CONCRETE ON THE FARM
AND
IN THE SHOP

CAMPBELL
CONCRETE ON THE FARM
AND
IN THE SHOP

A COMPLETE PRACTICAL TREATISE ON THE COMMONEST EVERY-DAY USES OF CONCRETE. WRITTEN IN PLAIN ENGLISH, SO THAT THE INEXPERIENCED PERSON DESIRING TO UNDERTAKE A PIECE OF CONCRETE CONSTRUCTION CAN, BY FOLLOWING THE DIRECTIONS GIVEN, SECURE SUCCESS.

THE CONSTRUCTION OF TANKS, TROUGHS, CISTERNS, FENCE POSTS, STABLE FLOORS, HOTBEDS, HOG WALLEWS, WALLS, FOUNDATIONS, PANEL FENCES, FEEDING FLOORS, AND ALL THE PURPOSES FOR WHICH CONCRETE IS AN INVALUABLE AID TO THE FARMER ARE INCLUDED

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VERY FULLY ILLUSTRATED

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INTRODUCTORY

Within recent years there has been increasing attention given to the use of concrete as a building material. Nowhere has this interest been relatively greater than on the farm. The appeal of concrete is due largely to the fact that care and faithful observance of fundamental principles enable a large portion of the actual labor to be performed by those who are relatively unskilled. The increasing cost of lumber has made concrete not only a formidable competitor but successful rival. Not only is this true but those who have once used concrete have come to a realization that in the concrete structure expensive upkeep is eliminated. There is no longer the continual annual outlay for repairing, painting, straightening up, and rebuilding or patching the work to put it into condition equal to new, or to maintain it in serviceable condition.

Concrete is also fireproof. This is another strong appeal. On the farm fireproof construction is doubly advantageous since the country dweller is without the protection which his city friend enjoys; namely, the well-equipped and usually efficient fire department. But concrete in town is just as good as in the country. Another advantage comes from the sanitation resulting
where concrete construction is properly applied. Feeding floors, hog wallows, watering troughs, all do their share on the farm—and it is a large one—toward preventing the filthy conditions that in a large percentage of cases are responsible for the epidemic stock diseases which annually exact a costly toll from farmers throughout the country.

There are concrete books galore. No apology need be made for this one. The concrete worker who so far has met with scant success, will learn the "why" by carefully reading and following its message. The engineer or contractor thoroughly experienced in concrete work may find but little to interest him in this book. He will say that he has heard all of these subjects discussed before. Perhaps, however, he has not heeded many of the cautions which the writer has endeavored to put into plain language and which he knows are essential to success. In that respect the book may profit the engineer or contractor who heeds. It has, however, been primarily prepared with the beginner first in mind—the man who knows nothing of concrete but wants to learn.

Concrete ordinarily is a technical subject and most writers have described the methods of using it in high-sounding terms which are beyond the understanding of the average man without some engineering or construction experience. The writer has endeavored to translate technical expressions and technical terms into plain everyday English, that any one who can read can under-
stand. Simple drawings accompany the text. In some cases these are purposely exaggerated to better show what is meant. In many cases construction illustrated by drawings is shown in a reproduction of photograph illustrating the work in progress or completed.

In the limited space of this booklet not all of the possibilities of Concrete on the Farm and in the Shop could be dwelt upon. The fundamentals of concreting, however, have been presented at some length, and these apply regardless of the construction. The examples used for purpose of illustration, that is, the various types of construction described, are such as to give the beginner who follows all directions the necessary experience to undertake more pretentious uses of concrete.

THE AUTHOR.

March, 1916.
CONCRETE ON THE FARM AND IN THE SHOP

WHAT CONCRETE IS, HOW IT SHOULD BE MADE, AND SOME OF ITS USES

GENERAL

Increasing interest in the advantages of permanent, fireproof and sanitary construction has resulted in recognition of the adaptability of concrete for most buildings required upon the farm. Here its range of use is almost unlimited; barns, hog houses, poultry houses, dairy buildings, silos, watering troughs and tanks, feeding floors, barn floors, foundations—practically all types of farm building construction—seem to be best solved by proper application of concrete.

Notwithstanding the fact that there have been volumes written concerning the uses of concrete, a great deal of the so-called information scattered broadcast has been simply the recounting of individual practices and experiences, which have not by any means always represented what those best qualified to know would endorse as correct methods of using concrete. Too often those who attempt concrete construction act upon the impression that a little cement a little sand, gravel
and water, then a few turnings with the shovel, and presto! the trick is done. This is far from the truth.

**WHAT CONCRETE IS**

Concrete consists of a certain quantity of broken stone or gravel of properly graded sizes, firmly bound together by a mortar consisting of Portland cement, sand and water. It is, therefore, a composite product, a manufactured one, so to speak, therefore success in the use of concrete involves observance of certain established requirements of selection and mixing of ingredients, and proper placing.

Like the black man and the red man, Portland cement's identity was established through color. It looks like the Portland stone of England; but nowadays when Portland cement is spoken of, only the manufactured product is meant. Natural cements are not suited to the general run of concrete construction.

**WHAT PORTLAND CEMENT IS**

Portland cement is a carefully manufactured product, consisting principally of lime, silica and aluminum oxide. It is not necessary that the user should know the exact nature of its ingredients nor just how they are combined. There are so many reputable manufacturers of Port-
land cement in the country to-day that the person contemplating concrete construction need not concern himself with the process of manufacture. All he need do is to inform himself as to the known reliability of any particular brand he contemplates using. This can be done by corresponding with the United States Department of Agriculture or the United States Bureau of Standards, both of Washington, D. C., and if the reply received indicates that the particular brand conforms to established engineering requirements he will be safe in using that brand.

TESTING CEMENT

The testing of cement is a science in itself that requires experience and skill acquired only in laboratories with special equipment, and the user need not concern himself with tests if he has been properly assured that the particular brand is known to meet with the requirements mentioned.

If cement is properly stored before use by being protected against the possibility of absorbing moisture, it will keep a long time. It should be stored in a dry shed, piled on a tight board floor that is raised several inches above the ground. Any cement containing lumps that cannot be easily crushed between the fingers has probably been exposed to dampness. The lumps should always be discarded.

Portland cement is usually sold packed in cloth
or paper sacks, each containing 94 pounds net. Four such sacks constitute a barrel. A sack of cement is considered one cubic foot.

AGGREGATES DEFINED

Aggregates is the term used to refer in a general way to the sand, stone screenings, gravel, broken stone such as granite and slag, or whatever other rock material is used to mix with the cement to form concrete. Sand is usually referred to as the fine aggregate. For convenience, sand is described as a clean rock material free from clay, loam or other foreign substances and ranging in size from the fine particles up to those which will just pass a screen having \( \frac{1}{4} \)-inch square meshes. (Four meshes to the linear inch or 16 meshes to the square inch.)

Gravel, usually called coarse aggregate, is defined as clean rock material, such as pebbles, ranging in size from \( \frac{1}{4} \) inch up to 1, 1\( \frac{1}{2} \) or 2 inches, depending on which maximum size of particles would be allowable for the particular concrete work. As a rule, 1\( \frac{1}{2} \) inches is the maximum size specified for gravel or broken stone aggregate in most concrete construction.

IMPORTANCE OF CLEAN MATERIALS

Gravel or broken stone used as coarse aggregate also must be free from clay, loam or other foreign materials. The presence of these in any considerable quantity, usually fixed at from three
to not more than five per cent, is likely to be injurious in concrete mixtures. Such foreign materials not only affect the strength of the resulting concrete, but exert an influence on its tendency to harden, sometimes delaying hardening so that the mass will not acquire any considerable strength for perhaps a number of days.

**BANK-RUN GRAVEL NOT SUITABLE**

The fact that nature has been very lavish with its distribution of sand and gravel, has led many users of concrete to think that bank-run material, that is, combined sand and gravel as dug out of a so-called gravel bank or pit, makes suitable aggregate for concrete. This is not correct, and has been responsible for much unsatisfactory concrete construction, especially for the large amount of leaky and porous concrete.

Bank-run material almost invariably consists of too large a percentage of sand—usually twice as much sand as gravel—and for good concrete, the proportions should be practically the reverse. It is always economy to screen bank-run material (see Fig. 1), separating the fine material (sand) from the coarse (pebbles) by passing over a quarter-inch mesh screen so that the two volumes (sand and gravel) can be reproportioned suitably for the particular construction.

Many persons who have done concrete work will be inclined to question the truth of this state-
ment, but they should at once make a few experiments and convince themselves of its truth. A 1:2:4 mixture, for instance, which means 1 sack (1 cubic foot) of Portland cement, 2 cubic feet of well-graded sand and 4 cubic feet of well-graded gravel or broken stone, will, when prop-

![Screening Bank-run Gravel](image)

**Fig. 1.—Screening Bank-run Gravel.**

erly combined and mixed with water, form a bulk slightly exceeding 4 cubic feet. This proves that the sand has gone to fill up the voids (air spaces) between the particles of gravel and that the cement has gone to fill up the voids (air spaces) between the particles of sand. If instead of using a definitely proportioned 1:2:4 mixture the concrete worker were to take 1 sack of cement,
and mix it with 6 cubic feet of material as coming from the gravel bank, he would then have 6 cubic feet of concrete containing 1 sack of cement as against slightly over 4 cubic feet containing the same quantity of cement. It should require but a moment's thought to prove that the 1:2:4 mixture contained proportionately more cement, hence should be a stronger, denser mixture. This is true. It might require several sacks of cement to make the mixture containing 6 feet of natural bank-run material as strong as the 1:2:4 mixture. Therefore, it should be seen that true economy follows correct proportioning of materials.

**PRINCIPLES OF PROPORTIONING CONCRETE MIXTURES**

Correct proportioning is based on the following conditions: voids or air spaces must be filled; every particle of sand must be coated with cement and every pebble of gravel or particle of broken stone must be coated with sand-cement mortar. Both strength and density, consequently watertightness in finished concrete construction, are dependent largely upon careful proportioning of materials.

Several methods of proportioning are practiced, but all consist essentially of ascertaining the percentage or bulk of voids or air spaces in the coarse material (pebbles or broken stone) to be filled by the finer material (sand), then ascertain-
ing the percentage of voids or air spaces in the combined sand and pebbles to be filled by cement. Therefore, when definite mixtures are specified for any construction, best results cannot follow if instead of the separate and definite volumes of sand and gravel called for, a bank-run material of the same total volume is substituted.

HARD, DURABLE AGGREGATES NECESSARY

In addition to being free from the foreign substances mentioned, both sand and gravel or whatever aggregate is used, must be hard and durable. Flat, soft, shale-like pieces of stone cannot be combined in a concrete mixture so as to produce concrete of great density and strength, nor watertightness.

WASHING AGGREGATES

One of the simplest arrangements for washing sand and gravel is shown in Fig. 2. This consists merely of a trough into which water is introduced by a pipe or hose at the higher end, where the sand and gravel are shoveled in also. The action of the water upon them as they roll over and over while descending the trough is such that they become thoroughly washed and the sand passes through the screen at the lower end, while the gravel is deposited in a pile at the open end of the trough beyond the screen.
A washing platform or box like that shown in Fig. 3, can be arranged for by making a frame of 2

by 6-inch lumber around a tight bottom, then raising up this platform slightly at one end, shoveling the sand and gravel to be washed upon it at the
high end and turning against them a strong stream from a hose, stirring the materials about while the water is being applied. Any clay or loam will be carried away in suspension in the water and will overflow with it at the low end of the platform or box.

CLEAN, PURE WATER NECESSARY

Another requirement is that the water used to mix the several materials shall also be clean. The best specification for mixing water is to say that water which is good to drink is best for concrete. Any considerable amount of clay making the water "cloudy" is just as injurious to a concrete mixture as though this clay were on the particles of sand and gravel. Water containing an excess of alkali or any oil is also objectionable. Remember, therefore, to use clean, pure water in mixing the concrete—water that you would not be afraid to drink.

MIXING CONCRETE

Concrete may be mixed by hand, but by far the better way is to use a power-operated batch mixer, as this insures a more thorough and uniform combination of the several materials. Power-operated mixers that will meet the rural worker's needs can be purchased with self-contained gasoline engines for as little as $70 or $75, and for any
one contemplating a considerable amount of concrete construction, they represent a wise investment that will eliminate most of the labor where much concrete is to be mixed. Many farmers have found it advantageous to combine co-operatively in purchasing such an equipment, then to charge each person so much per day for the use of the outfit, thus eventually absorbing its cost among them.

**HOME-MADE CONCRETE MIXER**

Home-made concrete mixers have been constructed by attaching cubical boxes to a shaft of gas pipe, and revolving the box by a pulley attached to the shaft belt driven by a gasoline engine. To obtain best results from a cubical drum without placing interior vanes or deflectors inside the box, the shaft on which it is mounted should not extend exactly from corner to corner of the cube but so that the cube will be hung "off center," thus giving a sort of zigzag motion to the contents of the box while it is being revolved.

In mixing concrete in the proportion 1:2:3, 6 cubic feet of loose materials are required for a one-bag batch, while in a leaner mixture such as a 1:3:5, 9 cubic feet of loose materials are put into the mixer. Mixing batches as large as these in a box or drum operated by a gasoline engine requires that the construction be very rigid. The box should be 3 feet in each dimension, so will have a volume capacity of 1 cubic yard. Best
results in mixing are secured when the mixer cube or drum is not over ½ full. Gears should be arranged so that the drum may be revolved at a proper speed. If revolved too slowly, too long a time will be required for mixing, and if revolved too rapidly the materials will tend to cling to the sides of the box or drum and will therefore not be tumbled about enough to insure thorough mixing.

Two types of home-made mixers are shown in accompanying reproduction of photographs, Figs.
Fig. 5.—Another View of the Mixer Shown in Fig. 4.

