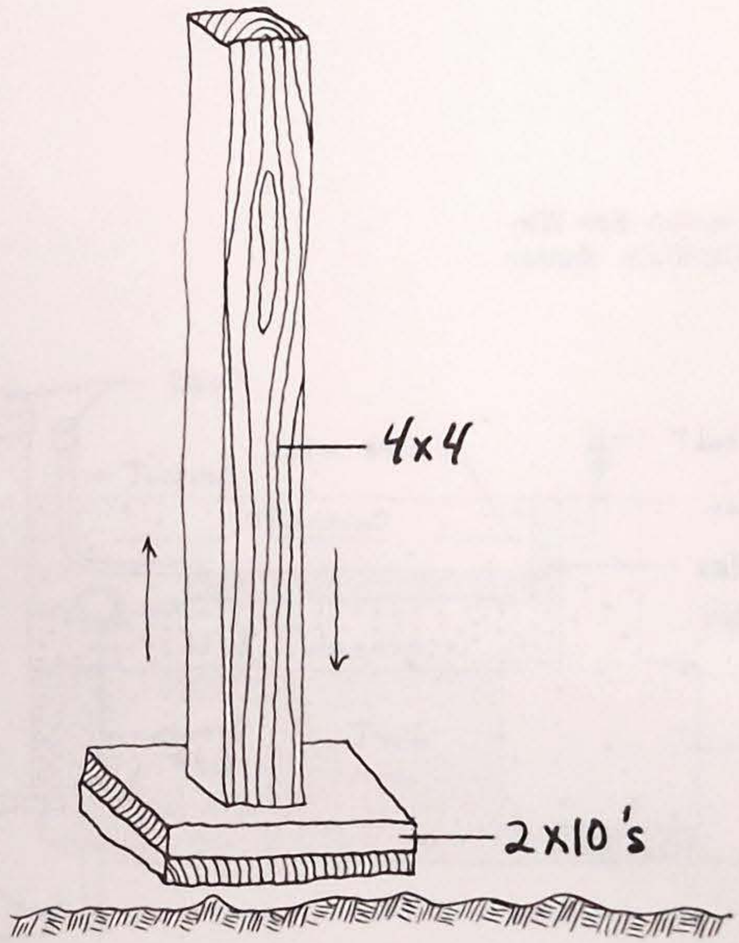


Fig. 13 - Homemade Tamper

PREPARING THE AREA UNDER THE POUR

Compacting The Dirt

The earth under a concrete slab must be compacted (packed down) so that the ground doesn't settle and cause the concrete that is to be poured to crack. The packing can be done by hand, by tamping the earth with a six foot 4x4" which is raised vertically a foot or two off the ground and dropped on the dirt to pack it. One or two pieces of 2x10" can be nailed to the bottom of the 4x4" like a T. Fig. 13. The woman tamping must wander all over the area to be poured, making sure every inch has been packed. Compacting is especially necessary if the slab is to be poured over fill or loose dirt that has been brought in by dump truck

Capillary action–See Windows: Capillary Action

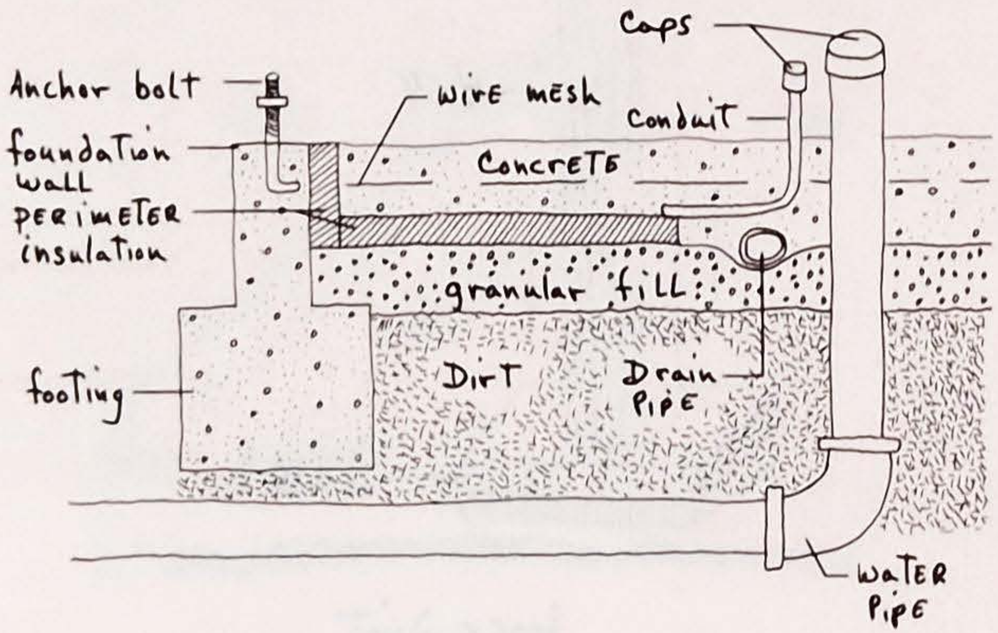


Fig. 14- Objects in & under the Slab

Frostline

or bulldozer. However, if the ground has just been leveled off with a bulldozer or by hand, the ground remaining has settled naturally for years, and packing isn't so crucial. It is easier but more expensive to rent a gasoline-powered tamper, which is a heavy machine that you push along the ground as it packs the earth.

Granular Fill

Over the dirt there should be a coarse granular fill of gravel or crushed stone, to a minimum depth of 4" (particle size 1/2"-1"). This fill should not be packed because the air spaces between the stones serve as good insulation, and if the stones were too close together capillary action would attract subsoil moisture up into the slab.

Pipes In The Slab

At this point any pipes, electrical conduit or heating ductwork that are to go below the slab are embedded in the gravel fill.

If water lines are to go below the slab, they should be buried deep enough in the dirt below the fill to prevent them from freezing. (To avoid extra work the water pipes should be buried before the earth is compacted and the granular fill laid.) Any local construction company, building inspector or building code can provide frostline information for your area. In Iowa the frostline (the level below which the ground doesn't freeze), is 3 1/2'.

If the pipes in the slab are to connect to utilities in the structure to be built on the slab, they should be brought up to a level about a foot above the finish concrete floor level before the concrete is poured. To prevent concrete from clogging the open ends of these pipes, or conduit sticking vertically through the slab, the open ends should be taped over. Electrical conduit and drainage pipes are usually laid over the vapor barrier. Water pipes that have to be buried come up through the vapor barrier.

The construction of the forms should not be started until after the earth is compacted and the gravel fill has been dumped and spread. The forms can be built simultaneously with the laying of the pipes, vapor barrier, insulation etc.

