Concrete fence posts

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CONCRETE FENCE POSTS

The Agronomy Farm fences at Iowa State College

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

C. F. Curtiss, Director

AGRICULTURAL ENGINEERING
SECTION

AMES, IOWA

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Concrete fence posts, when properly made, give very satisfactory service, but success with them depends very much upon good design, good workmanship and good material. These facts are clearly shown in the investigation of concrete posts conducted over a long period of years by the Agricultural Engineering section of the Agricultural Experiment Station and reported in this bulletin.

The essentials of design, the requisites in materials and the methods of making are also presented and the whole subject discussed from the standpoint of service, practicability and economy, including an estimate of the cost of the various types of posts, adjusted to the present prices of material and labor.

THE EXPERIMENTS

In 1914 the Agricultural Engineering Section outlined an investigation into the practicability, durability, essentials of construction and the cost of production of concrete fence posts which included the making of a number of posts of various types, and forms of construction and their test in the laboratory and in service when set in fences. For the latter tests, over 700 posts were made during the summer of 1914 of which 48 were reserved for laboratory tests and the remainder used in fencing the Agronomy Farm of Iowa State College. These posts and

Fig. 1. No. 1 Post mold gang and a post made in the mold. The molds should be assembled with the ends more nearly even

* This bulletin is published from a revision of a manuscript prepared in 1916 by W. G. Kaiser, then assistant in agricultural engineering, but which was not published owing to the war time conditions which then prevailed.
the methods used in their production are described in the following pages.

THE FORMS USED

In the original experiment seven styles of forms were used, but one additional type was tried out later, making a total of eight. The shape of the mold, and the dimensions and weights of the posts produced are shown in fig. 12. The forms are described as follows:

No. 1. A commercial mold made from a single piece of 16 gage sheet steel formed into a trough with a semi-circular bottom and vertical sides. A gang of five or six molds, depend-

Fig. 2. A group of post molds. No. 2 is at the left and No. 5 at the right

ing on their size, was placed on a frame having flexible supports which permitted a vibrating motion to be imparted to the molds for compacting the concrete.

No. 2. A commercial mold made of 24 gage galvanized sheet steel shaped so as to form a post with one rounded face.

No. 3. A commercial mold formed for giving a tee-shaped cross section to the post. These molds were fastened together in gangs of six.

No. 4. A commercial mold forming a triangular post of uniform cross section, except for an enlargement or knob on the lower end. This knob adds materially to the stability of the post when set.

No. 5. A home made wooden mold, assembled with five others in a gang of six, and forming a post of square cross-section but with chamfered corners. The construction of a wooden form is described on page 37 of this bulletin and illustrated in figs. 6 and 25.
Fig. 3. No. 3 Post mold gang and sample post

Fig. 4. No. 4 Post mold gang and sample post

Fig. 5. No. 5 Home-made wooden post mold and sample post
Fig. 6. Line of fence in which the posts made with No. 4 mold are set

Fig. 7. Fence made with the No. 5 posts
No. 6. A home made mold made of 20 gage galvanized sheet steel so shaped as to form a post of triangular cross-section. These forms were made by a local sheet metal worker.

No. 7. A home made sheet metal mold so shaped as to form a post with a rectangular cross-section. The sheet metal was not galvanized and was stiffened by a wooden frame.

No. 8. A commercial post machine added to the equipment after the experiment was started. Provision is made for making a round post filled from the end of the mold. The machine provides for the lowering of the form into a well or below a platform for filling, a means of jarring for compacting the concrete, and a windlass for raising the post out of the well.

The shapes and sizes of cross-sections of the bottom ends of the seven types of posts included in the tests are shown in fig. 11.

THE CONSTRUCTION OF THE EXPERIMENTAL POSTS

Proportion of materials: Three different mixtures were used in making the experimental posts. The first 84 posts were made of a mixture of 1 part portland cement, $1\frac{1}{3}$ parts fine sand and 3 parts coarse sand. The coarse sand passed thru a $\frac{1}{4}$ inch mesh
screen and was retained on \(\frac{1}{8}\) inch mesh screen. The next 50 posts were made from concrete of 1 part portland cement, \(2\frac{1}{2}\) parts bank run gravel which contained about 7 percent of clay. The remainder were made with 1 part portland cement to \(2\frac{1}{2}\) parts of washed gravel. It was the intent to make a good strong concrete with the materials at hand. The same strength could have been obtained with less cement, providing more coarse aggregate were used.