Fig. 6.—Home-made Barrel Mixer. Hand or Power Operated.
4, 5, 6 and 7. One of these is cylindrical in shape and was made of two round board heads fitted into a drum frame which was composed of narrow boards of the desired length, bolted to two old wagon tires. The other home-made mixer consists of a barrel mounted on a suitable frame and fitted with a set of gear castings which are so connected to a shaft with pulley, as to be operated by a belt driven by gasoline engine. This mixer can be hand driven also. The frame, as will be seen, has been made so that the barrel can be tilted after mixing has been completed to
dump the concrete into a wheelbarrow for transferring to where it is to be used.

In machine mixing it is desirable to revolve the mixer at least one minute after all materials, including the mixing water, have been placed in the drum. One and one-half minutes would be better.

**HAND MIXING**

The greater portion of home-made concrete is mixed by hand. In such cases a watertight platform (Fig. 8) should be provided. This should be made of smooth 1\(\frac{1}{2}\) or 2-inch boards, preferably tongued and grooved so that the platform will be tight to prevent water carrying away cement by leaking through cracks during mixing of materials.

**MEASURING MATERIALS**

A practical method of measuring materials is to use a bottomless box. This box may be made to hold either 1 cubic foot or 4 cubic feet. In the latter case there should be marks on the interior indicating levels for 1, 2 and 3 cubic feet. (Cement need not be measured as 1 sack (94 pounds) is considered 1 cubic foot.) The measuring box is first set on the mixing platform, and when the required amount of sand has been measured, the sand is spread out in a layer on the mixing platform. Next the cement is spread over
Fig. 8.—Watertight Platform for Hand Mixing of Concrete.
the sand in a thin layer. Square-pointed shovels are used to turn the cement and sand several times until the mixture is of a uniform color, disappearance of brown and grey streaks indicating thorough mixing of the mass. Then the gravel or crushed stone, first thoroughly wet, is measured and spread in a layer on top of the cement and sand and all of the materials again turned with shovels. A depression is then shoveled in the center of the pile and water is added while preferably two men turn the mass thoroughly. If running water is available the water should be sprayed from a hose to avoid washing away the cement. At any rate it should be added gently, shoveling being carried on while water is added and continued until the entire batch is of a uniform consistency and color. This will generally require that at least three turnings be given the materials after the necessary amount of water has been added.

Thorough hand mixing will produce a good concrete mixture, but the labor involved is considerable if much concrete work is planned, and there is a tendency to slight mixing, so it quite often follows that improperly mixed concrete is used. For this reason the concrete worker should endeavor to provide means for mixing his concrete by a power-operated batch mixer.
AMOUNT OF WATER REQUIRED

The amount of water required in a concrete mixture varies to some extent, depending upon the construction in which used. For most classes of work, what is known as a "quaky" consistency best fills requirements. Such a mixture is one that is wet enough to settle in place with very little working or spading in the forms, or, if placed in a pile, as in building feeding floors or barnyard pavements and walks, it will slowly spread out or flatten of its own weight. Too much water will cause the mortar to separate from the pebbles or broken stone, and thus result in stone pockets in the finished mass. Where reinforcing steel is used, too wet a mixture would also result in pockets where the concrete had not bonded or united with the steel. Finally, after the concrete had hardened, the evaporation of the excess water would cause the mass to have a porous texture.

In making such concrete products as block, brick and tile, which are usually made in iron molds, these products being removed from the mold immediately after tamping, a drier mixture must be used. In that case the general rule is to use as much water as possible without interfering with the quick removal of the molds, yet enough so that with hard tamping free moisture will flush to the surface of the concrete.

In reinforced concrete fence posts, where den-
sity and compactness are secured not by tamping the concrete but rather by shaking or jarring the molds, the mixture must be quite wet—slightly wetter than described by "quaky"—as wet as possible without causing separation of mortar and gravel in handling and placing. Such products as fence posts are left in the molds for perhaps 24 hours, or until the concrete has hardened sufficiently to permit removing sides of the molds without injury to the concrete.

**PLACING CONCRETE**

All concrete should be placed where it is to be used within 30 minutes after water has been added to the mixed materials. This is important because concrete begins to harden within this time, and to disturb the mass after hardening has begun destroys the final strength of the concrete, and in the case of floors or pavements impairs the wearing quality.

Methods of placing must necessarily vary in accordance with the several types of construction. To mention a few simple examples:

Concrete for feeding floors or barnyard pavements is dumped from a wheelbarrow upon a previously prepared sub-grade or foundation and as rapidly as the forms for alternate slabs are filled, the concrete is struck off level by using a straightedge rested upon the top of forms. The surface is then finished by smoothing with a wood
float. Such a tool is preferable to a steel trowel as it gives an even surface yet one not smooth enough to be slippery. In the case of small troughs and watering tanks, that can be built without stopping concreting once it has begun, part of the concrete for the floor of the trough or tank is placed, then the reinforcing, then enough concrete to finish the floor, then the inside form is quickly set in place, concrete for side walls deposited immediately and spaded or tamped, so that every portion of the forms is filled. A tool like a garden spade or hoe flattened out, or a flat piece of wood with the edge protected by sheet iron, is used for this purpose. Spading next to the forms forces back the coarse aggregate and causes the mortar to flow against the form face, giving a smoother finish and a denser surface.

In constructing walls for buildings, forms are filled in a manner similar to that just described, particular attention being given to spading the coarse material away from the outside faces in order to give a smooth exterior surface when forms are removed, this, of course, assuming that the exterior surface is to be left in its natural condition. If, however, the surface is to be plastered finally, spading should be done only between form faces so that the exposed surface will be a little rough, making the plaster bond or "key" better to the wall face.
PROTECTION OF CONCRETE AFTER PLACING

Proper protection of concrete after placing is of utmost importance, because while concrete generally begins to harden noticeably within thirty minutes after mixed, the subsequent changes in the mass tending toward complete hardening take place somewhat slowly and can be brought about satisfactorily only in the presence of favorable moisture and temperature conditions. Concrete of "quaky" consistency generally has sufficient water in it to result in proper hardening, if, after placed, the concrete is protected from exposure to sun and drying winds. If not so protected, the concrete instead of really hardening will simply dry out.

Many persons believe that drying out is the natural and required process following the work of placing concrete. Nothing could be farther from the truth. The expression "curing" has been quite generally used, but the word suggests drying rather than hardening. In any concrete work the finished structure must be so protected that the concrete will retain the water already in it. To accomplish this, concrete floors, for instance, must be covered with wet straw or damp sand, and this covering sprinkled or otherwise kept moist for a period varying from one to two weeks according to weather conditions.

Concrete hardens much more rapidly in warm
than in cool weather. In the case of walls of buildings or vertical faces, which cannot be covered with straw, canvas or similar material is hung over them and kept thoroughly moist by sprinkling. The concrete surface also is sprinkled: Most concrete should not be subjected to its intended use until it has hardened under favorable conditions for a week or more, depending upon the nature of the construction. Longer time will be required in cold weather.

**WINTER CONCRETING**

A great deal of concrete work can be done as well in winter as in summer if simple precautions are taken to prevent the concrete from freezing during the periods of mixing, placing and hardening. No material containing frost or frozen lumps should ever be used in preparing a concrete mixture. Sand and gravel should be heated in winter or kept in a room where the temperature does not fall below 50 degrees Fahrenheit. Water used for mixing should not contain ice, and in very cold weather should be heated. The idea is to heat materials (except the cement) enough so that the concrete when placed will have a temperature not lower than 80 degrees Fahrenheit. This temperature, with proper precautions to protect the concrete immediately after placing, will be retained for some time, especially as it is supplemented by heat developed within the
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Concrete during the early hardening process as a result of chemical action between the cement and water. Consequently, if concrete in this heated condition is protected from freezing during the first 48 hours after it has been placed, it will not usually be harmed by subsequent exposure to freezing temperatures.

Floors placed in the winter time should be covered with a foot of straw, or with tar paper with 6 inches of dry manure shoveled on top, which should be left in place from ten days to two weeks. Manure should not be placed immediately on or against the fresh concrete as it has been known to injure the surface previous to thorough hardening.

CONCRETE PRODUCTS EASILY MANUFACTURED IN WINTER

Fence posts and similar concrete products may be manufactured in winter just as well as in summer, provided they are made in a workroom where the temperature is kept above 50 degrees and the materials are heated as suggested. Such manufactured products should be kept indoors until they are two weeks old before exposure to the usual winter weather.

Permanent farm improvements of concrete are rapidly supplanting all other kinds of construction for the reason that concrete is, with the exception of the cement, made from materials which are obtainable on or near every farm.
With a little experience, ordinary farm structures may be built by home labor. Consequently the cost of these improvements is moderate, while their upkeep is nothing. They require neither painting nor repairs; on the contrary, the older they get the better they get if the concrete work has been properly done, because good concrete increases in strength with age.

No doubt the chief merit of concrete for buildings is its fire-resistance. Concrete will not burn, and insurance on a structure entirely of concrete is unnecessary, although insurance may be required upon its contents. To secure complete protection from fire, roofs as well as walls of buildings should be of concrete.

By no means least among the advantages of concrete on the farm is protection against the depredations of rats and mice. This brings us to the question of sanitation also, which has recently assumed such vast importance owing to the number of epidemic stock diseases which periodically take their toll in various sections of the country. Nothing is a better preventive of disease than cleanliness, and nothing is so conducive of cleanliness in farm buildings as concrete in all the surroundings of live stock.
RECOMMENDED MIXTURES FOR VARIOUS CLASSES OF CONCRETE CONSTRUCTION

The following table gives suggested mixtures for various classes of concrete work. In each case the first figure represents 1 sack, or 1 cubic foot, of Portland cement; the second figure represents the required number of cubic feet of clean, well-graded sand ranging from the finer particles to those that will just pass a $\frac{1}{4}$-inch mesh screen; the third figure represents the number of cubic feet of clean, well-graded pebbles or crushed stone ranging in size from $\frac{1}{4}$ to not more than $1\frac{1}{2}$ inches. Further limitations on the maximum size of coarse aggregate (pebbles or broken stone) will be given later when each particular class of construction is described more in detail.

**TABLE OF CONCRETE MIXTURES**

A 1:2:3 mixture for:
- Feeding floors and barnyard pavements
- One-course floors and walks
- Roofs
- Fence posts
- Water troughs and tanks

A 1:2:4 mixture for:
- Beams and columns
- Engine foundations
- Watertight basement walls
Reinforced concrete floors
Work subject to vibration
A 1:2\(\frac{1}{2}\):4 mixture for:
  Building walls above foundation
  Silo walls
  Base of two-course walks and floors
  Backing of concrete block and similar concrete products
A 1:3:5 mixture for:
  Basement walls where watertightness is not essential and foundations belowground
  Mass concrete footings, etc.

MORTAR

1:1\(\frac{1}{2}\) mixture for:
  Wearing course of two course floors
1:2 mixture for:
  Scratch coat of exterior plaster
  Facing blocks and similar cement products
  Wearing course of two course walks, feeding floors and barnyard pavements
1:2\(\frac{1}{2}\) mixture for:
  Finish coat of exterior plaster

Table I shows the cubic feet of sand and gravel (or crushed stone) to be mixed with one sack of cement to secure mixtures of the different proportions indicated in the first column. The last column gives the resulting volume in cubic feet of compacted mortar or concrete.
Table II gives the number of sacks of cement and cubic feet of sand and gravel (or broken stone) required to make 1 cubic yard (27 cubic feet) of compact concrete proportioned as indicated in first column.

Following are given a number of examples which will illustrate the method of using Tables I and II.

**Example I.** How much cement, sand and gravel will be required to build a feeding floor 30 by 24 feet, 5 inches thick?

Multiplying the area (30 by 24) by the thickness in feet gives 300 cubic feet, and dividing this by 27 gives $11\frac{1}{3}$ cubic yards as the required volume of concrete. A one-course floor should be of 1:2:3 mixture. Table II shows that each cubic yard of this mixture requires 7 sacks of cement,
14 cubic feet of sand and 21 cubic feet of gravel or stone. Multiplying these quantities by the number of cubic yards required \((11\frac{1}{3})\) gives the quantities of material required (eliminating fractions) as 78 sacks of cement, 156 cubic feet of sand and 233 cubic feet of gravel or stone. As there are 4 sacks of cement in a barrel, and 27 cubic feet of sand or gravel in a cubic yard, there will be needed a little less than 20 barrels of cement, 6 cubic yards of sand and 9 cubic yards of gravel or stone.

**Example II.** How many fence posts 3 by 3 inches at the top, 5 by 5 inches at the bottom and 7 feet long, can be made from 1 sack of cement? How much sand and gravel will be needed?

Fence posts should be of a 1:2:3 mixture.
Table I shows the volume of a 1-sack batch of this mixture to be 3\(\frac{2}{3}\) cubic feet. The volume of one concrete post, found by multiplying the length by the average width and breadth in feet \((7\times\frac{3}{4}\times\frac{4}{3})\) is \(\frac{7}{3}\) cubic foot. By dividing 3\(\frac{2}{3}\) by \(\frac{7}{3}\) we find that five posts can be made from 1 sack of cement when mixed with 2 cubic feet of sand and 3 cubic feet of gravel.

**Example III.** What quantities of cement, sand and gravel are necessary to make 100 unfaced concrete block, each 8 by 8 by 16 inches?

The product of height, width and thickness, all in feet \((\frac{8}{3}\times\frac{8}{3}\times\frac{16}{3})\) gives \(\frac{128}{9}\) cubic feet as the contents of a solid block. As the air space is usually estimated as 33\(\frac{1}{3}\) per cent, the volume of concrete in one hollow block will be \(\frac{5}{3}\) of \(\frac{128}{9}\), or \(\frac{200}{9}\) cubic feet; in 100 blocks, the volume of concrete will be \(\frac{2000}{9}\) or 39\(\frac{1}{2}\) cubic feet, which being divided by 27 gives a little less than 1\(\frac{1}{2}\) cubic yards. Unfaced concrete block should be of 1:2\(\frac{1}{2}\):4 mixture. Table II shows that each cubic yard of this mixture requires 5\(\frac{10}{7}\) sacks of cement, 14 cubic feet of sand and 22\(\frac{14}{7}\) cubic feet of gravel. Multiplying these quantities by the number of cubic yards required (1\(\frac{1}{2}\)) gives the quantities of material required as 8\(\frac{2}{3}\) sacks of cement, 21 cubic feet of sand and 33\(\frac{3}{7}\) cubic feet of gravel.