Vapor Barrier

To further prevent moisture from seeping through slabs on which a house is to be built, a vapor barrier is spread over the gravel fill. (A vapor barrier is not necessary in sidewalks and driveways.) 55 lb. roll roofing, 4-mil polyethylene plastic or asphalt impregnated kraft paper can be used as vapor barrier. There should be a 6" lap at all joints. Be careful not to puncture the vapor barrier as it is being laid.

Vapor Barrier

Kraft paper

Insulation

If the slab is being poured in a cold climate, insulation should be installed under the slab around the perimeter either vertically along the foundation wall and/or horizontally under the slab extending in 2' from the edge. The insulation is laid over the vapor barrier and prevents loss of

Insulation–See Putting It All Together: Fig. 41

heat through the slab. The insulation should be rigid like styrofoam and not break down in wet concrete. It should be 1"-2" thick depending on climate. Fig. 14.

Expansion Joint

Expansion joint is black and is made of asphalt impregnated felt. It comes in strips 6' long, 6" wide and 1/2" thick. It is a compressable substance which is placed between two slabs of concrete to absorb the expansion and contraction of each slab, which happens with changes in temperature. During the summer the concrete slab expands with the heat. If there were no expansion joint between a slab of concrete and a brick wall or another concrete slab, the expansion of the concrete would crack the wall or buckle the other slab of concrete.

Sometimes the new concrete will come in contact with existing walls or slabs. If so they can be used as part of the form. One less form to build; all you have to do is to protect them with expansion joint. Expansion joint is attached to these existing walls and slabs, by nailing with 3/4"-1" case hardened concrete nails or by gluing with a heavy duty industrial cement like P-300. The top edge of the expansion joint should be at grade. Level across the grade stake to the wall using a level and straight edge or water level. Make several marks on the wall at grade. Snap a chalk line through these grade marks. Nail the expansion joint to the wall so that the top of the joint is even with the grade line (chalk line). Fig. 15.

If the slab is to be poured against any already existing concrete walls or foundations, an expan-

Case hardened

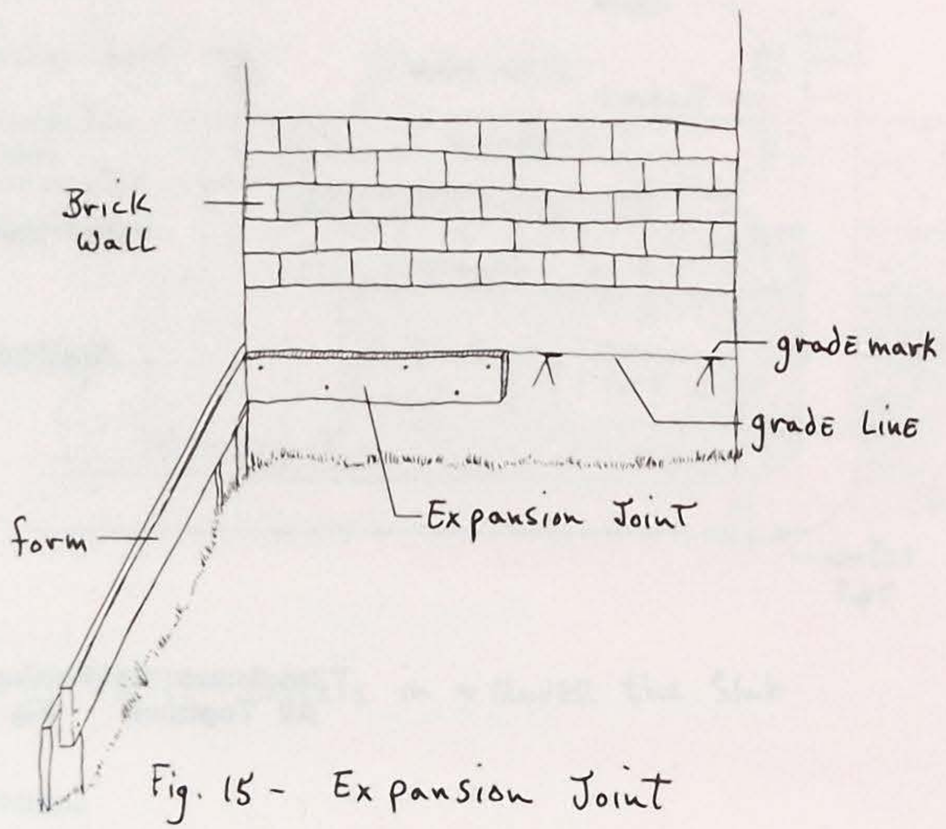


Fig. 15 - Expansion Joint

sion joint should be laid between the existing wall and the new pour to prevent them from bonding and to keep the new pour from cracking the existing walls. Besides patented expansion joint, insulation (such as styrofoam) laid against the foundation wall also works as expansion joint.

Reinforcing Steel Or Wire Mesh

On top of the vapor barrier and over all the pipes in the slab is laid the wire mesh--the material that will hold the concrete together, help keep it from cracking and help it resist twisting, stretching and bending. Concrete has very high compression strength but low tensile strength. Tensile strength is the resistance of a material to forces tending to tear it apart. To increase the tensile strength of concrete, reinforcing steel rods are used within walls, columns, beams and decks. Wire mesh is used in concrete floors that rest on the ground. In 4" thick basement floors, sidewalks and driveways, 6x6" 10 gauge wire mesh is used. Its place in the thickness of the slab is 1"-1½" below the surface, so during the pour the mesh should be pulled up to this position each time after the concrete has been dumped, or the force of the concrete falling on it will push it down. The mesh will stay up once it is pulled up, but don't wade around in that part of the pour too much.

Reinforcing steel rods or wire mesh is required for all concrete pours. They are put inside the form before the concrete is poured. The thickness of rod and how many are used vary with the specifications for the wall. Check with an engineer, iron worker or building code.