**Mixing:** The first few posts were made from concrete mixed on a mixing board with shovels, but for most of the posts a small power driven batch mixer was employed. A rather wet mix was used in order to obviate the necessity of much tamping but less water and more thorough tamping if practicable would have furnished stronger concrete.

**Reinforcement:** Three forms of reinforcement were used, viz: \(\frac{1}{4}\) inch square twisted bars, no. 3 unannealed wire, and \(\frac{5}{8}\) inch by 18 gage band steel. The influence of the reinforcement on the strength of the posts will be found in the table reporting the results of tests and the conclusions will be given later.

Spacers were used for the first 22 posts but were omitted from the remainder as the workmen objected to the time required for making and placing the spacers. The weakening of the posts by misplacement of the reinforcement, as revealed by the tests, indicates that spacers are a very important factor in securing proper location of the reinforcement.

Usually the mold was filled about one-third full of concrete

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Fig. 10. No. 8 Fence post mold and machine used in making round posts
which was worked down. The bottom reinforcement was then placed at the proper distance from the bottom and the mold filled with concrete. The top reinforcement was then placed at the desired depth and the surface of the concrete smoothed with a trowel.

Cleaning the Molds: The molds were cleaned and oiled before each filling with concrete to insure that the post could be removed easily when the concrete had set. It was found that machine oil applied with a brush gave satisfactory results.

Records: A record of each individual post was made, includ-

<table>
<thead>
<tr>
<th>NUMBER OF MOLD</th>
<th>CROSS SECTION</th>
<th>LENGTH</th>
<th>WEIGHT: LBS.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>7-6</td>
<td>116-127</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>7-0</td>
<td>75-80</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>7-0</td>
<td>83-90</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>7-0</td>
<td>59-65</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>7-0</td>
<td>112-120</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>7-0</td>
<td>95-103</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>7-0</td>
<td>112-120</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td>7-0</td>
<td>80-85</td>
</tr>
</tbody>
</table>

Fig. 12. Table giving the shapes, dimensions and weights of the posts tested.
Fig. 13. Posts after testing showing the three kinds of reinforcement used
ing type, materials, mixture and reinforcement. A copper number plate was cast in each post for identification.

TESTING THE POSTS

The Concrete Post Testing Machine: For testing the posts for strength a simple machine was designed and built which furnish loads similar to those to which the posts are subjected in service. The machine (figs. 15 and 16) consisted of a framework of hard wood with a post or rest at one end and a platform scale at the other. The load was applied by a screw and ratchet lever between the fixed supports at a point corresponding to the ground line when the post is set. The location of the scale and screw may be moved to accommodate posts of different lengths. The points of supports were one-half inch rods.

Testing: Figs. 15 and 16 show the testing machine with posts under test. The ends of the posts were supported four inches from each end, or as near the ends as it was thought practicable to apply the loads without danger of failure from the ends shearing off.

The load in all cases was applied to the post two feet six inches from the bottom end, or at a point corresponding to the ground line when the posts are set in the ground. When stressed to the point of failure the load on the scale indicated the pull at the top of a set post that would cause failure.

Fig. 14. A device for making hooks on the ends of reinforcement
No correction was made for the dead load due to the weight of the post. The load on the post was increased by increments of 25 to 50 pounds and the deflections produced were measured and recorded. Fig. 17 shows how a micrometer was used to measure the deflection. Table I lists the posts tested for strength and the results.