**Example IV:** How many 6-foot hog troughs, 12 inches wide and 10 inches high, can be made from 1 barrel of cement?
Use a 1:2:3 mixture. Table I shows the volume of a 1-sack batch of this mixture to be $3\frac{1}{10}$ cubic feet. As there are 4 sacks in 1 barrel, a barrel of cement would be sufficient for 4 times $3\frac{1}{10}$, or $15\frac{5}{10}$ cubic feet of concrete. The product of the three dimensions, all in feet, gives the volume of one trough as $15\frac{5}{10}$ cubic feet. However, approximately 30 per cent of this volume is in the open water basin or inside of the tank, leaving $3\frac{5}{10}$ cubic feet as the solid contents of concrete in one trough. Dividing $15\frac{5}{10}$ by $3\frac{5}{10}$, we find that 4 troughs (and a fraction over) can be made from 1 barrel of cement when mixed with 8 cubic feet of sand and 12 cubic feet of gravel.

FORMS FOR VARIOUS CLASSES OF CONCRETE CONSTRUCTION

Forms or molds are the receptacles in which concrete is placed so that it will have the desired shape or outlines when hardened. Forms are constructed of wood, cast iron or sheet steel, or of wood lined with sheet iron or steel, depending upon the nature of the work and the surface finish which it is desired to obtain. By far the greater portion of concrete is placed in wood forms. The character of the work and the cost of lumber generally determine the kind of lumber that shall be used for forms. For work where a very smooth surface finish is required, planed lumber is best, and if ornamental trim is to be
reproduced in concrete, then white pine is best. For ordinary work, however, white pine is too expensive, and too soft to be durable under repeated use. Therefore spruce, Norway pine, and southern pine are generally the most economical kinds of form lumber. California redwood will stain the concrete surface so should not be used where such staining would be objectionable. Where spruce can be readily obtained, it is perhaps the best material for form studs and posts. Hemlock is too coarse grained for sheathing and splits so easily as to be unsafe where forms must be strong and heavy to support a great load of concrete. Most of the hardwoods are too expensive and too difficult to work.

Form lumber should be free from defects that will affect its strength or cause the concrete to show a reproduction of the markings on the lumber, where surface markings on the concrete would be undesirable.

Air-seasoned lumber is better than kiln-dried; the latter will swell and bulge at the joints, while green lumber will shrink if not kept wet, thus opening cracks in the forms through which water carrying cement will leak out when the concrete is placed. Even for plain work, lumber that has been dressed at least on one side and on the edges is best, because the boards will fit closely together and the smooth surface will reduce the labor of removing and cleaning forms. Tongued and grooved lumber is often used for form
sheathing. This makes tight forms and prevents leakage of water through forms when wet concrete is being placed, hence, will prevent the loss of cement from the concrete mixture. But for most farm work, tongued and grooved lumber is unnecessarily expensive.

Form lumber should be uniform in thickness, as any inequalities of thickness cause unevenness on the concrete surface. Posts and studs for supporting forms must be sufficiently stiff and strong to hold forms in true line and to prevent bulging or sagging under the load of concrete.

Careful thought should be given to constructing forms so that if it is desired to use them again or to use the lumber of which they have been made for further concrete form work they can be knocked down with least injury to the lumber. It may often be found advantageous to assemble certain forms with screws instead of with nails. Forms should be so designed that they can be taken down with the least amount of hammering, thus preventing possible injury to the concrete before it has thoroughly hardened.

For some foundation work, especially where the earth is so firm that the sidewalls of the excavation will stand without caving, forms will not be necessary for portions of the construction underground; but when placing and tamping the concrete, care must be taken not to knock down earth into the concrete. This will cause weak porous spots in the wall.
Economy of lumber and consequently reduced cost of form construction will result from planning the forms in units so far as possible; that is, as panels or sections which can easily be removed and reset in other places on the same job without alteration. This is especially true of building-wall construction aboveground.

Depending upon the mass of concrete to be supported, form lumber may vary in thickness from 1 to 2 inches. Likewise studding to which the sheathing boards are nailed may be spaced from 18 inches to perhaps 2½ or 3 feet apart, depending upon the thickness of sheathing and the mass of the concrete to be placed, and, hence, upon its tendency to cause forms to bulge. Studs should be selected with this in view also, hence may vary from 2 by 4 to 2 by 8 stock.

If forms of planed lumber are to be used repeatedly on the same construction, it is advisable to give the form face against which the concrete is to be placed, several coats of shellac to render the lumber non-absorbent. This will prevent loss of water from the concrete and will also keep the concrete from sticking when hardening. This, however, applies rather to forms used in ornamental work and is not usually warranted in the average construction. The common practice is to oil or wet forms at each setting just before depositing the concrete. A mixture of equal parts of boiled linseed oil and kerosene is very effective for this purpose; and such a
mixture should be painted on by using a swab, or a brush like a whitewash brush. Thorough wetting down with water will also prevent concrete from sticking if before used the first time the forms have been thoroughly oil-soaked. All concrete adhering to forms from previous work should be carefully removed before placing new concrete.

While no high degree of skill is required to make forms for ordinary concrete construction, nevertheless, thoughtful care should be exercised when measuring and cutting lumber, so that the concrete placed in them will correspond in line and dimension to the plan intended. If properly planned, forms can be assembled in part by clamps and wedges, and only a few nails partly driven will be necessary. This will permit taking them down with least injury to the lumber and to the partly hardened concrete.

After forms are made they should be set up perfectly plumb, and well braced in position so as to withstand the pressure of the fresh concrete, also of tamping it into place. Wood spacers should be used to hold opposite form faces exactly the correct distance apart, then bolts or wire ties be passed through or around form studs and across the space between forms to tighten the forms against the spacers and thus hold them in true alignment so that in wall construction, for instance, the finished structure will have a uniform thickness throughout.
Bolts used as form ties should be greased before placed so that they may be readily knocked out of the concrete when taking down forms. Removing them of course leaves holes in the concrete, which must afterward be pointed up with a cement mortar, usually consisting of 1 part cement to 2 parts of clean, coarse sand. Generally wire ties are cheapest, as the wire can be cut and all except the projecting ends be left in the concrete. Wire ties are tightened by twisting between form faces. Spacers, of course, are removed as concreting progresses.

The length of time forms should be left in place cannot be definitely stated. This depends altogether upon the nature of the work and the weather conditions, which govern the rapidity with which the concrete will gain strength enough to be not only self-supporting but to carry any load which is placed upon it.

It is particularly important that column forms be left in position long enough to prevent failure of the concrete after form removal. The same applies to forms used for supporting roof and floor slabs. Where no particular pressure is brought against the concrete or no load other than its own weight must be carried, forms can sometimes be removed in from one-half to two days, or as soon as the concrete will withstand hard pressure of one's thumb without showing a mark. On massive walls without load one to three days are generally required; but where the wall must
withstand earth pressure, as in a retaining wall, the forms may have to be left in place three to four weeks. This depends largely upon the time of year, which influences the rapidity with which the concrete gains strength.

**SIMPLE FORM SYSTEM**

Although there are a number of form systems which considerably simplify concrete construction, most of these are subject to patent control, hence the user must pay a royalty to the patent owner for the privilege of using the systems; or where patented forms may be purchased outright, their cost is greater than usually warranted for the limited use made by the home concrete worker.

Probably no use of concrete shows the material to more advantage than does monolithic construction. But the unit system, in which various pre-cast members are ultimately set up in place, possesses its advantages also, because doing away largely with expensive form construction. Yet frequently members must for various reasons be cast of such size as to be unwieldy when necessary to assemble the structure.

A form system which combines simplicity with cheapness is illustrated in Fig. 9. This produces what in a way is a combination of unit and monolithic construction. Columns, piers or posts are formed of hollow blocks cast in simple molds,
then laid up as masonry. The core or hollow space is afterward filled with concrete, reinforcing rods being inserted if necessary or desirable,

thus resulting essentially in a reinforced monolithic column.

Blocks when cast are made in a mold that provides for ribs on each end against which planks may be clamped to serve as forms for placing
the concrete of intervening panels. By varying the relative position of these ribs on the block, as shown in Fig. 10, one can see the possibilities of constructing walls or panels of practically any desired thickness.

Most of the commercial block machines could be equipped with a mold that would permit manufacturing such blocks by machine, yet as they form but a small portion of the entire construction where this system is used, most home workers will find it quite as desirable to make a simple mold and manufacture the block by hand.

A 1:2:4 or 1:2\(\frac{1}{2} : 4\) mixture in which the coarse

Fig. 10.—Illustrating How the System Shown in Fig. 9 may be Readily Varied.
aggregate does not exceed 1 inch in greatest dimension should be used for the block and the concrete should be of a drier consistency than is expressed by the word "quaky," yet not so wet that the forms cannot be removed immediately after the concrete has been tamped in the mold. Just enough water should be used in the mixture to cause a slight flushing of free water to the surface when compacting the concrete.

In constructing columns or piers for building-walls, foundation walls aboveground, or for panel fences, these blocks should, after thoroughly hardened, be laid up in a 1:2 cement mortar. Blocks should be thoroughly wet before being laid up so that they will not absorb an excess of water from the cement mortar thus preventing the mortar from bonding them together. Piers or columns are built up 5 or 6 feet high before filling the hollow space with concrete. Whether reinforcing will be necessary or not can be determined only when it is known to what purpose the construction is ultimately to be put.

Forms used to place the monolithic panels between columns, posts or piers, consist simply of 12 or 14-inch planks 2 inches thick, bolted together with \( \frac{1}{2} \)-inch bolts. Holes for bolts should be so laid out in the planks that it will be possible to turn planks end for end if necessary to correct warping or twisting from previous use. Bolts should be well oiled before placing concrete so that when form removal is started
they can be readily driven out of the wall and again used. The holes left may be easily pointed up with a 1:2 cement mortar. In some wall construction holes will need to be closed only on the outside face of the wall, wood plugs being driven in the holes on the inside face to serve as nail holds for attaching furring strips if lathing and plastering is contemplated later.

Four planks are commonly used to a panel, and after being bolted in place the space between them is filled with concrete. When the concrete has sufficiently hardened, forms are reset for further use by removing the lower pair of planks first and placing them on top of and resting on the pair above where they are bolted against the projecting lugs of blocks. After concreting has been carried to the height at which piers were built in the first instance, more blocks are laid to extend the piers or columns to a higher point, and so on. Reinforcing of panels can be easily done where necessary.

This system of form construction practically eliminates carpenter work and requires no outlay of lumber that after concreting represents waste. In fact there is no waste of lumber where this system is used.

Blocks cast after the manner suggested yet without projecting lugs form convenient units for building porch piers and may be filled with concrete if such added strength is necessary, and may also be reinforced. On the other hand, if
it is desired to enclose the foundation with walls or panels between piers then naturally the blocks with projecting lugs will be used.

CONCRETING TOOLS

In addition to the advantage of being able to secure most of the concrete materials near the work, is the advantage that but few tools are required in ordinary concreting. A carpenter's square, hammer and saw, nails and screws to assemble lumber, a sand screen (Fig. 1) so that the fine and coarse materials may be separated for proper reproporportioning afterwards, perhaps a trough or washing box (Figs 2 and 3) in which dirty material can be freed from clay, loam and similar foreign matter, a mixing platform (Fig. 8), measuring box, water barrel, square-pointed shovels, strikeboard, spade, or similar tool already described, a tamper, and a hand float, similar to a trowel, are the essential tools.

A sand screen of convenient size can be made by nailing a frame of 2 by 6 lumber over wire mesh having quarter-inch openings; that is, 4 openings to the linear inch, or 16 openings to the square inch, or, a screen fabric consisting of 3⁄8-inch slotted screen wire with cross wires as braces from 4 to 6 inches apart. Legs should be attached to one end of the frame so that the screen when set up for use will stand at an angle of about 45 degrees with the horizontal.
A very serviceable type of mixing platform can be made by nailing 2-inch lumber planed on one side and the edges, to a frame of 2 by 6's. Tongued and grooved lumber is preferable, however, so that joints will be tight enough to prevent mixing water leaking through and carrying with it a quantity of cement. The 2 by 6 stringers to which the platform boards are nailed should be spaced not farther than 2 feet apart and if the outer two have holes bored at the ends, so that clevises can be attached to them, a horse can be used to drag the platform easily about wherever needed.

A bottomless box 3 feet long; 1 foot 4 inches wide and 1 foot deep, inside measurements, made of 1½-inch lumber, has been found of convenient size for measuring materials, because such a box holds exactly 4 cubic feet. It should be marked on the inside at 3-inch intervals so that the volume of sand and gravel may be easily measured in multiples of one cubic foot. In other words, the measuring box is really a frame with handles, and when in use is set on the mixing platform which serves as a bottom.

Suppose it is required to prepare a 1:2:4 mixture; sand is shoveled into the box until there are 2 cubic feet, which would fill the frame half full or 6 inches deep. Then the box is lifted and the sand spread level over the center of the platform. One sack of cement (which equals 1 cubic foot) is then dumped on top of the sand and
spread about evenly. The cement and sand are thoroughly mixed and leveled off. The measuring box is now set on top of the mixed sand and cement or on the platform beside them and filled level full of gravel or broken stone. The box is then lifted, leaving 4 cubic feet of gravel or broken stone to be mixed with the sand and cement. Mixtures made up of different proportions of sand, gravel and cement are prepared in a similar manner.

Although concrete should always be mixed as near to the place where it is to be used as possible, it is almost always necessary to handle it some distance from the mixing platform or mixer. For transferring concrete from the mixing machine or platform to the place where it is to be deposited, a wheelbarrow may be needed. One having a sheet-iron body is preferable, as less concrete is likely to adhere to the surface and after use it can more readily be cleansed than a wood one. A type should be chosen that has the front portion of the body higher than the back, so that when the handles are lifted to wheel it the concrete may lie level in the barrow without flowing over one end and thus being wasted.