Tensile strength

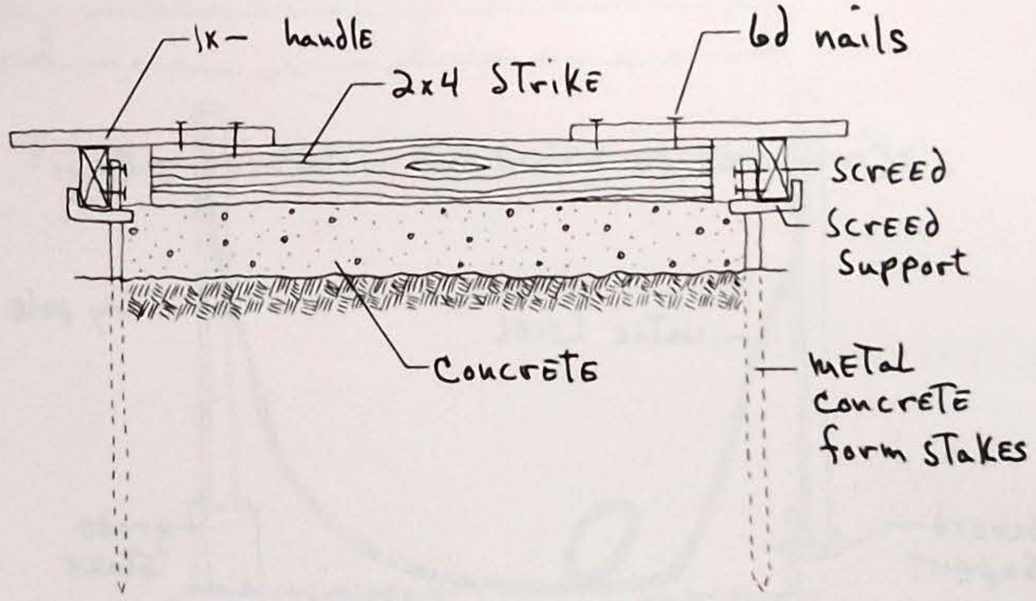


Fig. 16- Screeds for Concrete

Screed

Strike--See This Chapt.: Figs. 16 and 17

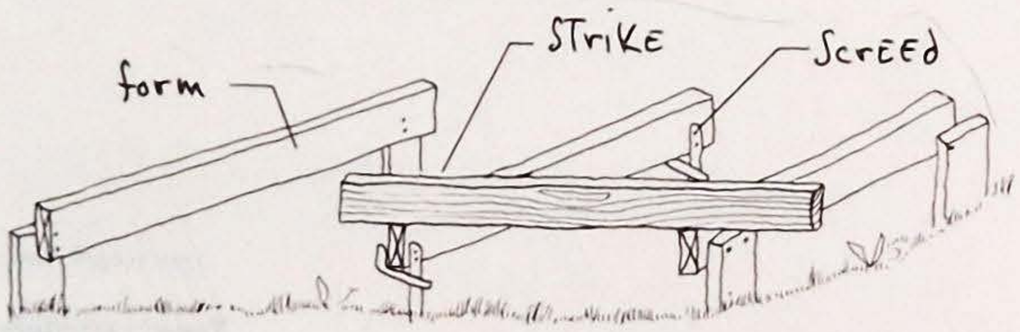


Fig. 17 - A Screed in The Middle of The Pour

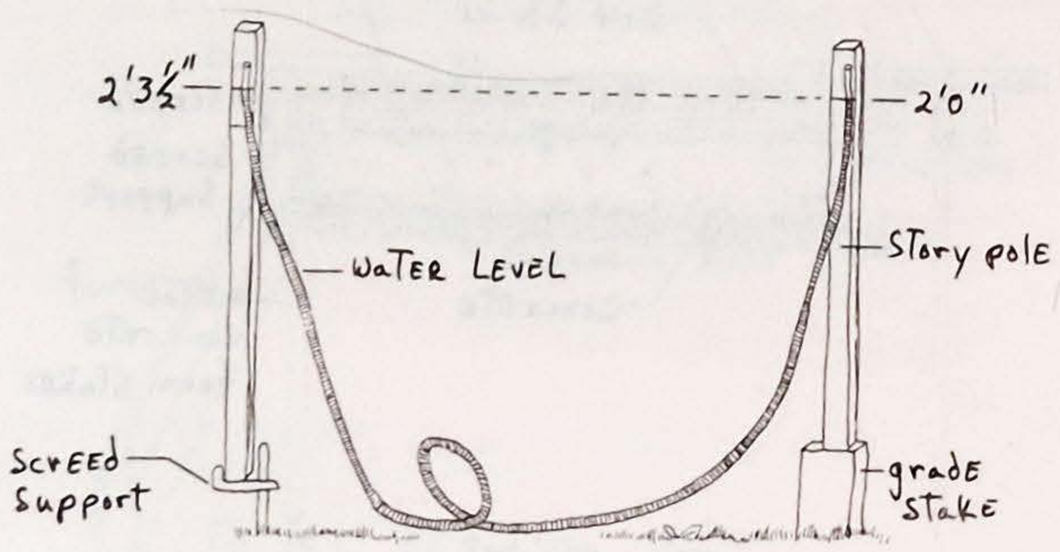


Fig. 18 - Setting Screeds with a WaTER LEVEL

Setting Screeds

Screeds are strips of metal or wood placed in the area to be poured to aid in the even application of the concrete. They are rentable and should be set before the concrete is poured. Fig. 16. Screeds consist of straight lengths of pipe or 2x4" which have been leveled into grade and rest on screed supports, which are attached to metal stakes (also rentable) that are driven securely into the ground. The strike is guided by the screeds as it is pulled across the surface of the concrete, distributing it evenly to all areas. Sidewalk pours do not need screeds because the forms have been leveled in and the strike can be drawn along the top edge of the 1x4's to even up the surface of the concrete. It is in the wider pours, such as slabs for houses or basements, where the strike cannot reach from one form to the other, that you need a screed set in the middle. Fig. 17.

The screed supports are leveled to grade in the same way the forms are: with a level and straight edge or water level and story pole. The height the screed supports are leveled into depends on the type of strike used. If the strike is to be offset as in Fig. 16, the top edge of the screed support on which the screed rests is set at grade. If the strike is to bear directly on the screed as in Fig. 17, the top edge of the screed support on which the screed rests is set one 2x4's width below grade. Fig. 18.

Let's say the area to be poured in Fig. 17 is 20'x60' and the longest 2x4" suitable for a strike that can be found is a twelve footer. In this case the screeds should be set in one row down the middle, 10' away from and parallel to the long 60'

side forms. The concrete should be poured in small areas, first on one side of the screed and then on the other, proceeding down the length of the slab. Fig. 19.

THE POUR

Using The Break Down Mixer

Pouring concrete requires several women and they must work together. Everything happens very quickly when the concrete begins to set up, so the crews should be organized and efficient.

For a pour that is 60'x20' as in Fig. 14, it would be a good idea to rent two mixers and have them working simultaneously. Even so this pour will take all day, because one of the break down mixers can mix only 2-3 cu. feet of concrete at a time and there are 60'x20'x1/3' = 400 cu. ft. or 14.8 cu. yds of concrete in the pour.

One or two women can work the mixer while another woman shovels the concrete into the corners of the area and screeds the surface until it's even. One mixer can be set up in area 1 or Fig. 18 and the other can begin operating in area 2. When areas 1 and 2 are filled with concrete, the mixers can be moved to areas 3 and 4 and so on. If the pouring is going too slowly with the mixers each in separate areas, they can both be put in the same area.