THE POSTS AT THE END OF NINE YEARS

It is a notable fact that not one of the 650 posts set in 1914 has been replaced at the end of nine years. Few of the posts show any defects. Fifty-nine posts show longitudinal cracks, usually directly over the reinforcement rods because the latter were not placed far enough from the surface to secure adequate protection from corrosion. Only a few, however, are seriously injured. The worst example of this kind of defect is shown in fig. 24. Fourteen of the posts have been chipped by contact with wagons or implements, but only in three posts is the injury serious. In general, most of the posts show little or no deterioration and it would be difficult to estimate their probable life. It is safe to suggest that many ought to be intact at the end of 50 years.

Fig. 15. The machine used for testing the posts with a No. 3 post in place for testing
Fig. 16. A view of post in testing machine showing a failure by the yielding of the reinforcement.

Fig. 17. Fence post testing machine showing the use of micrometer for measuring deflection.
### TABLE 1. RESULTS OF TEST

All loads applied in direction of least strength

<table>
<thead>
<tr>
<th>Mold</th>
<th>Post. No.</th>
<th>Age in days</th>
<th>Mixture</th>
<th>Reinforcement</th>
<th>Distance from extreme edge</th>
<th>Ult. load lbs.</th>
<th>Max. Def. in inches</th>
<th>Kind of failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1</td>
<td>583</td>
<td>294</td>
<td>1:2 ½</td>
<td>4 ½” sq. tw.</td>
<td>1”</td>
<td>1975</td>
<td>620</td>
<td>.87 wire permanently stretched</td>
</tr>
<tr>
<td>No. 1</td>
<td>232</td>
<td>306</td>
<td>1:2 ½</td>
<td>4 ½” sq. tw.</td>
<td>1½”</td>
<td>1900</td>
<td>597</td>
<td>1.125 wire permanently stretched</td>
</tr>
<tr>
<td>No. 1</td>
<td>14</td>
<td>322</td>
<td>1:1 ½ 3</td>
<td>4 18 gauge ⅜” bars</td>
<td>1”</td>
<td>957</td>
<td>300</td>
<td>1.125 bars permanently stretched</td>
</tr>
<tr>
<td>No. 1</td>
<td>594</td>
<td>296</td>
<td>1:2 ½</td>
<td>4 18 gauge ⅜” bars</td>
<td>1½”</td>
<td>863</td>
<td>270</td>
<td>.96 bars permanently stretched</td>
</tr>
<tr>
<td>No. 1</td>
<td>13</td>
<td>322</td>
<td>1:1 ½ 3</td>
<td>4 18 gauge ⅜” bars</td>
<td>1½”</td>
<td>1050</td>
<td>340</td>
<td>.44 bars permanently stretched</td>
</tr>
<tr>
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<td>586</td>
<td>295</td>
<td>1:2 ½</td>
<td>4 18 gauge ⅜” bars</td>
<td>1½”</td>
<td>985</td>
<td>310</td>
<td>.31 bars permanently stretched</td>
</tr>
<tr>
<td>No. 1</td>
<td>15</td>
<td>322</td>
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<td>4 18 gauge ⅜” bars</td>
<td>1½”</td>
<td>957</td>
<td>300</td>
<td>.47 bars permanently stretched</td>
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<td>No. 1</td>
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<td>299</td>
<td>1:2 ½</td>
<td>4 No. 3 wire</td>
<td>1”</td>
<td>1210</td>
<td>340</td>
<td>.75 wire permanently stretched</td>
</tr>
<tr>
<td>No. 1</td>
<td>507</td>
<td>298</td>
<td>1:2 ½</td>
<td>4 No. 3 wire</td>
<td>1½”</td>
<td>1130</td>
<td>355</td>
<td>.44 wire permanently stretched</td>
</tr>
<tr>
<td>No. 2</td>
<td>143</td>
<td>314</td>
<td>1:1 ½ 3</td>
<td>4 ½” sq. tw.</td>
<td>1”</td>
<td>1155</td>
<td>300</td>
<td>1.00 wire permanently stretched</td>
</tr>
<tr>
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<td>4 ½” sq. tw.</td>
<td>1½”</td>
<td>1210</td>
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<td>700</td>
<td>240</td>
<td>.75 wire broken permanently stretched</td>
</tr>
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<td>540</td>
<td>185</td>
<td>wire permanently stretched</td>
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<td>3 No. 3 wire</td>
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<td>673</td>
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<td>3 No. 3 wire</td>
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<td>1½”</td>
<td>1310</td>
<td>450</td>
<td>wire permanently stretched</td>
</tr>
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<td>1½”</td>
<td>1300</td>
<td>445</td>
<td>wire permanently stretched</td>
</tr>
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<td>3 ½” sq. tw.</td>
<td>2”</td>
<td>1095</td>
<td>375</td>
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</tr>