Watertightness of concrete construction is largely dependent upon the proper proportioning of materials and suitable consistency; nevertheless, it is in part secured by spading the concrete in the form so as to force back from the form face the coarse particles and allow the sand-
cement mortar to flow next to the forms. In use the spading tool (Fig. 50) should be worked up and down, not only in the center of the mass, but next to the form face as concrete is deposited. Little or no tamping will be required if a "quaky" mixture is used.

Ordinarily concrete should be deposited in layers not more than 6 or 8 inches thick, never more than 12 inches, preferably 6 to 8, because if more than this is placed in the forms at one time, it will not be possible to tamp or spade it to maximum compactness and density.

In foundation work, especially where most of the concrete is placed below ground level and there is to be no basement within the foundation walls, hence watertightness is not essential, concrete is often mixed with slightly less water than is required to produce a "quaky" mixture, in which case the concrete is tamped into position rather than spaded. For this work a tamper may be made by fastening a piece of 1-inch gas pipe, 5 feet long, into a hardwood block 8 by 8 by 12 inches, by boring a hole into the end of the block and driving in the pipe. The durability of such a tamper may be increased somewhat, by "shoeing" it with a piece of sheet-iron; or, a steel tamper can be purchased, and will of course be more durable. For most work, however, the home-made tamper described will be sufficient. One of smaller square dimensions than mentioned may be needed where the dis-
tance between form faces will not permit using a tamper 8 inches square.

In building floors, walks, and barnyard pavements, a straightedge is used to level or strike off the concrete after it has been placed in the forms. The straightedge (see Fig. 46) is used by resting it upon the top edge of forms, and should be long enough to project beyond the forms so that it may be conveniently handled by working it back and forth with a saw-like motion. A piece of 1\(\frac{1}{2}\)-inch lumber, from 4 to 6 inches wide and 6 feet long, planed to a true face on the lower edge, makes a good straightedge to strike off a slab 5 feet wide. For a wider surface a longer one will be needed.

Although it is now common practice to lay concrete floors and pavements of one-course construction, that is, of the same mixture throughout, sometimes such work is laid in two courses; that is, the base is of a "leaner" mixture than the top (having less cement in it) and in such case a base gage or strikeboard is necessary which is similar to the ordinary straightedge but notched at the ends so that when resting upon the sides of the forms it will project into them 1 inch and consequently strike off the concrete at that depth below the top of the forms so there will be a 1-inch space remaining to be filled immediately with the richer concrete top or wearing course.

Most classes of concrete work such as pave-
ments, walks, barn floors, driveways, etc., are now finished by using a wooden finishing trowel, called a wood float, because of its similarity to the float used by plasterers. Such a tool should be from 4½ to 6 inches wide and from 10 to 12 inches long, and can very readily be made by fitting a wood handle to a piece of ½-inch board of the desired size. The edges which are to come in contact with the concrete should be very slightly rounded. The wood float gives to the surface of a concrete walk, feeding floor or pavement a texture which is even but not slippery, and one that is much preferable for stock to walk upon than a concrete surface finished with a steel trowel. Danger of slipping is entirely removed if the surface is wood floated in final finishing. Corrugations in walks, floors and pavements are not necessary then.

For most home concrete work, the tools described will be sufficient. It may be necessary to buy three small ones: a rectangular steel trowel, a groover and an edger. The steel trowel is not recommended for general use, but is of advantage in finishing the inside of mangers, water-troughs, and work where a particularly smooth surface is desired. Care should be taken not to overtrowel the surface, as this causes a separation of the cement from the sand, bringing the former to the surface as a fine film which is not at all durable under wear.

The groover, as indicated by its name, is for
making a groove at the joints of walk or pavement slabs, but is used only on two-course work, one-course work being laid in alternate slabs to secure perfect joints of separation. As one-course work is largely replacing two-course construction, the groover will seldom be required. The edger, however, is necessary to finish the edges of all slabs in walk, floor or pavement construction regardless of whether the work is one or two-course. These three small tools may be purchased from almost any hardware dealer, or can readily be obtained by him. They are not expensive and if kept clean and well oiled after laid away will last almost indefinitely.

FOUNDATIONS

No material lends itself more readily to the construction of foundations than does concrete. The very ease with which it may be made to fill irregular excavations simplifies foundation construction by comparison with brick or stone masonry. Furthermore, the rapidity with which the work can be carried on with unskilled labor is another advantage. Where the nature of the ground is such that the walls of the excavation are self-sustaining, it may not be necessary to use forms for that portion of a foundation wall below ground. But if the interior of the excavation is to form a basement or cellar, then inside forms at least will be necessary so that a smooth surface can be given to the concrete while placing.
LAYING OUT FOUNDATIONS

As most buildings are square or rectangular, laying out the foundation is a relatively simple matter. (See Fig. 11.) A stake should be driven where one corner of the proposed building is to come. From this stake a string should be stretched in the direction of one side of the building and to a point where another corner is to fall. For instance, suppose in Fig. 11 one corner of the building is to be located as indicated by the stake A, and another at the stake C. After these two points have been fixed, a string should be tightly stretched from stake A to stake C. Then measure off the required distance from A to B, stretching a string also between these points. When setting stake B, endeavor to locate it so that the string A-B will be nearly at right angles.

Fig. 11.—Method of Laying Out Foundation to Square Corners.
with the string \( A-C \). Now measure off on the string \( A-C \) 8 feet and drive a stake into the ground directly beneath the string at this point. Mark the 8-foot distance by a small brad or nail driven in the top of the stake at \( Z \). Measure off on the string \( A-B \) 6 feet and drive a stake at \( Y \), marking the 6-foot point also on the top of stake \( Y \). The stake \( Y \) may now be shifted slightly, either to the right or left as may be necessary, until the distance between the mark on the top of stake \( Y \) and stake \( Z \) is exactly 10 feet. When this has been fixed, the stake \( B \) can be moved to the right or left as necessary until the string \( A-B \) exactly crosses the mark on top of stake \( Y \). This will make the foundation corner as indicated by the strings \( B-A \) and \( A-C \) a right angle. Other corners can be then squared in the same manner.

Piers that are necessary within the foundation enclosure can be readily located by following similar methods. These strings serve as a guide for the exterior line of the foundation trench.

**DEPTH OF EXCAVATION FOR FOUNDATIONS**

Excavations for foundations should in all cases extend deep enough to reach firm bearing soil and to be below possible frost penetration. If not placed below the level to which frost may enter the ground, heaving may result and this may eventually cause cracking of the construction.
This may mean that the bottom of the foundation or footing must start at a point 3 or 4 feet below ground level.

For light structures, perhaps no footing will be needed, although it is best to provide a footing somewhat wider than the actual foundation wall thickness, as this insures a firm bearing for the load that is to be carried.

Ordinary footings may vary in width from 18 inches to 2 feet or more and from 6 to 12 inches in thickness. For most farm structures it will rarely be necessary to build a foundation wall more than 10 or 12 inches thick, probably the former will be sufficient, unless the building is to be a very heavy one or carry heavy loads. Building walls aboveground will vary from 6 to 10 inches thick, depending on the size of structure. Foundations ordinarily require no reinforcing.

Form construction for the portions of the foundation wall aboveground is simple, and consists merely of panels which are constructed by nailing sheathing boards to 2 by 4-inch studs spaced from 18 inches to 2 or 2½ feet apart, depending upon the thickness of the sheathing and the weight of the concrete. The forms should, of course, be well braced, so as to hold them in true line and enable them to resist the pressure or thrust from concrete while being placed and spaded in the forms.

Where the enclosure within foundation walls is not to be used as a basement or cellar, and hence
need not be thoroughly watertight, a somewhat drier mixture than is described by the word “quaky” may be used for foundation construction; and unless the load to be carried is an extremely heavy one, a 1:3:5 mixture will be suited to that portion of the foundation belowground. Just as soon as ground level is reached, however, the mixture used should be a richer one, preferably a 1:2:4 or 1:2½:4. Concrete should be placed continuously in layers not exceeding 6 or 8 inches thick, and carefully tamped or spaded as placed. A somewhat dry mixture needs thorough tamping; a “quaky” one needs thorough spading but little tamping. Spacers should be removed from inside the forms as fast as concrete is placed up to a level with them. In placing the concrete the layers should continue of uniform thickness all around the foundation enclosure and at a uniform level. This means that the work should not be finished all at once in one place until the forms are filled, unless a stop-board is fastened vertically in the forms to make a vertical joint, and then only for work belowground where such a joint would be no objection. Under no circumstances should more concrete be mixed at one time than can be placed within thirty minutes, and in case any of that which has been mixed commences to stiffen or harden before it can be used, it should not be softened up (“retempered”) by adding more water and remixing it, but should be thrown away.
Retempered concrete will not acquire the desired strength when finally hardened.

If a stop-board has been used to form a vertical joint in the construction, then when concreting is resumed in the adjoining section, this stop can be removed and the concrete previously placed will have so hardened that it will serve as an end form.

Where a certain piece of work cannot be finished in one day, the work at the close of a day should be left with a rough top surface in the forms. Preparatory to placing concrete the following day, the surface of the previous day's work should be well scrubbed and washed off with a broom and water and painted with a mixture of pure cement and water, mixed to the consistency of cream and applied with a whitewash brush. Fresh concrete should at once be placed and will practically unite with the old without leaving a construction seam or a joint. Such a precaution is not necessarily required in ordinary foundation work where the building is not to have a cellar or basement, but if watertightness is desired it is imperative that such a precaution be taken to join two days' concreting.

An admirable service is performed by concrete in the construction of foundations for gasoline engines, cream separators, and similar small machines. For such work excavation should be carried to a sufficient depth to insure a firm bearing and necessary provision must be made when
designing the forms to make a template with holes bored in it in the same relative position as the holes in the machine base, so that bolts can be embedded in the concrete to permit afterward bolting the machine to the foundation. Just how this work is provided for will be seen in an accompanying illustration (Fig. 12).

Fig. 12.—Simple Form for Machinery Foundations.

Some of the principles which must be observed to secure the best results will be briefly mentioned. Carrying capacity is a quality chiefly sought in any foundation, and permanence is a consideration secondary only to strength. The cost of a well-built concrete foundation is considerably less than that of one constructed of any other suitable building material when strength
and durability are considered. Under average conditions, the time required for building a concrete engine or machinery foundation is shorter than that required to build of brick or stone. Concrete is the only foundation material that may readily be adapted to slopes, change of grade or other irregularities in the subgrade on which the foundation is to be placed.

Where soil is reasonably firm, no form will be required for an engine foundation, except for the portion above ground level, as shown in Fig. 12. Consequently the excavation should be carefully made in a manner to prevent caving in of the sides and should not be larger than the size of foundation required satisfactorily to hold the engine or

Fig. 13.—Simple Form for Foundation Construction Belowground.
machine to be placed thereon. The size of the foundation and the corresponding size of the ex-

Fig. 14.—Form Construction for Concrete Wall Aboveground.

Fig. 15.—Method of Tying or Locking Wall and Column Form.

cavation will, of course, be determined by the type and size of engine or machine to be set, and will usually be indicated by instructions for set-
ting the engine, which are furnished by all engine manufacturers. Concrete meets all requirements of rigidity and appearance required in foundations for gasoline engines, cream separators and other stationary machinery.

It is seldom necessary to reinforce concrete engine foundations unless they are to be subjected to excessive side thrusts, vibration, or other unusual strain. Where they extend aboveground some distance, reinforcing is occasionally used in large foundations to counteract the effect of contraction and expansion from temperature changes, but this does not apply to small work.

The safe loading of concrete in foundation construction is as follows:

- 1:2:4 concrete, 47 tons per square foot,
- 1:2½:5 concrete, 41 tons per square foot,
- 1:3:6 concrete, 36 tons per square foot.

(A "factor of safety" of 4 was allowed in computing this loading.)

Engine foundations should be made with sufficient footing so that the allowable pressure upon the soil will not be exceeded. The bearing power of soils varies, and is usually considered to be as follows:

- Ledge Rock 36 tons per square foot,
- Hardpan 8 tons per square foot,
- Gravel 5 tons per square foot,
- Clean Sand 4 tons per square foot,
Dry Clay 3 tons per square foot,
Wet Clay 2 tons per square foot,
Loam 1 ton per square foot.

To avoid spreading, sand must be confined when wet.

Two-inch lumber is to be preferred for the form aboveground although 1-inch boards may be used for small foundations. Notice that the boards are shown extending beyond the form corners. This overreaching is merely to avoid cutting and thus save lumber, as by following this method the lumber may be cleaned, nails removed, and the boards again used for some other purpose.

Anchor bolts of the size specified by the engine manufacturer may be set by the method illustrated. A template should be constructed of straight-grained, 1-inch material, fastened together by screws. Holes slightly larger than the bolts should be bored in the template to conform to the location of the holes in the engine base. The bolts are suspended head downward, from the template, with threaded ends projecting above the template, a distance not less than the thickness of the engine base and nuts to be used. Anchor plates or large washers should be placed over bolt heads to prevent bolts from pulling out of the concrete. Bolt ends projecting above the template should be covered to prevent concrete from touching them when filling the forms. Care should be exercised to keep the bolts as nearly
perpendicular as possible while placing the concrete. When the concrete has partly hardened, the template may be removed and the foundation top finished to a level surface, care being taken not to strike the projecting bolt ends, as the fresh concrete offers but slight resistance. By making bolts 2 inches longer and threading them 2 inches farther from the end, the concrete may be allowed thoroughly to harden before removing the template, which in that case is supported by 2-inch blocks placed on top of the forms, allowing space for finishing the concrete surface under the template. The engine may be placed in position after the concrete has thoroughly hardened, which will require from ten days to two weeks, depending upon weather conditions. The same principles as are described in the foregoing paragraphs apply to setting any other machines.

PRINCIPLES OF REINFORCING AND THE MATERIALS USED

Concrete shows great strength in supporting loads that are placed directly upon it, but it is relatively weak when subjected to strains that tend to pull it apart (see Fig. 16). In some parts or types of construction it is therefore necessary to reinforce the concrete by embedding in it at the time of placing, wires, steel rods or some kind of metal fabric, to increase its ability to withstand pulling strains (tension) and at the
same time obtain full benefit of its compressive strength. Reinforcing also often results in economy of concrete required.