The woman working the mixer measures the proportions of each ingredient by shovelfuls. For each shovelful of portland cement thrown into the mixer she should put in two shovelfuls of sand and three of gravel. If the pre-mixed gravel and

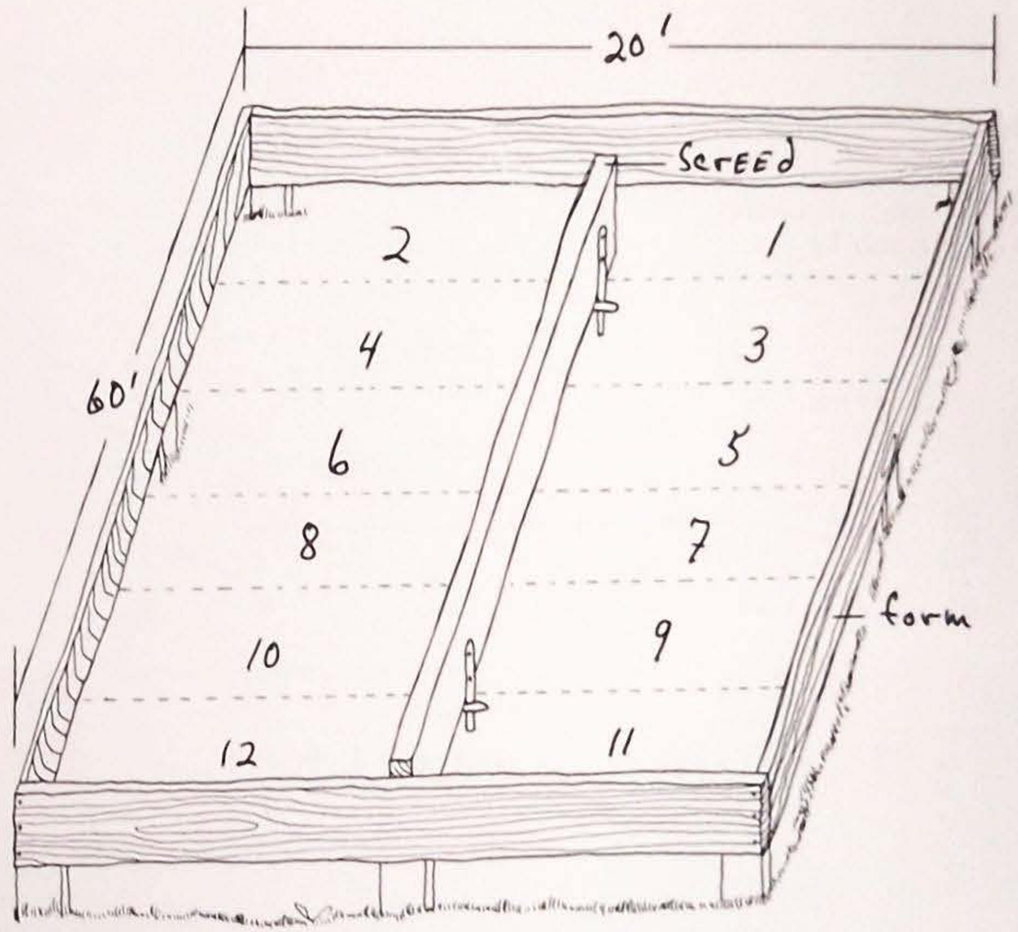


Fig. 19- Screed in the Middle of the Pour

sand mixture called "concrete mix" is being used, the proportions are one shovelful cement to five of concrete mix. Four sets of these proportions go into the small break down mixer to yield 2-3 cu. ft. of concrete.

The woman doing the mixing will probably have to shovel the correct proportions of sand and gravel into the wheelbarrow, wheel it to the mixer and shovel it in. The other alternative is to place the mixer outside of the area to be poured, near the piles of sand and gravel, and shovel directly into the mixer. The only problem with this is that then the concrete will have to be wheelbarrowed to the area to be poured, and liquids are hard to handle in a wheelbarrow. There is more to wheeling a wheelbarrow than meets the eye.

These small breakdown mixers can be easily taken apart and carried from one area of the pour to another. They will also fit into the trunk of a car. Larger mixers that are towed behind a car or truck can also be rented. They have the advantage of mixing larger amounts of concrete each time, but they must be set up near the piles of sand and gravel and the concrete must be wheelbarrowed to the pour.

While two women are working the mixers, two other women should be shoveling the concrete into all parts of the area, vibrating it and striking the surface.

Vibrating

The concrete must be vibrated to remove air pockets and make it settle. This can be done by hand by poking a 1"-1½" diameter pipe, rod or board down into the concrete continually through-

Vibrator

out the area. An electric vibrator can be rented and it does the job easier and better. Too much vibrating with an electric vibrator can cause honeycombing, a formation of air spaces, against forms or existing walls.

Striking

Striking is leveling and smoothing the surface of the concrete to grade by drawing a straight 2x4", called a "strike," along the top edges of the screeds. The surface should be struck whenever a 1"-2" wide strip of concrete has been poured between one side form and the middle screed. As the strike is pulled along the top of the form and screed, it levels the concrete, pulling excess concrete into new areas and showing the places that need more.

Wear rubber boots when working with concrete and try not to touch it, as it will draw all the moisture and oil from your skin for days. Everyone working on a pour should wear boots because they will be standing in the middle of the concrete most of the time.

Making A Strike

If there is not a straight 2x4" to be found, a crooked one can be ripped with the circular saw to make a strike. Fig. 20. Hold a chalk line against the same edge at either end of the 2x4". The line that is snapped will be perfectly straight. The 2x4" is cut along this line to form a straight edge for striking.

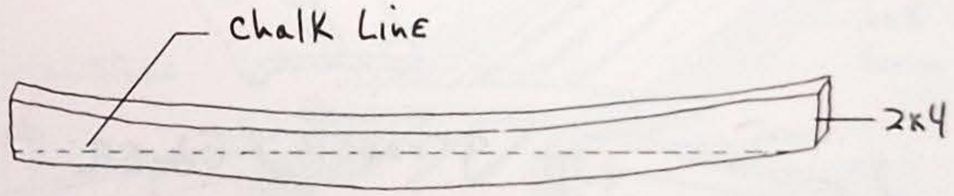
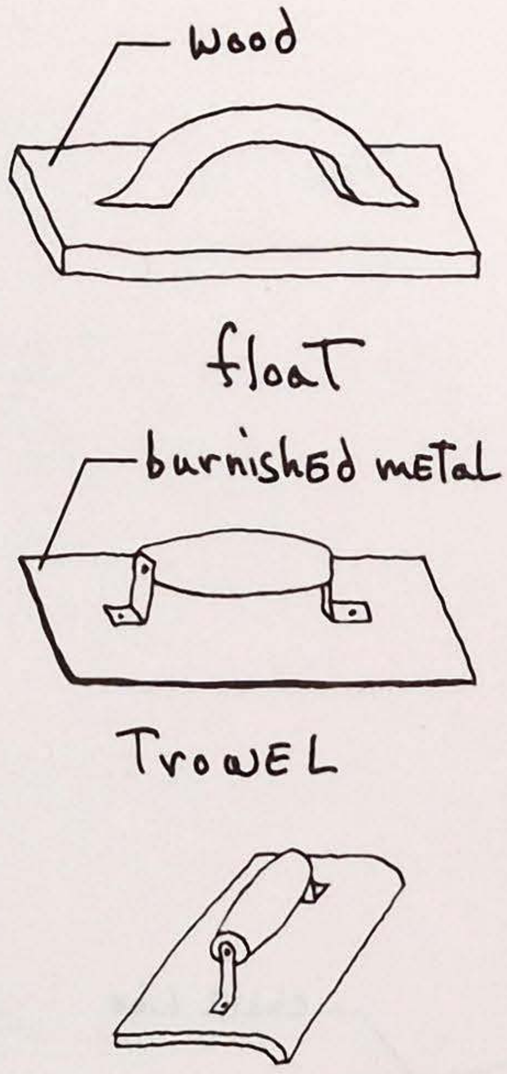


Fig. 20- Making a STrike

FINISHING THE SURFACE

After the slab is level, take a float (Fig.