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<td>482</td>
<td>165</td>
<td>.81 wire permanently stretched</td>
</tr>
<tr>
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<td>289</td>
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<td>3 No. 3 wire</td>
<td>1½”</td>
<td>410</td>
<td>140</td>
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<td>438</td>
<td>150</td>
<td>.92 wire permanently stretched</td>
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<td>3 No. 3 wire</td>
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<td>165</td>
<td>1.74 wire permanently stretched</td>
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<td>300</td>
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<td>3 No. 3 wire</td>
<td>1½”</td>
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<td>1.60 wire permanently stretched</td>
</tr>
<tr>
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<td>1:2 ½</td>
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<td>1½”</td>
<td>760</td>
<td>240</td>
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<td>4 ½” sq. tw.</td>
<td>1”</td>
<td>1185</td>
<td>475</td>
<td>.87 bar broke</td>
</tr>
<tr>
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<td>171</td>
<td>319</td>
<td>1:2 ½</td>
<td>4 ½” sq. tw.</td>
<td>1”</td>
<td>1850</td>
<td>635</td>
<td>1.31 bar broke</td>
</tr>
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<td>128</td>
<td>321</td>
<td>1:2 ½</td>
<td>4 ½” sq. tw.</td>
<td>1”</td>
<td>1850</td>
<td>635</td>
<td>1.25 bar broke</td>
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<tr>
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<td>1:2 ½</td>
<td>4 No. 3 wire</td>
<td>1”</td>
<td>860</td>
<td>295</td>
<td>.97 wire permanently stretched</td>
</tr>
<tr>
<td>No. 5</td>
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<td>1:2 ½</td>
<td>4 No. 3 wire</td>
<td>1”</td>
<td>905</td>
<td>310</td>
<td>.83 wire permanently stretched</td>
</tr>
<tr>
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<td>3 ½” sq. tw.</td>
<td>1”</td>
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<td>1”</td>
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<td>420</td>
<td>1.44 bar broke</td>
</tr>
<tr>
<td>Mold</td>
<td>Post. No.</td>
<td>Age in days</td>
<td>Mixture</td>
<td>Reinforcement</td>
<td>Distance from extreme edge</td>
<td>Ult. load lbs.</td>
<td>Max. Def. in inches</td>
<td>Kind of failure</td>
</tr>
<tr>
<td>------</td>
<td>-----------</td>
<td>-------------</td>
<td>---------</td>
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<td>---------------------------</td>
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<td>-------------------</td>
<td>-----------------------</td>
</tr>
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<td>1-1/8&quot;</td>
<td>995</td>
<td>340</td>
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<td>No. 3 wire</td>
<td>1-1/8&quot;</td>
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<td>230</td>
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<td>311</td>
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<td>No. 3 wire</td>
<td>1-3/8&quot;</td>
<td>584</td>
<td>200</td>
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<td>1&quot;</td>
<td>670</td>
<td>230</td>
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<td>No. 7</td>
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<td>App. 300</td>
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<td>4</td>
<td>No. 3 wire</td>
<td>1-1/8&quot;</td>
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<td>App. 300</td>
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<td>1/4&quot; sq. tw.</td>
<td>1-1/8&quot;</td>
<td>1811</td>
<td>620</td>
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<td>No. 7</td>
<td>271</td>
<td>App. 300</td>
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<td>4</td>
<td>1/4&quot; sq. tw.</td>
<td>1&quot;</td>
<td>1811</td>
<td>620</td>
</tr>
<tr>
<td>No. 7</td>
<td>160</td>
<td>App. 300</td>
<td>1:2½</td>
<td>4</td>
<td>1/4&quot; sq. tw.</td>
<td>1&quot;</td>
<td>2060</td>
<td>695</td>
</tr>
</tbody>
</table>
THE MAKING OF SUCCESSFUL POSTS

The following suggestions gained from this investigation are offered as essential to the making of satisfactory posts.