Common types of construction where reinforcing is necessary are fence posts, watering troughs and tanks, beams, columns, large floor slabs, roof slabs, etc.

It is not possible to give a fixed rule that will serve as an invariable guide for determining the

![Diagram](image)

**Fig. 16.**—Illustrating Beam Fracture where Concrete is not Reinforced, and when it is.
amount of reinforcing required for various structures, but as an illustration, it may be said the quantity of reinforcing metal required in beams and roof or floor slabs may vary from \( \frac{1}{2} \) to \( 1\frac{1}{2} \) per cent of the cross-sectional area of the concrete section. More specific illustrations will be given later when describing particular types of construction.

The ratio of concrete's strength in resisting pulling strains (tension) as compared to its strength in supporting loads placed directly upon it (compression) is about 1 to 10. Steel is strong in tension, although rods and wire mesh, which are
the common forms of steel used for reinforcing, will bend easily, and therefore must be placed so as at once to take up the load of tension which may be brought upon the concrete. The ideal position for reinforcing steel is at the surface of the side or face of the concrete member that is to be subjected to tension. As this position is not practicable in practice, the steel must be embedded in the concrete just as near the outer surface where it is to resist tension as possible, and at the same time permit surrounding it with concrete to form a perfect bond or union between concrete and steel. The distance from the surface will sometimes vary in accordance with the size of pebbles or broken stone being used in the concrete mixture.

The side of any concrete member that may be exposed to pulling strains may not always be the same side as is true in a beam, where the lower side is always the one. As an example, take a concrete fence post (Fig. 17). As one cannot tell from which direction the strains may come, a fence post is reinforced at all four corners.

Sometimes a concrete structure may be of such shape and weight that it might crack on account of unstable foundation and unequal settlement; likewise a concrete trough full of water may freeze, therefore the strains of tension would be exerted on all sides of the structure by the expansion of the ice.

To be suitable for reinforcing concrete, steel
should possess certain particular qualities. This means that only steel manufactured to have certain chemical composition and other properties should be used. Generally speaking, the home worker had best confine his choice to some type of round or square twisted bars, or to some one of the woven mesh wire fabrics like those used for fencing, although the type of fabric made for reinforcing is not necessarily intended for fencing. Any attempt to substitute barbed wire, old scrap iron, pipes or similar odds and ends of scrap metal will not result in the same success.

Fig. 17.—Illustrating the Requirements of Fence Post Reinforcement.
and security of construction that will follow using proper reinforcing materials.

Round bars will be found easiest to obtain under most conditions and will be suited to the general run of home concrete work. One should remember that the steel or iron bars which he may be able to obtain from the local blacksmith shop may not have the desired qualities for concrete reinforcement. It will therefore be found best to purchase reinforcing steel from some dealer or manufacturer making a specialty of such material.

There are various types of so-called "deformed" bars used in reinforced concrete work. These are variously shaped in rolling, with the object of increasing the "mechanical bond" between concrete and steel. Most of these, however, are subject to some kind of patent-right control and therefore are higher priced than plain round or square twisted rods. If the concrete is mixed to the right consistency and properly placed there will be a good bond between the concrete and metal, so that there is really no advantage in using any of the deformed types of bars for ordinary concrete construction.

In a beam, floor slab or roof slab, steel must be near the bottom face of the beam or slab. In a wall that is to withstand earth pressure, it should be on the face farthest away from the earth. In a tank that is to withstand water pressure, it should in theory be near the outside (far-
concrete), but in practice it is more convenient in walls that are to withstand earth pressure and walls that are to resist the pressure of water to use a little larger reinforcing or more steel than might really be necessary if it were placed where it theoretically belongs, and to place it near the center of the wall. This makes placing of concrete easier. Whenever plans call for placing reinforcing in a certain position, the plans should be followed exactly. Sometimes walls are designed in which reinforcing is placed near both inner and outer faces.

One strain of tension which is brought upon concrete is the tension due to expansion of the mass under temperature changes, that is, when concrete rises in temperature corresponding to temperature changes of the air, the mass will expand as the temperature rises. Expansion is somewhere in the neighborhood of one inch per hundred feet. Fortunately steel expands at practically the same rate. Therefore, reinforcing steel not only resists the tendency for the concrete to crack, but in expanding with it at practically the same rate, the bond between the steel and concrete is not broken.

Reinforcing steel should be kept clean until used. Any coating of scaly rust or mill scale or a coating of oil will prevent the concrete from forming a good bond with it, hence will prevent the construction from having the strength that might be expected from incorporating the steel.
Whenever reinforcing bars have to be shaped, as in placing them around a corner of a tank, they should be very carefully bent so that the rods will lie in exactly the desired position in the concrete.

Any temporary block supports or stays that are to be used to hold reinforcing in correct position while concrete is being placed should be removed as rapidly as concrete is placed up to them. Both rods and mesh when lapped should be securely wired together. Soft black No. 16 or No. 18 gage wire is tough and pliable and is the common material used for binding or tying together rods and fabric when lapped or spliced.

**CONCRETE WALLS AND FENCES**

Concrete lends itself admirably to the construction of walls and fences, although in the latter class of construction there is a limit to the variety of work which can be produced by the average home worker. Form construction for anything like a fence having the appearance of a wood picket fence is very complicated and placing of the concrete is difficult. On the other hand fences which are essentially a post-and-rail combination are simple, as they represent unit construction; that is, the posts and rails are cast separately and the units afterward erected in just about the same manner as a wood post and rail fence would be set up (see Fig. 18). Considering the time element, however, such classes
of concrete fences would better be replaced by some one of several types of light panel wall construction. The form system shown by Figs. 9 and 10 is very adaptable to panel fence or wall construction.

In the post and rail fence (Fig. 18) posts are square and reinforced with $\frac{3}{8}$-inch rods, placed three-quarters of an inch from each corner. The "rails" are 2 inches thick and 6 inches wide, reinforced with two $\frac{1}{4}$-inch rods, running the entire length one inch distant from each edge. Posts should be made of a $1:2:3$ mixture, in which the large aggregate, that is, pebbles or broken stone, is not larger than $\frac{3}{4}$ inch in greatest di-

Fig. 18.—Post-and-Rail Type of Concrete Fence.
mension, while the rails should be made of a 1:2:3 mixture containing a uniformly graded aggregate ranging from the finer particles up to \( \frac{1}{2} \) inch in greatest dimension.

The particular disadvantage of a unit post and rail fence of this kind is that the different members must be thirty days old before they can be set in place, that is, they should be allowed to harden that length of time before being used, and as the "rails" should be left in the molds for a day or two before handling, this requires a large quantity of molds and considerable facilities for properly storing the units until used.

In the various types of panel wall or panel fence construction, the concrete is cast in place. Ordinary panel forms can be used and these may be removed usually within 24 hours after placing the concrete, thus not many forms are required. In Figs. 19, 20 and 21 the design represents a wall section 3 inches thick with triangular mesh fabric for reinforcement. The posts are cast in place and are of such shape (Fig. 19) that when
the panels are cast, they interlock with the posts. Concrete for such construction as this should be

![Image of concrete construction](image)

**Fig. 20.—Construction Illustrated in Fig. 19 in Process.**

a 1:2:3 mixture in which the coarse aggregate does not exceed ¾-inch in size.

In another design (Fig. 22) is shown a post and
Fig. 21.—Construction Illustrated in Fig. 19 in Process.
panel construction in which the posts are also cast in place, with a recess in two faces that will permit the wall panels to enter when they are subsequently cast. Wall panels rest on a foundation which is 10 inches wide and 18 inches deep, vertical rods being placed in this foundation (Fig. 23) so as to lap with the vertical rods in the wall panels. Posts may be of any desired dimension, but in this particular instance are supposed to be

10 inches square, reinforced with $\frac{1}{2}$-inch or $\frac{3}{8}$-inch rods, placed $1\frac{1}{2}$ inches from the outer face at each corner. The height may be varied as desired.

Panels are 16 feet long and 4 inches thick and reinforced with rods $\frac{1}{2}$ inch in diameter, placed 18 inches apart center to center, both vertically and horizontally, being assembled as a sort of lattice before being raised in position and well wired together where they intersect or cross (see Fig. 23). Enough forms should be provided for

![Diagram](https://example.com/diagram.png)
CONCRETE ON THE FARM AND SHOP 79

Fig. 23.—Various Details of the Construction Illustrated in Fig. 22.

Fig. 24.—Various Details of the Construction Illustrated in Fig. 22.
Fig. 25.—Various Details of the Construction Illustrated in Fig. 22.

Fig. 26.—Various Details of the Construction Illustrated in Fig. 22.
such construction to accommodate one day’s placing of concrete, then on the following day the forms first used the preceding day can be removed and placed ahead for commencing the day’s work, this operation continuing as concreting proceeds during the day. Figs. 24, 25 and 26 show details of the work.

A 1:3:5 mixture will be suited for the foundations for panels, although it may be just as convenient and in the end as economical if a 1:2:4 mixture is used throughout rather than go to the trouble of preparing and using two different concrete mixtures. Posts should be of a 1:2:4 mixture throughout.

FENCE, GATE, CLOTHES-LINE, AND GRAPE-ARBOR POSTS

Owing to the increasing scarcity in many sections of the country of wood suited to fence posts, one of the most timely uses of concrete on the farm is for fence posts. When one realizes the expenditure of time and labor necessary to keep a fence in which wood posts are used in proper repair, it is not surprising that concrete posts should have gained in popularity during recent years. Wood posts, especially those that are most desirable, have advanced in price until in most sections of the country they are just as expensive as concrete posts, with the latter in greater favor because being fireproof and rotproof. The
life of a cedar post under the most favorable conditions cannot be expected to exceed 15 years. Concrete posts properly made should have an almost unlimited life; and where good sand and gravel can be obtained on the farm or nearby, they can in some instances be made for less than a good cedar post now costs.

**POST MOLDS**

If a large quantity of fence posts is to be made it will well pay the home worker to purchase some one of the several types of commercial fence post molds. But it is very easy to make a home-made mold (see Fig. 27) that will answer admirably for concrete post making during spare hours.

![Fig. 27.—Home-made Gang Mold for Concrete Fence Posts.](image-url)
Commercial molds are usually of sheet steel and, taking all types into consideration, are manufactured so that concrete posts can be made of almost any shape desired—round, square, rectangular and semi-elliptical, and both straight and tapered. Choice of size and shape is largely a matter of individual preference, although for general line-fence purposes no post should be smaller than 3 by 3 inches at the top and 4½ by 4½ inches at the bottom, this for a length of 7 feet. In fact, it will be found perhaps easier to make a post 3½ or 4 inches square at the top and 5 inches square at the bottom, these dimensions being of advantage in facilitating the proper placing of reinforcing—one of the most important details of fence post manufacture.

**MIXTURES FOR FENCE POSTS**

Although concrete line fence posts have been made out of a mixture consisting of 1 part of cement and 3 parts of well-graded sand in which the particles ranged from the finest permissible up to ¼ inch, such a mixture will not ordinarily give a post of as great strength as a properly proportioned 1:2:3 mixture in which the coarse aggregate (pebbles or broken stone) consists of particles graded from ¼ up to ¾ inches. A 1:2:4 mixture for fence posts has often been recommended, but as the home worker is not always careful uniformly to grade his materials the
1:2:3 mixture compensates in a measure for possible neglect in this respect and therefore is a safer mixture to use.

**COST OF CONCRETE POSTS**

A rectangular post of average size may range in price from 20 to 35 cents, but will probably average around 24 or 25 cents. These figures are based on the assumption that all materials must be purchased, and that Portland cement will cost $2 per barrel, sand and gravel $1 per cubic yard, and reinforcing steel 2½ cents per pound. The farmer rarely need buy sand and gravel, and in many instances can obtain cement for less than $2 per barrel, so the cost can often be reduced. More than one farmer has found it possible to turn out standard size concrete fence posts for 19 cents each. Probably the cost may safely be estimated as never likely to exceed the highest figure previously mentioned and quite often may be below the lowest figure.

**REQUIREMENTS OF REINFORCING**

Many persons have a false impression of reinforcing requirements for concrete fence posts. Some have made posts with a single rod running through the center, thinking that if this one rod contained the same amount of steel as four smaller rods spaced near the surface at each corner, the result would be the same.
If a preceding explanation of the principles of reinforcing has been understood, one can see that the single rod at the center of the post does not accomplish the desired purpose. When set in place, a fence post may be subjected to strains or shocks from any direction. If the wires are tightly attached, it certainly may receive pulls from either direction along the line of the fence, as well as shocks or blows from inside or outside the enclosure, due to animals attempting to get into or out of the pasture lot. These possibilities must be anticipated, and the only way to do so successfully is to place suitable reinforcement near the face at each corner of a square or rectangular post, and in a circular post place the reinforcing at points corresponding to four corners of a square post and as near the surface at the circumference as possible, yet far enough away to permit surrounding the rods with concrete.

MATERIALS FOR REINFORCING

Another false impression often entertained is that almost any kind of scrap wire, even barbed fence wire, will serve as post reinforcing. While it is possible to place reinforcing in the form of wires in a fence post so that the amount of metal would correspond to that obtained by properly placing \( \frac{1}{4} \)-inch round rods, nevertheless, the inconvenience of handling wire makes it almost certain that when the post has been finished, the rein-
forcing metal will not be in proper position in the concrete, therefore will not accomplish the desired results. All of the kinds of wire commonly recommended or suggested for reinforcing are far more difficult to handle in placing than are straight rods. Reinforcing wire usually comes in coils and it is very difficult to straighten it so that it will lie in the proper plane while placing concrete. Greater economy of time and much more certainty of successful results follow the use of suitable steel rods.

An accompanying table will be of considerable assistance to the concrete worker in enabling him to choose suitable dimensions for his posts and the necessary reinforcing. This table also gives the volume of various size posts in cubic feet, the approximate weight each in pounds, and the quantity of materials required for ten posts of various dimensions, made of a 1:2:3 mixture.