Expansion groove

Fig. 21 - Concrete finishing Tools

21.) and smooth out the surface of the concrete with broad sweeping strokes.

From here on it's a waiting game. If the desired finish is a smooth glassy surface called a "hard trowel finish," wait until the surface is dry. This is when the standing concrete juice has dried from the heat of the reaction going on in the concrete. "Too dry" is when the steel trowel doesn't easily make the surface smooth and shiny. When the surface is just right, use the steel trowel on it in sweeping, semi-circular motions until the surface is shiny. If the surface is too dry, water can be sprinkled on the area being troweled to help give it a shine.

Finishing concrete is quite a skill. It takes a long time to learn when a slab is ready for steel troweling, when the surface is too dry and how to use the steel trowel so it makes a glassy surface--it's all an art. The best thing to do when you aren't experienced is to never turn your back on the slab. Keep testing it until you know it is ready for the trowel. Don't let it get away from you. On a hot day a slab will set up an hour or two quicker than on a cool one.

Sidewalks and driveways require a rougher finish, which can be put on by dragging a broom across the surface. A hard steel troweled surface is suitable for floors that will be bare or covered by linoleum, tile, etc.

Expansion grooves should be put into the still wet concrete of sidewalks and driveways with a groover and straightedge. They should be 4'-5' apart and 1/5 the thickness of the concrete deep.

Anchor Bolts

If there is to be a house built on the slab and

the bottom plate is to go directly on it, then right after the concrete has been leveled, 1/2" anchor bolts should be imbedded in the concrete not less than 4' apart along the plate line. At least 2" of the bolt should be sticking up out of the slab. Fig. 22.

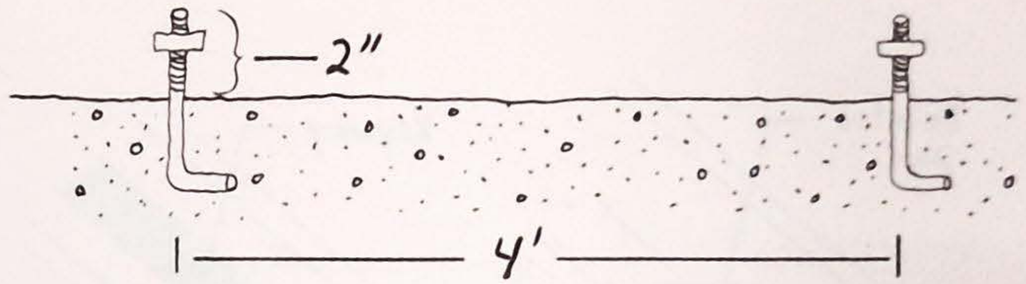


Fig. 22 - Anchor bolt Spacing

FORMS FOR FOUNDATIONS

Footings

Buildings are built on foundations made of poured concrete or concrete block. A foundation consists of a foundation wall which rests on a footing that originates below the frostline. The footing is made of poured concrete and should be as deep as the foundation wall is thick and twice as wide as the wall. A footing can be poured using an excavated trench as the form, or a form can be built. The footing is reinforced by 2 or 3 #5 (5/8") steel rods running the length of the footing. Fig. 23.

When the foundation wall and the footing are to be made in separate pours, a cold joint is formed between the wall and the footing. A cold joint is the coming together of two slabs of concrete that have been poured at separate times and are not bonded together. No bonding takes place between the slabs, so something must be done to lock the wall to the footing and keep it from sliding around. This is done by putting a keyway in the top of the footing while the concrete is still green and workable. A keyway is a groove made by running a beveled piece of 2x4" down the center of the form. Fig. 24A.