Mixture: Only a dense mixture of concrete should be used in the making of concrete fence posts. Sufficient cement should be used in all cases to fill the voids in the sand and aggregate, the amount varying with the character of the sand, gravel or broken stone used. The proportion of cement, sand and coarse aggregate commonly used for concrete fence posts is 1:2:3. In this mixture one cubic foot of portland cement is mixed with two cubic feet of clean coarse sand (varying from the finer particles to those passing thru a ⅛ screen) and three cubic feet of clean well graded pebbles or broken stone ranging from ¼ inch to a maximum of ⅜ inch. If pit gravel with a surplus of sand be used more cement must be used.*

Owing to the fact that the fence post mold or form is usually shallow it is best to use a rather wet mixture as much tamping is not practicable unless the mold is filled from the end. Although a wet mix tends to produce less dense mixture, better results are obtained than with a dryer mixture.

* Information in regard to the use of pit run gravel may be obtained in Bulletin 60, Method of Proportioning Concrete Materials, Screened and Unscreened Gravel, by R. W. Crum, Iowa Engineering Experiment Station.

Fig. 18. Table showing the strength of seven types of posts as determined by test and the influence of the kind of reinforcement.
Fig. 19. Posts reinforced with No. 3 wire. Failure due to the slippage or breaking of reinforcement.
Fig. 20. Posts reinforced with ¼ inch square twisted bars. Bars were broken or concrete crushed.
Fig. 21. Posts that failed when the concrete was crushed
Fig. 22. Reinforcement carelessly placed
Molds or Forms: Steel molds offer advantages in that they give a better surface finish to the post and also better withstand the effects of use than wooden forms. Forms nos. 6 and 7 were home-made molds of sheet metal and were used successfully. Commercial molds have added advantages in convenience for handling which are not easily secured in forms made by the user. Shaking and jostling devices contribute especially to the ease of making and the general improvement of the posts.

Where a few posts, however, are to be made molds made of wood are the most convenient to make and the following description is that of wooden molds which have proven successful.

The Making of Wooden Molds or Forms: The wooden molds used by the Agricultural Engineering Section in 1914 are shown in fig. 6 and a modification of these forms, introducing some conveniences, is shown in fig. 25. Wooden forms for concrete posts can best be assembled on a stiff floor, tight and smooth. A good grade of straight grained lumber carefully dressed should be used, white pine, fir or cypress being particularly satisfactory. The sides and ends of the molds should be of two-inch material and the partitions of one-inch material. The lower corners of the post in the mold may be chamfered or beveled by nailing triangular strips to the sides of the forms. The sides and ends of the molds may best be held in place by wedges supported by blocks. These wedges permit the forms to be dismantled easily for the removal of the post after the concrete has sufficiently hardened. Rods with tail nuts for adjustment are often used to hold the molds together. It is good practice to cast the posts on pallets laid in the bottom of the molds. These pallets facilitate the handling to the post while green. Often two by four pallets are often used on account of convenience which gives a post with two parallel sides, the taper in this case being confined to the partitions.

The Construction of Wooden Forms: Where care is taken in making wooden forms and handling the material the results will be satisfactory. The convenience of making wooden forms will

<table>
<thead>
<tr>
<th>Number of Mold</th>
<th>Section of Post</th>
<th>Number Ring</th>
<th>Placing</th>
<th>Mixture</th>
<th>Breaking Load at Top of Post Tested in Lb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1-2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1, 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1, 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 23. Chart showing the influence of the location of reinforcement upon strength of concrete posts
justify their use, particularly where the number of posts to be made is limited, but on the other hand metal forms not only have the advantage of giving a better surface to the post but tend to hold their shape much better. For those who prefer to use lumber forms the following suggestions based on the experience with such forms will be of interest.