Referring again to the desirability of making fence posts of a 1:3 cement-sand mixture, one can see by examining the table that for 7-foot posts 5 inches square at the bottom and 3 inches square at the top, one barrel of cement will be a little more than sufficient to make fourteen posts, while if a 1:2:3 mixture is used, the same quantity of cement will make twenty posts of the same size. Hence there is economy in the 1:2:3 mixture, equalling very nearly 33\(\frac{1}{3}\) per cent.

Most of the commercial fence post molds are relatively inexpensive, yet if a person does not
<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>1-Cement, 3-Sand</td>
</tr>
<tr>
<td></td>
<td>No. Posts per Bbl. Cement</td>
</tr>
<tr>
<td></td>
<td>For 10 Posts</td>
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<tr>
<td>(1)</td>
<td>(2)</td>
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<tr>
<td>6' 6''</td>
<td>3'' x 3''</td>
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<tr>
<td>7' 0''</td>
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<tr>
<td>7' 6''</td>
<td>3'' x 3''</td>
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<td>8' 0''</td>
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<td>6' 6''</td>
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<td>7' 0''</td>
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<td>7' 6''</td>
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<td>6' 6''</td>
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<td>7' 0''</td>
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<td>7' 6''</td>
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<tr>
<td>8' 0''</td>
<td>5'' x 5''</td>
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</tbody>
</table>
desire to make the expenditure necessary to secure such equipment, the home-made mold shown will answer all purposes admirably. Such a gang mold can be made to make a post of any desired dimensions, and of any capacity up to the limit of floor space or bottom board used to rest the mold on.

Sides and ends of molds are held in place by blocks and wedges. After the concrete has been in the mold 12 hours, wedges can be knocked out so that sides, ends and partitions may be removed, then the posts allowed to remain undisturbed on the pallet or bottom board until they have become strong enough to handle without possible injury. One-inch lumber will be suited for the ends and interior strips of such a mold, but 2-inch stock should be used for outside pieces. Before being used the entire mold must be protected from warping by painting with two coats of boiled linseed oil and kerosene, equal parts of each, which will also prevent the concrete from sticking to the mold. Molds should be well cleaned after use and oiled before each filling.

**PLACING CONCRETE AND REINFORCING**

After having placed three-quarters of an inch in the bottom of the mold the two reinforcing rods for that side are laid in proper position, then additional concrete placed until within about three-quarters of the top, when the two remaining re-
inforcing rods are pressed into proper position in the concrete and the mold filled level. Concrete for fence post manufacture should be mixed a little wetter than quaky consistency, so that it will settle to all parts of the mold with little stirring or puddling and completely surround and bond with the reinforcing. It is very important that concrete fence posts be dense, and added density is secured by jarring or rapping the mold in some manner so as to release air bubbles which may be in the concrete mixture and thus prevent resulting air pockets in the finished post. Some of the commercial fence post mold outfits are used in connection with a vibrating table to jar the concrete, thus making it dense and compact. If the home worker does not find it feasible to arrange his gang mold on some support so that the mold can be vibrated or shaken while the concrete is being placed, then it is well to take a stick or a rod and stir the concrete gently along the form faces to release air bubbles, and to tap the mold while placing concrete.

SPACERS FOR REINFORCING

To hold reinforcing rods in correct relative position when placing them in the concrete, it will be found advantageous to take some small pieces of No. 16 gage wire and twist it as shown in Fig. 28 so that loops are formed around the rods. They will thus be held at the desired separation in the mold while placing concrete.
If concrete is placed at proper consistency, jogging the mold will result in a smooth, dense surface on the post and cause a perfect bond or union between the concrete and the reinforcing. One must be careful not to use too much water for fence post mixtures. The concrete should not be slushy nor soupy, as that will cause the sand-cement mortar to separate from the pebbles, and when the post has thoroughly hardened there will be pockets in the concrete—possibly some of the reinforcing steel may be exposed.
HARDENING THE FINISHED POSTS

Posts must not be allowed to dry out quickly. They must be protected from drying wind and sunlight and should be covered with wet straw or chaff, which should be kept wet for a week or ten days before attempting to store them anywhere out of doors. If they have been made under usual summer weather conditions it will be safe to lift them from the floor or bottom support of the mold within 36 hours after placing the concrete. Extreme care, however, should be used in handling them, as cracks will affect the strength of the finished post. Posts may be carefully piled in some convenient shed (not corded up, however, in piles one on top of the other, but spread out on an even support so that the protective wet chaff covering may be kept over them) until hardening has progressed sufficiently to permit moving them out of doors to complete hardening naturally. Here they may be set up on end, resting against a building or a wall, and by the time they are 30 days old, they will be in good condition to set in the fence line.

FASTENING LINE WIRES

Numerous suggestions have been made as to the best way of fastening line wires to concrete fence posts. Some advocate inserting wood or metal pegs in the concrete at the time of placing,
then withdrawing these pegs when the concrete has stiffened, leaving a small hole entirely through the post to receive a tie wire, the ends of which are wrapped around the fence wires. Other methods have consisted of embedding eyelet fasteners in the concrete, or embedding small bolts with loops at one end in the same manner. Holes in the post, no matter how small they may be, tend to weaken it. Eyelet fasteners will eventually rust off. By far the simplest method that has been used consists of tying the fence wire to the post by means of a loop of wire passed around it on three sides using the ends which project at the back of the post to wrap around the line wire, exactly as telephone or telegraph wires are fastened to the glass insulators on poles.

**CORNER POSTS**

Concrete corner posts on account of the strains to which they are subjected must, of course, be larger than line posts (see Figs. 29 and 30). Depending upon the length of the fence stretched from them, the size required may vary within a considerable range. Corner posts may be from 6 inches square up to 10 or 12 inches square; and the amount of reinforcing required will depend upon the strain to which the posts are to be put and therefore upon their square dimensions. In a 6 by 6 or 7 by 7 post there should be four rods at least \( \frac{\sqrt{2}}{16} \) of an inch in diameter.
A 10 by 10 post should have four $\frac{3}{8}$-inch rods; a 12 by 12 post, four 1-inch rods.

On account of their weight and the consequent inconvenience of handling, corner posts larger than 8 inches square are usually cast in place; that is, a hole is dug in the ground, rods properly placed, concrete deposited to ground level, and the form set right up in position, properly braced where the post is to stand, and the concrete placed in the form from the end. Reinforcing rods should extend from the bottom of the foundation right up through the post. When the earth is firm there will be no need to use a form for the part that is to be underground; if not firm, it is best to build a form for the entire post,
that is, for both the portions below and above ground. The portion belowground had best be

of larger square dimensions than aboveground, for stability.

Fig. 30.—Corner Post with Brace Cast Monolithic with it.
BRACES FOR CORNER POSTS

Sometimes corner posts complete with braces are cast as one piece as in Fig. 30. Form construction will readily suggest itself. Of course, the brace also must be suitably reinforced with rods in each corner, of proper size.

GATE POSTS

Gate posts or entranceway posts are also massive and are cast in place the same as heavy corner posts. If subjected to strains of fence stretched from them they must be braced. Likewise, reinforcing rods must be chosen as regards size with reference to the size of post and the load or stains to which it is to be subjected, such as heavy, swinging iron gates, and fence stretched from them. The reason why reinforcing must extend down below ground level in corner and gate posts is to resist the possibility of their breaking at ground level under severe strains or load.

FORMS FOR GATE POSTS

Form construction for entranceway or gate posts is simple or complicated, depending upon the design which it is intended to execute. Usually such posts are made square or round. In the latter case a very convenient way of making the form is to use a section of old metal smoke-
stack of the required diameter, first cutting this down the entire length so that after concrete has been placed, the form can be removed. Wires or other fastenings will have to be wrapped around this form after it has been cut to prevent it from spreading open while concrete is being placed.

**RUBBLE CONCRETE POSTS**

Another and easy way to construct entrance-way or gateway posts consists of using rubble stones or field stones ranging from 3 to 5 inches in diameter. Such stones are selected so that they will form a pleasing arrangement on the exposed face of the work when forms are removed. They are laid around against the inside of the form as shown in an accompanying sketch, Fig. 31, a 1:3 cement mortar being used to bed them. Then a quaky 1:2:4 concrete mixture is used to fill in the center. Work should be done so that concrete is placed in layers no greater than 6 inches at a time. Proper reinforcing must be used and placed a little back of the stones. Rubble stones must be wet when placed so that the concrete will bond to them. A concrete cap can be cast separately and placed on the rubble construction later if desired, or the forms can be so built that this cap will be monolithic with (a part of) the remainder of the work.

After forms have been removed the surplus mortar in the joints between stones should be
picked back slightly and any mortar adhering to the face of the stones washed off with a stiff

![Diagram of Concrete Gate Post]

Fig. 31.—Sketch Showing Method of Constructing a Rubble Concrete Gate Post.

brush and water. The appearance should be as in Fig. 32.
Fig. 32.—Appearance of Finished Rubble Work.
Provision should be made while placing concrete to embed necessary fittings for hanging the gates. Hangers should be threaded on the end that is to be placed in the concrete and a nut be passed over the threads so as to prevent the hangers from pulling out when gates are hung.

Corner posts and gate posts must also be made of a quaky concrete. While the concrete is being placed in the forms, a long-handed spading tool should be used to spade the concrete next to the form face (except in rubble work) so that there will be a smooth, dense surface free from stone pockets when forms are removed.

CLOTHES-LINE POSTS

Concrete posts from 9 to 10 feet long make durable and practical grape arbor and clothes-line posts (see Fig. 33). They need reinforcing the same as do other concrete posts and the quantity of metal required depends upon the square dimensions of the posts and the loads or strains to which they are to be subjected. They should be of a 1:2:3 mixture. Wires upon which to train vines or hang clothes may be attached in the same manner as fence wires are attached to line fence posts, but usually short pieces of iron rod are embedded near the top of clothes-line posts and in grape-vine posts wood plugs are inserted in the soft concrete while placing and these plugs withdrawn when the concrete has
Fig. 33.—Clothes-line Posts of Concrete.
stiffened, thus forming holes through which wires may be strung, or if posts are to form an arbor, then the wood plugs may be left in the concrete and be used as nail holds when attaching wood slats. What has already been said as regards subjecting fence posts to pulls and strains until after they are a month old applies also to grape arbor and clothes line posts. They should be protected against too rapid drying by being covered with wet straw, hay, or similar covering, and sprinkled often enough to keep them moist.

CONCRETE TANKS

Among the various classes of concrete construction which may be considered as coming under the heading of tanks are hog wallows, watering troughs, feeding troughs, manure pits and cisterns. All these require that the construction be watertight. This makes a 1:2:3 mixture preferable, although if one can be certain that the materials are properly proportioned and uniformly graded throughout, a 1:2:4 mixture may accomplish the desired results. However, the first mentioned mixture is safer and is recommended. Small troughs or tanks such as are to be used for hog feeding or watering (see Fig. 34) can very readily be cast upside down (see Fig. 35) on some smooth level surface like a barn floor and when the concrete has properly hardened forms can be removed and the con-
Fig. 34.—Small Portable Hog Feeding Trough Cast Upside Down.

Fig. 34a.—Another Portable Type Trough also Cast Upside Down.
crete protected for a week or ten days by a moist covering. Then the trough may be set up where intended to use it.

**REINFORCING SMALL TROUGHS**

Poultry netting or similar fabric can often be used for reinforcing small troughs in place of rods. Sometimes a combination of both is used and desirable. Fig. 35 illustrates clearly how the forms for such construction are made and set up. No further explanation should be necessary.

**STOCK TROUGHS**

Large stock watering troughs on account of their bulk and weight must be constructed at the point where they are to be used. For the same reason it is quite essential that
a suitable foundation be provided for them, otherwise unequal settlement of the ground will most likely result in causing the concrete to crack, owing to the strains put upon it not only by the weight of the structure itself but also the weight of contents. Construction like that involved in large tanks, troughs, cisterns and manure pits makes it impossible to lay down invariable rules as to how such structures shall be reinforced.

![Diagram of Concrete Watering Trough or Tank](image)

**Fig. 36.** Concrete Watering Trough or Tank.

This depends entirely upon its size and consequently upon the weight of contents which it is to carry. Illustrations show a stock watering tank (Fig. 36), a small concrete trough (Fig. 35), cistern (Fig. 39), and hog wallow (Fig. 40) and manure pit (Fig. 41). All of these belong essentially to the same class of construction. Reinforcing required for the stock watering tank of the dimensions shown (Fig. 36) is specified in the drawing. For the other structures, reinforcing will depend on the size of the structure. For the
Fig. 37.—Finished Tank Similar to that Illustrated in Fig. 36.

Fig. 37a.—Concrete Cistern Built Partly Aboveground.
cistern, if 6 feet square and 8 feet deep, probably \( \frac{1}{4} \) or \( \frac{3}{8} \)-inch rods 12 inches center to center will be sufficient. For the small trough use \( \frac{1}{4} \)-inch rods and 1-inch poultry netting.

**WATERTIGHTNESS. HOW SECURED**

As tanks and cisterns must be watertight to accomplish the desired purpose, one should, before commencing work, have all materials on hand ready for use, forms properly constructed and in place, so that work may proceed continuously, if possible, thus preventing seams or construction joints that would later open up and cause leakage. If, however, it becomes necessary to suspend work after concreting has started, then the surface of concrete in the forms should be left
rough, and when concreting is to be resumed this surface should be well brushed and washed with water, painted with cement and water mixed to the consistency of thick cream and applied with a whitewash brush and concreting resumed immediately; that is, before the cement grout paint has had a chance to commence hardening.

In stock watering troughs, cisterns and similar structures where the floor is constructed monolithic with the sides, it is desirable that the reinforcing of the floor extend up into the sides, thus forming vertical reinforcing for those portions of the structure. So the rods must then be bent to the shape of three sides of a square or rectangle depending upon the shape of the structure. Horizontal rods must be tied to vertical rods with wires where the two intersect, so that all reinforcing will be held in correct relative position while concrete is being placed.