Frostline--See Putting It All Together: Foundation

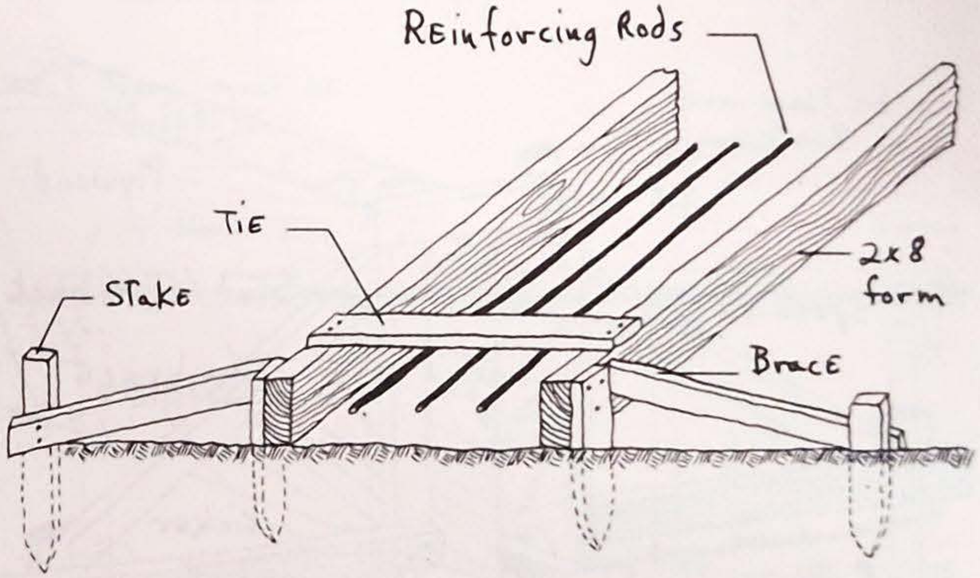


Fig. 23 - A Footing form

Cold joint

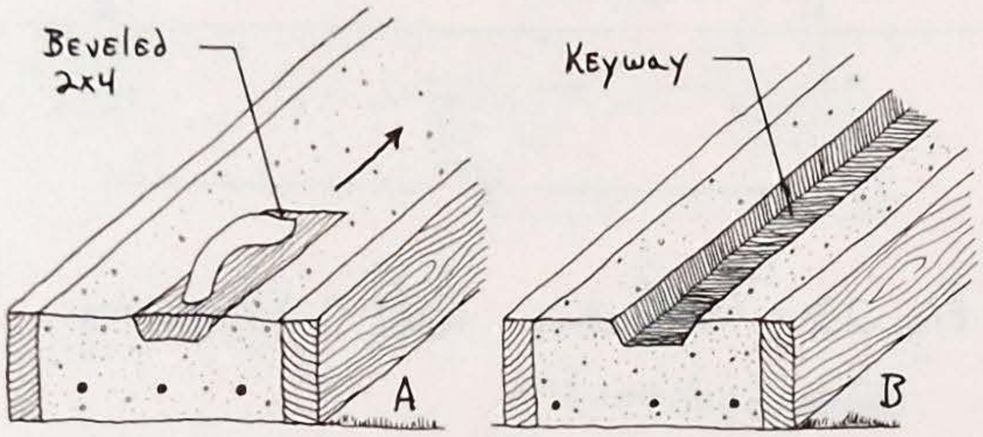


Fig. 24 - Putting a Keyway in a footing

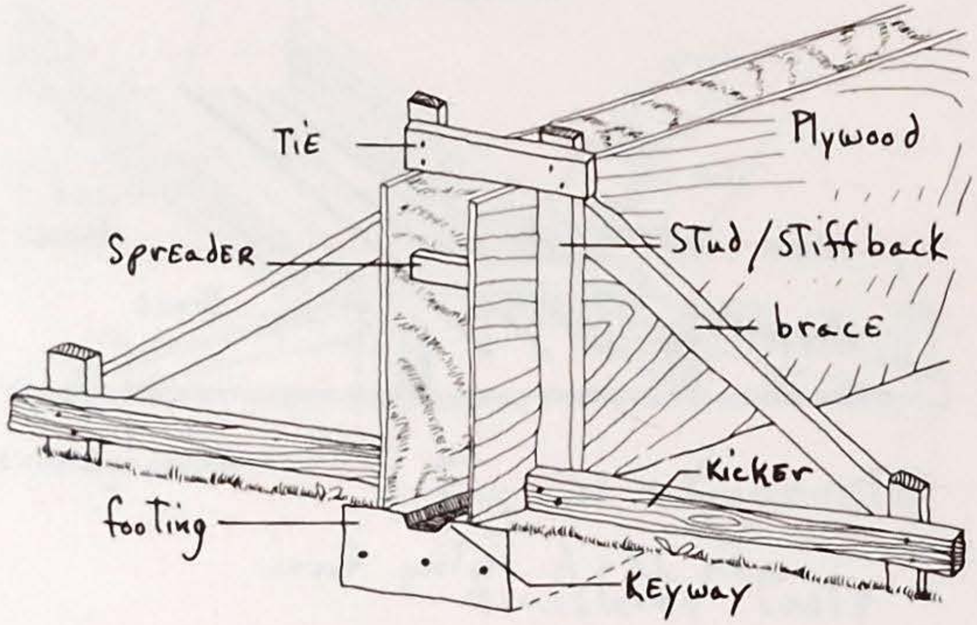


Fig. 25 - Form for foundation Walls

Foundations And Short Walls

The forms for short walls or foundations for houses are made of 3/4" boards or plywood. Fig. 25. Plywood is nailed to the studs with 3 or 4 6d common nails per stud. 1x-- material should be nailed to the studs with two 6d nails at each stud. Both plywood and common boards should break on a stud.

The forms should be strongly made and braced to resist the pressure of the concrete, which wants to push the form walls farther apart. A cubic foot of concrete weighs 150 lbs. When concrete is in its plastic state, it will exert a pressure equal to 150 times the height of the form (in feet).

Forms for walls up to 3' in height can be made of 3/4" boards or plywood braced every 2' by units of 2x4's composed of a stiffback, a brace and a kicker. These units are placed directly across from each other, one bracing one side of the form wall and the other bracing the other side at that particular place along the length of the wall. If the studs are placed closer together, the height of the form can be increased by about a foot. Fig. 25.

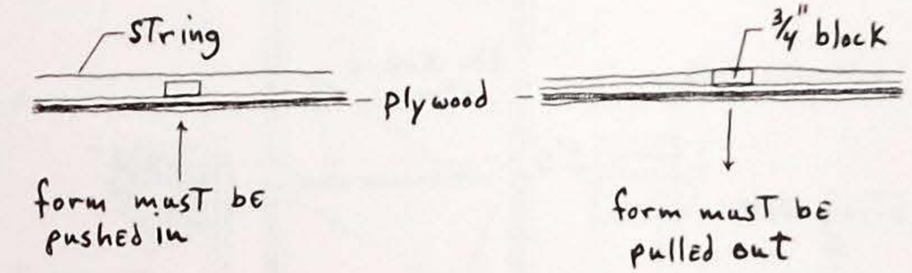
Aside from the diagonal brace which runs from the top of each stud (stiffback) to a stake in the ground, there is also a kicker at the bottom and a tie across the top of the form which holds it the correct distance apart. Cut a spreader to the

desired thickness of the wall from a piece of 2x4" or 1x4". For an eight-inch wall, the spreader would be exactly 8" long. Insert the spreader in between the walls at the bottom of the form to hold them 8" apart while the kicker at the bottom of the form is nailed first to one stake and then to the one across from it. Loosen the spreader and insert it near the top of the form. Now nail the tie first to one 2x4" stud and then to the one across from it. Knock the spreader loose and move it down to where the next tie will go and repeat.

After all the ties and kickers are nailed in place down the length of the wall form, plumb the wall at each stud along one side of the wall and, while holding the wall plumb, nail the diagonal brace to the stake. Repeat this plumbing and nailing process for each diagonal brace along one side of the wall. Finally, nail the diagonal braces on the other side of the wall.

THE THREE BLOCKS AND A STRING METHOD OF STRAIGHTENING WALLS

If the wall has not become straight during the plumbing process, straighten it using 3 blocks and a string line. Cut three 3/4" blocks off of the same piece of 1x--. They should be about 2" square but it doesn't matter for the accuracy how big they are. Fig. 26. String a line along the entire inside face of one of the form walls, parallel with and 1" down from the top edge. When the line has been pulled tight, slip a 3/4" block under each end of the string, thereby lifting the string 3/4" away from the inside face of the form. If the string is tight enough, the end blocks should stay in place, but they may have to be