**Size of Post:** There seems to be no definite way to determine just how large or how strong a concrete post should be. Altho the posts tested in service varied in weight from 60 to 127 pounds and had an average breaking strength from 157 to 609 pounds applied at the top to the post when set, all these posts have held the fences in place. The service has not been particularly severe such as would be the case of lot fences. It would appear, however, that a seven-foot post having a strength of 500 pounds would be above the average requirement. A post of the dimensions of no. 5, or those made in the form shown in fig. 25, when of good concrete properly reinforced will easily have this strength.

**Reinforcement:** This investigation revealed that concrete posts were in general inadequately reinforced to secure the maximum strength of the concrete. Four 1/4 inch bars of reinforcing steel of high tensile strength is not too much for a post of the size and strength suggested. Soft or annealed steel should be avoided, and twisted or special form steel is clearly more desirable than smooth round steel rods.

**Curing:** The concrete post, on account of its slender form and large amount of surface, should be carefully cured. The posts should be handled carefully until fully hard-
ened and during the curing process should be kept moist by sprinkling for ten days after making. Posts ordinarily should not be set until they have cured for at least three months.

**Fastening the Wire:** Various schemes have been suggested as a means of attaching the fence wire to the posts. The loop tie shown in figs. 24 and 26 has been proven to be satisfactory. The setting of a strip of porous concrete in the middle of the post face was experimented with and it was demonstrated that a staple could be successfully driven into this porous strip. The staple, however, had only a limited grip and the process lowered the strength of the posts.

**Corner and End Post:** End and corner posts for withstanding the pull of the stretched fence may be made successfully of concrete. Two general styles are in use. The monolithic post cast integrally with the brace is shown in figs. 27 and 28. This post is made particularly strong for withstanding the pull of the heaviest of farm fencing. The braced post is shown in fig. 9. This type of post, is usually eight or ten inches square and eight to nine feet long, four \( \frac{3}{4} \) inch square bars are heavy enough for light fences. The braces are usually five inches square, are ten to twelve feet long and reinforced with four \( \frac{3}{8} \) inch rods.

**COST OF CONCRETE POSTS**

When the concrete posts used in the experiment were made in 1914 the cost of material ranged from 17\( \frac{1}{2} \) cents to 30\( \frac{1}{2} \) cents each. The following estimate is based upon the actual cost of 1914 with corrections made for current price of material.
The labor required in making posts will vary widely with the conveniences and equipment available for the mixing and handling of the materials. Five to ten posts per hour for each worker is an average rate of production but with special factory equipment the production may be materially increased.

**ESTIMATE OF COST OF MATERIAL FOR CONCRETE POSTS**

<table>
<thead>
<tr>
<th>Mold</th>
<th>Cement $3.20 per barrel</th>
<th>Gravel $1.50 per yard</th>
<th>Reinforcement</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1</td>
<td>25.6c</td>
<td>6.7c</td>
<td>28.7c</td>
<td>61.0c</td>
</tr>
<tr>
<td>No. 2</td>
<td>16.0</td>
<td>4.2</td>
<td>19.5</td>
<td>33.7</td>
</tr>
<tr>
<td>No. 3</td>
<td>18.4</td>
<td>4.8</td>
<td>19.5</td>
<td>32.7</td>
</tr>
<tr>
<td>No. 4</td>
<td>12.5</td>
<td>3.3</td>
<td>19.5</td>
<td>35.3</td>
</tr>
<tr>
<td>H. M. W.</td>
<td>25.0</td>
<td>6.4</td>
<td>19.5</td>
<td>40.9</td>
</tr>
<tr>
<td>H. M. S.</td>
<td>20.6</td>
<td>5.4</td>
<td>19.5</td>
<td>35.5</td>
</tr>
<tr>
<td>H. S.</td>
<td>25.0</td>
<td>6.4</td>
<td>19.5</td>
<td>41.9</td>
</tr>
</tbody>
</table>

The results of the tests indicate that the strength of the posts varied widely, or from about 200 to 620 pounds for a load applied at the top of the posts. It is to be noted in this connection that the following factors affect the strength of the post:

1. The cross-section shape and size.
2. The kind and amount of reinforcement.
3. The location of the reinforcement.
4. The strength of the concrete or the mixture.