DETAILS OF PLACING CONCRETE FOR CISTERNs, ETC.

Concrete used for cisterns and similar construction, however, should be of quaky consistency, therefore it is sometimes difficult to construct the side walls and floors monolithic. Hence it is easier to build floor and walls separately. In such a case, the walls should start in a trench that has been excavated deep enough to be below possible frost penetration. After the walls are
finished and concrete has hardened sufficiently to permit removing the forms, then the bottom or floor of the structure can be placed. The earth should be excavated to a depth sufficient to secure a firm foundation and if necessary there should be placed a fill of clean gravel or cinders well tamped up to the bottom of the proposed floor level. On top of this concrete from 4 to 6 inches thick for the floor can be placed. If the area does not exceed 100 square feet or if no one dimension of the floor exceeds 10 feet, it is not likely that reinforcing will be needed in the floor when placed separate from the walls and in one continuous concreting operation.

Before commencing to lay the concrete floor, a $\frac{1}{2}$-inch board strip should be placed all around the inside of the walls, the top of this strip being at the top of the proposed floor and held away from the side walls by $\frac{1}{4}$-inch wedges. These wedges will when released after the concrete floor has hardened make it possible easily to withdraw the wood strips. Then the space so made should be filled with hot tar or asphalt effectively to seal the joint against leakage.

**PROTECTION WHILE HARDENING**

Like all other concrete construction, tanks, troughs and cisterns must be protected against too rapid drying out. They should not be put into use until they are at least a week or ten days
old, and during this time the structure should be kept covered with wet canvas, burlap or straw, so that sun and wind will not cause rapid evaporation of water from the concrete and thus result in a porous structure. If such protection is not afforded for a week or ten days, then no matter how well the materials may have been proportioned and placed, the resulting structure cannot be expected to give as good satisfaction as would result were all necessary precautions taken.

Cisterns are sometimes constructed either entirely or partly aboveground. The one shown in the accompanying drawing may be constructed entirely belowground or entirely aboveground or partly aboveground. In the first case the walls may be uniformly 8 inches thick throughout because protected below the ground the contents of the cistern are not likely to freeze, therefore there will be no pressure caused from ice. If, however, the structure is partly or wholly aboveground, then the walls must be battered or sloped on the inside so that the pressure resulting from water freezing will be counteracted. This precaution must also be taken with the stock tank described; reference to the drawing will show that this batter has been provided for in the design.

Where entirely belowground, the cistern floor may commence at the same level as do the side walls. Fig. 37A shows how one of these structures would appear if partly aboveground and intended to receive its supply of water from the
roof of an adjoining structure. If the structure is built entirely aboveground, of course, both inside and outside forms will be necessary. But any portion of the cistern structure belowground can be built with inside forms only, if the earth is carefully excavated and firm enough so as to be self-sustaining. Care must be taken, however, when placing the concrete in the trench not to

Fig. 39.—Sectional View of Concrete Cistern.
knock down any earth that would thus become partly mixed with the concrete and result in porous and consequently leaky pockets in the wall.

**POSITION OF REINFORCING IN TANKS AND CISTERNS**

Theoretically reinforcing should be near the outer face of the wall for an aboveground structure, but it will be effective if placed at the center, and in such position will make it easier to place the concrete and spade around it in the forms next to the form face so as to produce a smooth, non-porous surface.

In all tank and cistern construction, or similar construction, when it is necessary to lap horizontal rods, laps should be made at the center of a side, never near or at a corner. Rods should be lapped from 50 to 60 times their diameter. In the case of ⅛-inch rods, this means not less than 12 inches. In the case of ¼-inch rods, this would mean not less than 25 inches. When mesh fabric is lapped the ends and edges must be well wired together.

**BUILDING COVER SLAB FOR CISTERN**

In setting the vertical rods to reinforce the cistern walls they should be at least 2 feet longer than required so that the projecting ends may be bent over and finally become a part of the reinforcing for the roof or cover slab. After walls
and floor have been concreted and the concrete floor has sufficiently hardened, a wood floor can be constructed level with the top of side walls to serve as a form on which to lay the cover slab. This slab would be 6 inches thick. A frame should be placed at the proper place on this floor to provide for the manhole opening in the roof or cover slab. This frame is nothing but a bottomless box with its edges sloping inward so that the resulting manhole opening in the slab will have a beveled edge to receive a correspondingly shaped concrete manhole cover. This cover can be cast in the manhole opening in the concrete, by lining this opening with building or tar paper to prevent the concrete from adhering to that of the cover slab. An eyebolt fitted with a ring should be embedded in the cover slab at the time it is cast to permit removal of the cover as occasion requires.

**WATER CONNECTIONS**

In tank and cistern construction suitable provision must be made when setting up forms to arrange for the necessary inlet and outlet for water supply and overflow.
FORM REMOVAL

Forms supporting the roof or cover slab of the cistern should not be removed until the concrete is at least two weeks old. This applies if the work has been carried on under favorable weather conditions. In cold weather it may be necessary to leave forms in place even twice as long.

PAVEMENT AROUND WATERING TROUGHS

All stock watering troughs should have a concrete pavement laid around them so that the vicinity will not be worked up into a mudhole when stock go to water. Directions for laying pavements will be given later. (Circular tanks have not been described because form construction is somewhat difficult. Usually commercial silo forms are best for such structures.)

HOG WALLOWS

In constructing a concrete hog wallow (Figs. 40 and 40A) a trench should be excavated so that the side walls will extend below frost level, then bring the walls up to slightly above ground level. Afterward the interior of the enclosure should be excavated and the ground firmly compacted so as to make a good foundation for the floor, which should be laid in the same manner as described for the cistern floor, except that one
Fig. 40.—Section of Concrete Hog Wallow.

Fig. 40a.—Concrete Hog Wallow in Course of Construction.
end should slope upward so as to be at a level with the top of the wall, thus making an incline for animals to enter and leave the wallow easily. The surface of this incline should be corrugated with grooves so that hogs can readily secure a firm foothold.

REGULATING VALVE FOR CONTROLLING WATER SUPPLY

It is well to make provision for a separate but adjoining chamber in which there is some kind of valve mechanism similar to that used in flushing water closets so that by connecting a pipe line to a source of water supply the amount of water in the wallow can be automatically maintained at the level desired. There should be an outlet arranged in the wallow so that when occasion requires the wallow can be drained and cleaned out. This means that it will be preferable to select a slight elevation as a site for the wallow, so that the drain leading away from the trap in the bottom will readily draw off the contents.

MANURE PITS

Manure pit walls may be made straight or battered inside. Probably the battered wall is best, inasmuch as it permits compacting the manure more solidly in the pit. The batter should be at the rate of 1 inch for every 4 inches of height.
The top of the walls should extend at least 6 inches aboveground so that surface water will not wash into the pit during rains. The floor of the manure pit need not be more than 3\(\frac{1}{2}\) feet below the top of the side walls, as it is not advisable to store manure more than 3 feet deep. Six inches will be a suitable thickness for the floor and this should be laid so that an upward slope at one end will permit backing a wagon into the pit for loading. Floors for manure pits must be properly reinforced and the concrete placed continuously to prevent joints.

Every manure pit should have as an adjunct a small cistern connected to it by a pipe drain so that liquids from the manure may drain into the cistern. A 1:2:4 concrete will be suited for manure pit construction throughout, although the adjoining cistern should be of 1:2:3 concrete.

Manure pits should be planned in size to accommodate the herd of stock for which they are to provide manure storage. If ten head of stock are to be kept the manure pit should be about 32 by 19 feet and have an adjoining cistern 3 by 5 feet. For twenty head the pit should be 32 by 32, with a 5 by 5-foot cistern. For thirty head, 50 by 32 feet, with an 8 by 5-foot cistern. For forty head, 65 by 39 feet with a 9 by 6-foot cistern. For fifty head, 82 by 39 feet, with a 10 by 7-foot cistern. As flies find a convenient breeding place in manure piles it is always advisable to house a manure pit with studding (see Fig.
41) and attach fly screen wire to these studs to prevent flies from using the manure pile as breeding headquarters. The pit shown however, is not screened; and being built entirely aboveground cannot be loaded from so easily as if arranged for backing in a wagon.

REPAIRING CRACKS IN TANKS, CISTERNS, ETC.

If properly constructed, stock watering troughs, tanks, cisterns and similar receptacles will not crack. Sometimes, as a result of neglecting a requirement of construction, cracks appear in the
concrete. If these are simply due to omitting proper precautions when joining one day’s work to the next, they can often be satisfactorily repaired to prevent leakage by the following method:

The cracks should be cut out so as to form a V-shaped groove, say 1\(\frac{1}{2}\) inches deep and about an inch wide at the surface. After being thoroughly cleansed out by brushing and washing, then allowing to dry, this groove may be calked with oakum soaked in tar so that about one-half of the depth of the groove is thus filled. Then the remainder should be filled with a plastic mixture consisting of pine tar and Portland cement combined in proportions so as to make a paste as stiff as can be conveniently plastered into the groove. This mixture may harden slightly while being used but can be kept soft enough to work with by subjecting it to moderate heat in the metal receptacle in which mixed.

Where cracks are due to insufficient reinforcing or to lack of reinforcing, the repair method suggested will be of little or no avail. The only thing that can be done with the tank is to use it as an inner or outer form and deposit a new shell of concrete inside or outside of the old structure. This may be from 2 to 4 or more inches thick, depending upon a number of conditions; and to prevent a recurrence of the cracking this shell should be properly reinforced.
REMEDYING A POROUS SURFACE BY PLASTERING

If as a result of improper mixtures or improper handling, there are porous spots in the construction through which contents leak, the whole interior of the tank may be given a cement plaster coat that, if properly applied, may remedy the trouble. Preparatory to applying this plaster coat, the surface to be treated should be thoroughly cleansed by scrubbing with a good stiff brush and water, or better still, wash the surface with a solution of 1 part of commercial muriatic acid to 3 or 4 parts of water, allowing this to remain for a few moments and then thoroughly rinse off the surface with clean water. The acid treatment removes the cement coating from the particles of sand and gravel, thus exposing clean surfaces to which the cement plaster will more readily bond or adhere.

APPLYING THE PLASTER COAT

Immediately before applying the plaster, the cleansed surface should be painted with a paint of cement and water mixed to the consistency of cream. This can be applied with an ordinary whitewash brush, but should not be applied very far in advance of the plastering, otherwise it will have commenced to harden and the plaster will not unite with it.
Plastering mortar should be mixed in the proportion of 1 part cement to $1\frac{1}{2}$ or not more than 2 parts of sand. No more mortar should be mixed than can be used within thirty minutes as once it has commenced to harden it will be worthless. Mortar can be applied with a steel trowel and the surface should be subsequently worked thoroughly as soon as possible with a wood float to make a dense impervious coating. Final smoothing may be done with a steel trowel, but one should be very careful not to overtrowel, as this will impair the quality of the coating by drawing a film of cement to the surface with water, thus robbing the mortar coat of uniform distribution of cement throughout. After having finished plastering the surface must be protected from too rapid drying out by being kept wet for several days so that the plaster coating will thoroughly and uniformly harden. The foregoing methods apply also in practically all cases where cement mortar is to be used as plastering on an old surface.

**APPLYING WATERPROOFING CHEMICALS**

Sometimes the porous nature of concrete in tanks and cisterns due to improper protection while hardening, can be remedied by applying a coating of what is called "waterglass"; this is chemically known as sodium silicate. The chemical is dissolved in water in the proportion of 1 part silicate to 3 or 4 parts water, depending
upon the porosity of the concrete to be treated. Two or three coats of this solution applied at intervals of 24 hours may be necessary to fill up the pores. Effectiveness of this method depends upon a chemical combination between the silicate and the alkalies present in the concrete, resulting in the formation of an insoluble compound; that is, one that water will not dissolve.

**CONCRETE HOTBEDS**

An admirable use for concrete is in constructing hotbeds (see Figs. 42 and 43). In the past farmers and vegetable growers have been in the habit of building these structures of wood, which being always in contact with the soil is subjected to alternate dry and moist conditions that contribute most to rapid rot. Concrete solves the problem of permanence, and hotbed construction represents about as easy an application of concrete as can be made.

A $1:2\frac{1}{2}:4$ mixture of quaky consistency will be suitable. Forms will be necessary only for that portion of the walls aboveground provided the earth trench is in firm soil so that the sides do not cave. As soon as concrete has been placed to ground level the forms for the structure aboveground must at once be set in position and concreting continued so that there will be a perfect bond formed between the wall belowground and that aboveground.
**Fig. 42.**—Sectional View of Concrete Hotbed.

**Fig. 42a.**—Hotbed Form Construction for the Walls Aboveground.
If the bed is not larger than 5 or 6 feet wide and 10 or 12 feet long, no reinforcing will be needed except one \( \frac{3}{8} \)-inch rod bent at right angles in each corner at the lower (front) side of the bed and two rods in each corner bent

**Fig. 43.—A Finished Concrete Hotbed.**
similarly in the back corners of the bed. These rods should lie along the center line of the wall, two feet around corners. Four-foot rods are therefore necessary. This will prevent possible cracking at corners due to temperature changes.

Whenever hotbeds are to be built longer than 25 feet, it is advisable either to provide an expansion joint in the walls to prevent cracking due to temperature changes or to reinforce the wall throughout its entire length so as to counteract the strains of expansion.

When laying up the back walls of hotbeds, arrangement should be made to embed carriage bolts or some kind of fittings in the concrete so that the sash hinges may be readily attached. Hotbeds and cold frames are alike as regards concrete construction, the difference simply being in the manner in which the seed bed is prepared and whether the resulting structure is covered with glazed sash or with cheese cloth. It is a very easy matter to embed rods in the walls so that wires can be attached to these and cheese cloth coverings hung over the bed to counteract the effect of strong sunlight which under certain conditions is often injurious to tender plants under glass.
The subject of concrete roofs is a broad one and cannot be covered thoroughly in the limited space of this booklet. Flat slab roofs are the simplest type to construct. Inasmuch as slab thickness and the amount and spacing of reinforcing must vary in accordance with the span to be covered, the best method of suggesting requirements will be by presenting a number of tables.