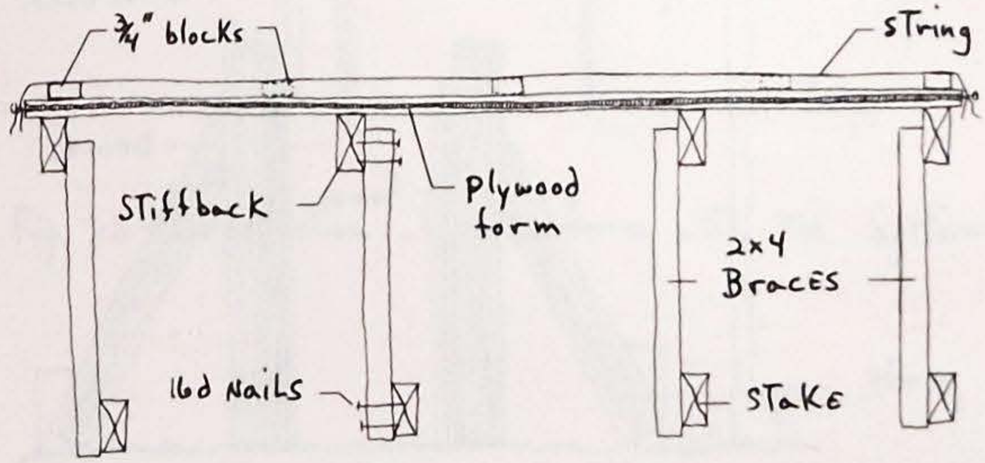


Fig. 26 - Straightening Wall with Blocks & String

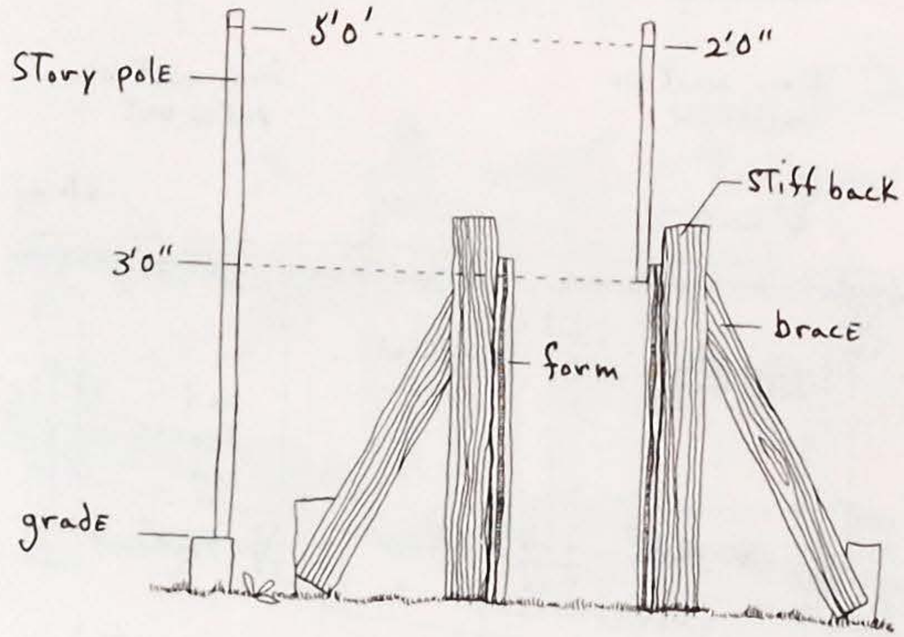


Fig. 27- Marking LEVEL of Concrete on form Wall

nailed. Now go along the length of the form, slipping the third block under the string in several places. If after the block has been slipped under the string there is daylight between the string and the block, then the form at that particular place needs to be pushed in toward the middle of the wall. If, after the third block has been slipped under the string, the string is being held out of line by the block, then the form at this place needs to be pulled out away from the center of the wall. Loosen the diagonal braces at the points along the wall that are out of line, and by using the third block as a gauge, either push the wall in or pull it out and renail the brace. The brace on the other side of the wall will have to be unnailed also if the wall is to be straightened at that point. When the wall is entirely straight, the third block should be able to be run along the inside face of the wall under the string and the string should just lightly touch the block.

MARKING GRADE ON SHORT WALL FORMS

Next we must chalk a line on the inside face of a wall form at the level up to which the concrete should be poured. Let's say the top of the wall is to be 3'0" above grade. Cut two story poles: one 6' and the other 3'. Measure up from the bottom of the 6' pole the distance that the top of the wall is above grade (3') and also measure up a distance two feet higher than the first mark. There should be two marks on this pole: one at 3' and another at 5'. On the other pole make a mark 2' from the bottom and square the line across the width of the pole. Fig. 27.

Place the bottom of the 6' story pole on top of the grade stake and hold one miniscus of the water level even with the 5' mark. Hold the bottom of the shorter story pole against the inside face of the form near the top. Hold the other end of the water level against this story pole and move the pole up and down until the miniscus is even with the 2'0" mark. Make a mark on the inside face of the form even with the bottom of the story pole. Make several more marks on the form in this fashion and snap chalk lines between them. This line is the line to which the concrete is poured. To help see it better when there is concrete around it, it is a good idea to partially drive in 6d nails along the line.

Manufactured Concrete Wall Ties

The purpose of bracing walls every 2' is to keep the wall forms the same distance apart along the length of the form. Manufactured ties can be purchased that do the same thing. They really don't save that much wood because 2x4's still have to be used to stiffen the 3/4" form material in between the ties. Holes are drilled through the 3/4" plywood; the ties run through the space between the forms and are dogged off (secured) on the outside of each of the wall forms as it emerges between two whalers. Figs. 28 & 29. Whalers are 2x4's that run horizontally along the outside of wall forms to add strength.

The ties remain in the concrete wall after it hardens and when the forms are removed, little tie loops are sticking out all over the wall. They are twisted with a screw driver or hammer and break off at a pre-stressed point within the form