In fig. 18, which shows graphically the average strength of the various types of posts, it is to be noted that those posts which have a cross section approximating a square are stronger for their weight (which indicates the volume of concrete used in the posts) than those posts of triangular or teeshaped sections. The posts were tested in each case in the direction of least strength and the triangular posts contained only three pieces of reinforcement.

The widest variation in strength, however, is related to the variation in reinforcement. One-fourth inch square twisted bars gave a de-
A STUDY OF THE RESULTS

Fig. 19 shows how posts reinforced with no. 3 wire failed by the stretching or breaking of the reinforcement. Fig. 20 shows typical failure of posts reinforced with \( \frac{1}{4} \) inch twisted bars.

An examination of the broken posts showed that with the no. 3 wire the bond between the steel and concrete was broken on either side of the fracture. With the \( \frac{1}{4} \) inch square bar the bond between the steel and concrete was not broken.

The no. 3 wire was purchased in straightened cut lengths. The straightening process twisted the wire and had an injurious effect upon its strength.

In the posts shown in fig. 21, (and reinforced with \( \frac{1}{4} \) inch
square bars) failure was due to the crushing of the concrete. In all cases the posts reinforced with no. 3 wire failed by the breaking or the stretching of the steel.

The reinforcement of band steel (no. 18 gage by \( \frac{3}{8} \) inch) did not show the strength of the no. 3 (fig. 18). The advantage claimed for band steel is that it provides extra surface for bonding with the concrete.

The placing of the reinforcement is an important matter. If not placed near the surface the strength of the post will be re-

![Diagram of post with reinforcements](image)
duced, while if not sufficiently covered with concrete the steel will not be protected from corrosion (see fig. 24). Altho an attempt was made to place the steel carefully in the posts, the test revealed that the steel was sometimes misplaced. Fig. 22 shows several posts in which the steel was improperly located, and fig. 23 indicates graphically the influence of the location of the steel upon strength.

A STUDY OF THE GENERAL SUCCESS OF CONCRETE FENCE POSTS

Proportions: Altho a good dense concrete was used for all the posts, it is significant that a 1-1½-3 mixture of graded material gave greater strength than a 1 to 2½ mixture of ungraded material. It is to be emphasized that much cement may be saved by using the proper proportion of coarse material.

An inspection of a large number of concrete posts has been made in several parts of the State. Altho some splendid posts have been found, enough failures were observed to justify a special effort to caution prospective makers of posts that the essentials of construction previously mentioned must be provided. In a few instances the users strongly condemned concrete fence posts. Failures were due to a number of causes, but chiefly corrosion of steel due to inadequate protection, wrong kind and insufficient reinforcement, insufficient cement in mix-
ture, improper curing and careless workmanship. It is very evident that the making of satisfactory concrete posts requires much care and skill.

CONCLUSIONS

1. Very satisfactory fence posts may be made of concrete.
2. The life of a first class concrete post is very long; nine years indicates little deterioration.
3. A post with approximately square or round cross-section is the strongest for the material used.
4. A dense or rich concrete is needed to protect the steel reinforcement from corrosion.
5. The minimum amount of cement will be needed if sufficient coarse graded aggregate is used. For reinforcing the common sizes and types of posts in general use, four \( \frac{3}{4} \) inch square twisted bars, or the equal, are needed for the utilization of the full strength of the concrete.
6. The steel reinforcement should be carefully placed, at least \( \frac{3}{4} \) inch beneath the surface of the concrete, to secure maximum strength with adequate protection of the steel from corrosion.
7. Concrete posts make a fence of splendid appearance.
8. The cost of maintaining a concrete post is very small.
9. The opportunity for failure is large with poor workmanship or low quality materials.

Acknowledgements. The post molds used in this experiment were furnished by the following companies:

No. 3. Ohio Post Mold Co., Toledo, O.
No. 4. Kimballton Construction Co., Atlantic, Iowa.
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