Table I shows the thickness of roof slabs in inches for various spans between walls.

Table II shows the recommended spacing of reinforcing rods in inches for the spans listed.

Table III shows quantities of cement, sand and stone for various slabs.

**TABLE I**

**THICKNESS OF ROOF SLABS IN INCHES**

<table>
<thead>
<tr>
<th>Width in Feet Between Center Lines of Walls</th>
<th>Length of Roof in Feet Between Center Lines of Walls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 Ft.</td>
</tr>
<tr>
<td>4 ft.</td>
<td>2 in.</td>
</tr>
<tr>
<td>6 ft.</td>
<td>2½ in.</td>
</tr>
<tr>
<td>8 ft.</td>
<td>3 in.</td>
</tr>
<tr>
<td>10 ft.</td>
<td>3½ in.</td>
</tr>
<tr>
<td>12 ft.</td>
<td>4 in.</td>
</tr>
<tr>
<td>14 ft.</td>
<td>5 in.</td>
</tr>
<tr>
<td>16 ft.</td>
<td>6 in.</td>
</tr>
</tbody>
</table>
### TABLE II

**CEMENT, SAND AND STONE**

**Width of Slab in Feet (Between Eaves)**

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<thead>
<tr>
<th></th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sacks of Cement (1 sack = 1 cu.ft.)</td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td>of rooft</td>
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<td>2.0</td>
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<td></td>
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<tr>
<td>6</td>
<td>1.0</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>rooft</td>
<td>8</td>
<td>1.7</td>
<td>2.6</td>
<td>4.2</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>10</td>
<td>2.2</td>
<td>3.3</td>
<td>6.1</td>
<td>7.6</td>
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<td>4.7</td>
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<tr>
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<td>6.2</td>
<td>10.1</td>
<td>14.4</td>
<td>20.8</td>
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<td>3.9</td>
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<td></td>
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<td></td>
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<tr>
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<td>5.2</td>
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<tr>
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<td>4.3</td>
<td>6.5</td>
<td>12.1</td>
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<td>Cu.ft. of Stone</td>
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<td>of rooft</td>
<td>6</td>
<td>3.1</td>
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<td></td>
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<td>99.8</td>
</tr>
</tbody>
</table>
Forms for concrete roofs should be very carefully made so that the concrete will have rigid support until it has hardened sufficiently not only to support its own weight but the weight due to wind, snow and driving rain. They must be stout enough absolutely to prevent the least sagging under the load of concrete.

Of course roofs must be watertight. This suggests a 1:2:3 mixture. It is very essential that roof reinforcing be properly placed so that the
full effect of the steel in tension will be secured. Reinforcing may be blocked up from the forms in proper place by using small concrete cubes previously made or by using small blocks of wood. The latter should be withdrawn as fast as concreting proceeds.

To be on the safe side, roof forms should be left in place a little longer than may seem absolutely necessary. Under ordinary conditions two weeks is not too long. In cold weather double this time, or more, may be necessary.

As concrete roofs expose a large area to sun and air, it is very necessary that the concrete be covered with some protective covering to prevent too rapid drying out. This may be canvas or burlap, kept wet, or a layer of 2 inches of moist sand, kept moist by frequent sprinkling daily for a week or ten days. After this the covering may be removed and several wettings per day be given by means of a hose or otherwise and the concrete allowed to progress in hardening under natural conditions. Where the area to be covered does not permit finishing the work in one continuous operation, provision must be made for a construction joint in the work. This can afterward be filled with hot tar or asphalt to seal it against leakage.
PAVEMENTS, WALKS, STEPS AND FLOORS

Pavements, walks, and floors all belong to the same class of construction. Steps are included in this section simply because they often serve to provide a means of entering a building from a walk, where the building is above or below the walk level. Barnyard pavements and feeding floors (see Figs. 44 and 45) are true time savers and money makers. They do away with barnyard and feeding lot mudholes and provide comfort and cleanliness for the stock, which means greater sanitation. They make doubly sure that all feed will be eaten; none can be tramped into the mud and lost.

The first essential to floor, pavement or walk (see Fig. 46) construction is that the foundation be firm and well drained. All turf or vegetation should be removed from the site where the concrete is to be laid and any soft spots should be dug out and refilled with clean material, well
tamped. The whole foundation area should be compacted by rolling or ramming to uniform solidity. In some cases it may be necessary to make a gravel or cinder fill or subbase (Fig. 46) upon which to lay the concrete. This, however, should not be done unless absolutely necessary, as

in a location where the soil does not drain readily and water would be likely to remain under the pavement in freezing weather. If this happened the expansion resulting from freezing would cause the pavement to heave and possibly would crack some of the slabs.

Wherever a cinder or gravel subbase is pro-
vided, arrangement should be made to connect short lengths of tile to this subbase to insure drainage of water from beneath the floor or pavement.

FORMS FOR WALKS AND FLOORS

Forms for walks (Fig. 46) should be set up so that the walk will have either a slope of $\frac{1}{4}$ inch to the foot in one direction to make surface water drain from it readily, or else the forms may be set up to the same level and a slightly curved template or strikeboard be used to strike off the surface, thus giving it a slight crown which will also accomplish quick drainage. This refers particularly to walks; barnyard pavements and feed-

Fig. 46.—Detail of Concrete Sidewalk Construction, Two-course Work.
ing floors (Figs. 44 and 45) should be laid with a uniform grade or slope in one direction, toward a gutter formed in the concrete at the low side, which in turn should be connected to a tile line leading to a manure pit so that all of the liquid droppings on the floor can be conserved, as these represent money.

**SIZE OF SLABS**

Walk and pavement slabs should not be greater than 6 feet in any one dimension and forms should be placed so that alternate slabs may be concreted first, then after these have hardened the forms should be removed and concrete for the remaining slabs placed. This will guarantee perfect joints of separation between adjacent slabs, which is quite necessary to prevent destruction of the pavement in case of unequal settlement or upheaval as a result of faulty foundation or to freezing.

**MIXTURES FOR FLOORS, PAVEMENTS, ETC.**

Barnyard pavements and feeding floors are now almost universally of one-course construction. This means a mixture of uniform richness throughout; a 1:2:3 mixture is preferable, although a 1:2:4 mixture is sometimes used. In this class of work also concrete should be of quaky consistency. If it is desired to have a smooth finish to walks, then it is common to use
a leaner mixture, such as 1:3:5 for the foundation and apply a 1 or 1\(\frac{1}{2}\)-inch wearing course of a 1:2 sand-cement mortar. The top or wearing course of two-course construction should be placed immediately after the base (before the base has commenced to harden) so that there will be a perfect bond or union between the two courses.

**FINISHING WALKS AND FLOORS**

The consistency of the top course should be rather stiff so that when attempting to dump the mortar from a wheelbarrow it will have to be scraped out. If mixed to such stiffness the top can be troweled to the desired finish a few minutes after striking off. Then only one troweling will be necessary and the resulting surface will be more durable and wear-proof than if the top course is mixed wetter, thus making it necessary to trowel several times at intervals to secure the desired finish. Repeated trowelings break up the chemical action taking place between the cement and water during the process of hardening and considerably affect the wearing qualities of the surface.

**PROTECTION OF WALKS, FLOORS AND PAVEMENTS**

Just as soon as concrete in feeding floor, walk or pavement construction has hardened sufficiently to permit throwing upon it a protective
Fig. 47.—Forms for Concrete Curb Construction.
layer of moist sand or earth this should be applied to protect the concrete so it may acquire strength slowly under favorable conditions. This covering should be kept wet by frequent sprinkling for a week or ten days. At the end of this time the walk, floor or pavement can be put to its intended use.

**CURB FOR FEEDING FLOORS**

Feeding floors should be built with a curb all around them extending 18 or 20 inches below ground level and 3 or 4 inches above the floor level. Forms for curbs are shown in Fig. 47. This prevents the animals from pushing feed off the floor, thereby wasting it; while the extension of curb below ground level will keep them from rooting underneath the floor.

**SANITATION SECURED**

Feeding floors and barnyard pavements, next to concrete watering troughs, are the most effective of barnyard appointments toward securing sanitation. They are largely cleaned by sunlight and rain, but they must, of course, occasionally be washed off with broom and hose to keep them in sanitary condition. Barnyard pavements and feeding floors should never be finished with a steel trowel but with a wood float, as it is desirable to have a surface that will not be slip-
pery. The wood-float surface will be even, but gritty enough in texture to make a safe foothold for the animals.

**INDOOR FLOORS**

Floors inside buildings are laid in the same manner as feeding floors or barnyard pavements, with the exception that slabs may be larger, even up to 10 feet square, as temperature changes under cover are not so great as those out of doors, therefore it is less likely that the slabs will crack from expansion.

**THICKNESS OF SLABS**

Walks, pavements and floors should not be less than 5 inches thick and preferably 6 inches thick if subjected to heavy usage such as would prevail in horse barns where subjected to the impact of heavy horses shod with steel shoes. For ordinary walks, feeding floors and barnyard pavements, 5 inches will be sufficient.

**STEPS**

Most woods in contact with soil, especially when lying upon rather than buried in it, rot rapidly. This is especially true of woods that are commonly used for porch or step construction. Probably no home owner has escaped the necessity of frequently replacing the steps at the front
or back of the house. When wood is used for such a purpose it should be easy to see that one’s labors are soon lost.

Constructing for permanence by using concrete involves little if any greater expense than required to build impermanently of wood. Furthermore, construction such as required either for front or back porches is relatively simple. Forms are of the simplest. Take the back steps by way of illustration. Figs. 48 and 49 show the simplicity of forms required and the finished porch steps.

Before commencing the work, the ground should be leveled and any soft spots or vegetation such as sod, dug out and removed. Then the area where the steps are to be placed should be filled in with clean, well-compacted gravel. Arrangements should be made to mix and place the concrete so that construction can be continuous from the time started until finished. A small job like
the one illustrated will not require more than a few hours of work, so there need be no construction seams in the work.

Concrete mixed in the proportions of $1:2\frac{1}{2}:4$ will be well suited to this work, and pebbles larger than 1 inch, also field stones, may be used on the interior of the mass, but it will considerably reduce the labor of finishing the surface when spading if no pebbles or broken stone larger than 1 inch is used in the concrete placed against forms. Use enough water to form a concrete of quaky consistency and mix no more concrete at one time than can be placed within 30 minutes after mixing. Do not retemper, that is, add
water and attempt to remix a batch of concrete that has commenced to harden.

In placing concrete use a spade or similar tool (Fig. 50) to work up and down against the inner form face, so as to remove air bubbles and force back the coarse gravel from the form and permit

![Fig. 50.—Method of Spading Concrete Next to Form Face.](image)

the sand-cement mortar to come forward so that a smooth surface which will require little or no finishing after the forms are removed, will be secured. Under favorable summer weather conditions forms can be removed within 24 hours from such construction, so that if there are stone pockets or similar imperfections appearing on
the face of the exposed work, these can be readily filled with a 1:2 cement-sand mortar. Then the whole surface is floated, that is, wet down and rubbed with a brick, wood float or similar finishing tool while it is wet.

Nothing has so far been said about the surface finish of the tread of the steps and top of the porch area. If forms are filled to within an inch of the top with a 1:2:4 mixture, a top, or wearing coat, mixed 1:2 or not leaner than 1:2½ provided the sand is well graded, can be applied before the mass of concrete has commenced to harden. A little 1:2 mortar can be spread around on the surface, then worked with a wood float. This will give an even and non-slippery finish. Use the edger around the forms just at final finishing.

Some persons desire the smoothness obtained by using a steel trowel for final finishing.

After the forms have been removed, the steps should be protected by some kind of a covering that will prevent too rapid evaporation of moisture so that the concrete can properly harden. Old burlap sacks kept wet for a week, or a covering of moist earth sprinkled down frequently will accomplish the purpose. The steps may be used after the time mentioned.

Such work can be done during cold weather provided there is no frost in the ground; but certain precautions must be taken, such as heating the sand and gravel and mixing water and protecting the concrete just as soon as it has been
placed, so as to prevent the possibility of freezing for at least 48 hours. The forms can be covered with canvas, burlap or building paper, and on top of this there may be piled 6 or 8 inches of hay, straw or manure, which will protect the work sufficiently so that after 48 hours no damage from freezing need be feared. Concrete hardens more slowly in cold weather than in warm weather, and it would be well not to use the steps until two weeks or more after doing the concreting.

**CONCLUSION**

Concrete falls in for a great many uses on the farm that could not be enumerated in the limited space of this book. It forms very suitable material for curbing springs of water, that is, building a protective wall around them so that surface water may be prevented from polluting them. This construction falls within the same requirements as that described for tanks and cisterns. The same applies to concrete used for well casings or curbs. If the well is a circular one, of course a circular form will be required on the inside. After this has been placed the earth may be excavated around the outside of this form and it will be possible, if the earth is firm, to deposit concrete without any outside form, otherwise outside forms will be necessary.

The curb may be reinforced with $\frac{1}{4}$-inch round rods bent to the desired curve or with woven wire
fabric such as is used for wire fencing. If fabric is used it serves for both vertical and horizontal reinforcing. If rods are used, they must be placed both vertically and horizontally to accomplish the desired results. Horizontal rods should be spaced 6 inches center to center and vertical ones from 18 inches to 2 feet apart around the circumference of the well. Vertical and horizontal rods should be tied together where they intersect so as to hold them in correct position while concrete is being placed. Reinforcing can be assembled above-ground, then set in place. If the curb is 6 inches thick, which will be sufficient, the reinforcing
should be midway between the inner and outer surfaces of the concrete.

Excavation should be made 4 or 5 feet deep so that the curb will extend at least that depth below ground level. This will largely prevent seepage of surface water into the well. After this curb has been laid and has properly hardened a concrete slab for a well platform (Fig. 51) should be constructed. This should be not less than 4 inches thick and should be reinforced with ¼-inch rods placed 6 inches center to center in both directions 1 inch from the slab bottom, suitable opening being provided in the slab to permit the passage of pump pipe.
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2
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