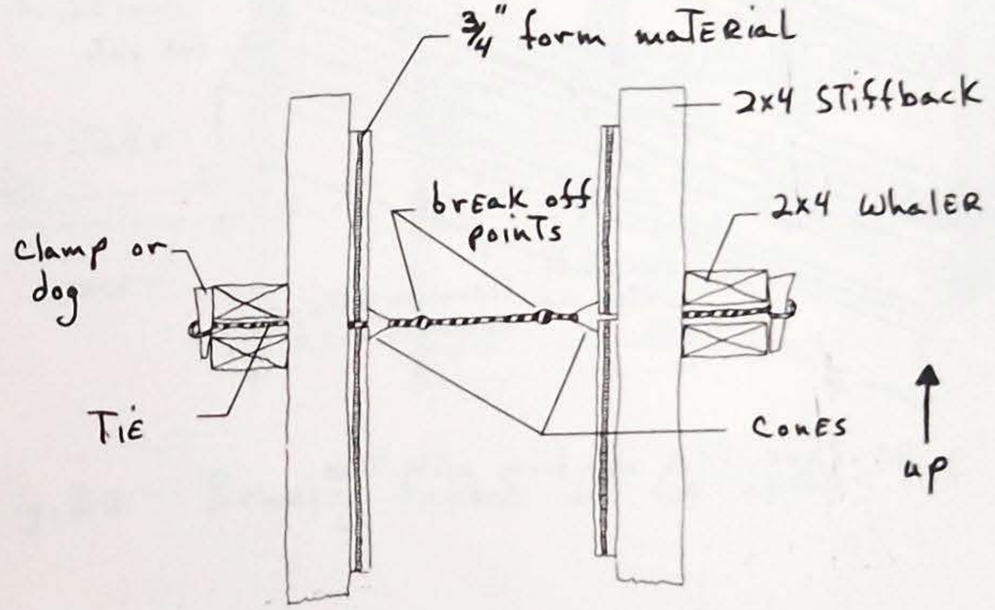


Fig. 28 - Crossection of Wall form with Tie System

Whaler

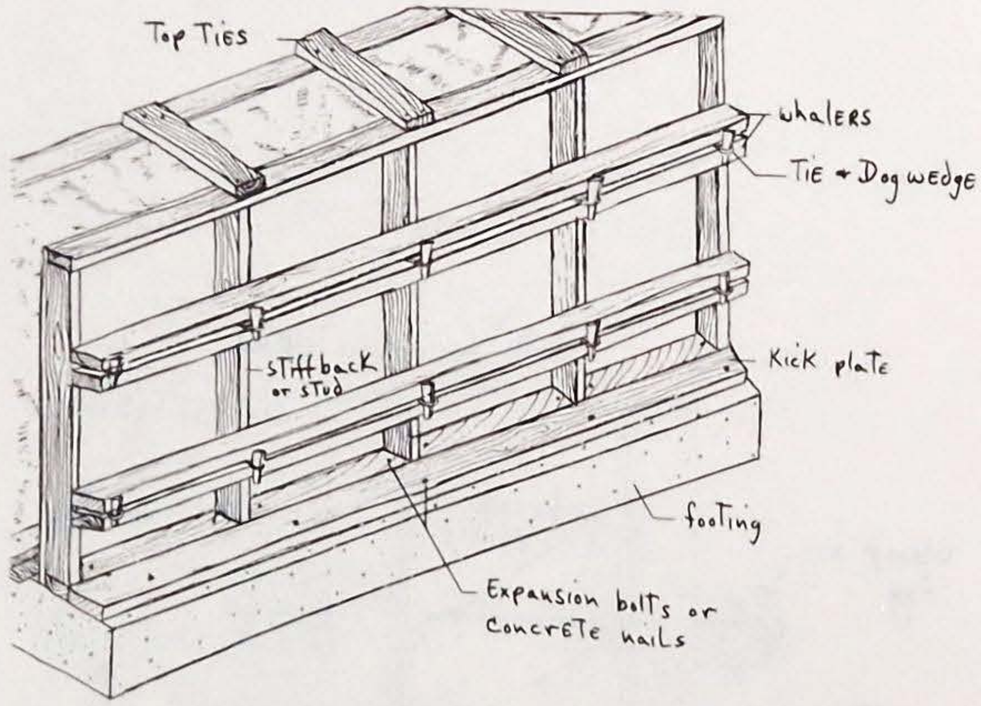


Fig. 29- Side View of form with Ties

so that they don't show. The little holes around each tie (made by the cones) must be filled with mortar or caulk or else rain will get in and rust the indented but exposed tie ends. Rust dribblings will mar the appearance of the wall.

The number of stiffbacks and whalers shown in Fig. 28 would brace one row of ties in a wall form more than 4' high. (For a short wall, less than 4', no whalers are needed.) The horizontal rows of ties and whalers should be approximately 2' apart and the individual ties should be spaced 15"-24" O.C. within a row. A kicker or kick plate is nailed with a power actuated tool to the footing to keep the bottom of the form from being pushed out of line by the pressure of the concrete.

BRACING CORNERS

There is an extra amount of pressure on forms at corners. Fig. 30 shows one way of bracing a corner. During the pour--and especially during vibrating--the corners should be watched carefully. If you think a corner isn't going to hold, add more bracing or more bolts and nails.

Making Concrete Beautiful

Many things can be done with concrete to make it beautiful and suitable as a finish material. Special coloring can be purchased to color concrete to a desired hue. Wood-like finish can be embossed in the concrete surface by using rough or surface textured lumber in the form. It will impart its wood grain texture to the concrete surface. Wood strips can be nailed to the inside of the form in a design of your own, and after the

concrete has hardened, the pattern will be preserved in the side of the wall forever. Forms that imprint a brick and mortar look to a wall are used extensively in modern basement construction.

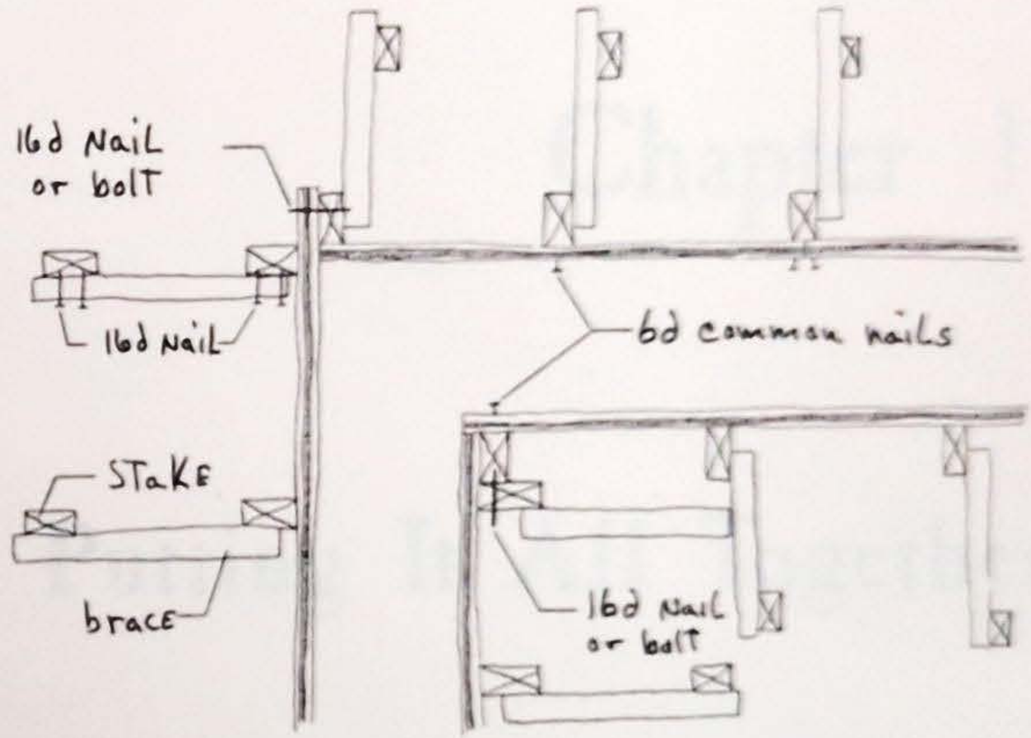


Fig. 30 - Bracing forms at Corners