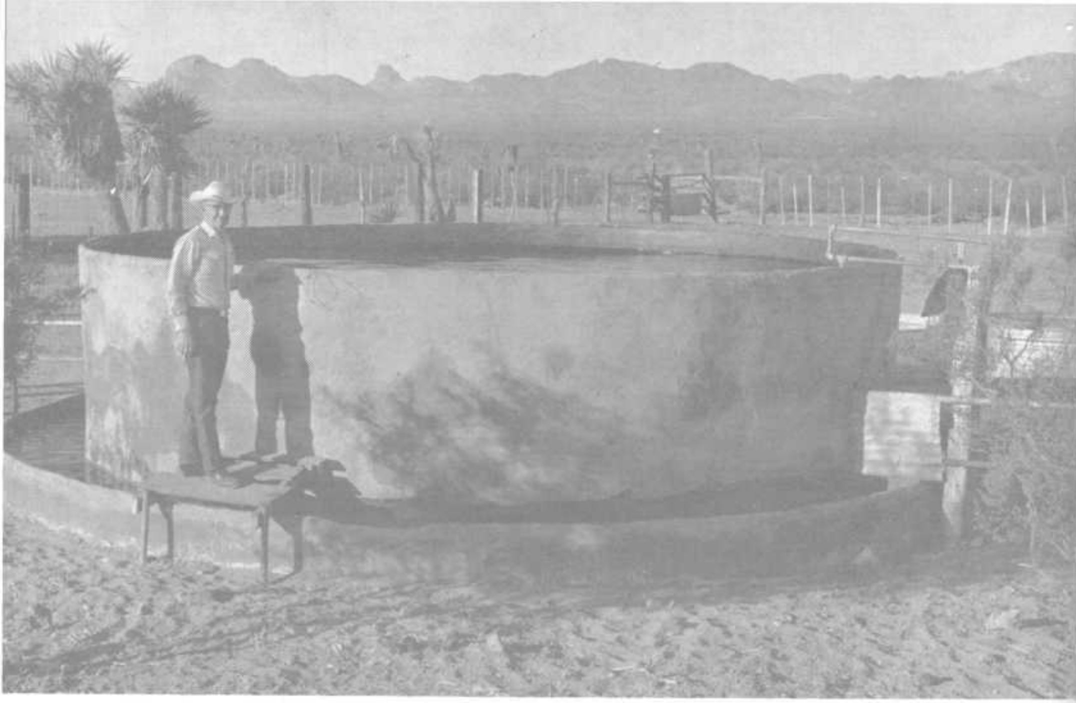
How to Make a

Plastered Concrete Water-Storage Tank

Bulletin A-41

Cooperative Extension Service & Agricultural Experiment Station

The University of Arizona



Mohave ASC County Committeeman Bill Logsdon inspects the finished tank. Bill stands on the platform that protects the water trough float valve. The trough around the base of the tank is a recent innovation.

Contents

Trade names used in this publication are for identification only and do not imply endorsement of products named or criticism of similar products not mentioned.

Issued in furtherance of cooperative extension work in agriculture and home economics, Acts of May 8 and June 30, 1914, in cooperation with the U. S. Department of Agriculture. George E. Hull, Director of Extension Service, The University of Arizona College of Agriculture, Tucson, Arizona.

5M — July 1965 — Bulletin A-41

How to Make a

Plastered Concrete Water-Storage Tank

By
W. T. Welchert
Extension Agricultural Engineer

And
J. N. McDougal, Jr.
Mohave County Agricultural Agent

The University of Arizona

Leonard Peterson, working with Bill Logsdon, Mohave ASC County Committeeman, originated a plastered concrete water storage tank construction system that has become quite popular in the Mohave County ranching area. A number of these units have been in service in the Kingman vicinity for more than 10 years.

County Agent McDougal and Leonard Peterson discuss the equipment and materials needed for constructing concrete plastered tanks in the remote range country. Besides the equipment shown, a pickup truck and a portable water supply tank are all that is needed.

As Mr. Peterson designed them, these tanks hold about 6 feet of water and are 10 to 30 feet in diameter. The economy of this system depends upon the availability of good quality aggregates on the range area near proposed tank locations.

Description

A 20-foot diameter tank can be constructed by one man with 90 to 100 hours of labor. The equipment required includes a pickup truck, portable mixer, portable water supply tank, ¼ inch sand screen, some 4′x8′ metal sheets, and conventional concrete mason's tools. Double hoops of 7-foot wide 6x6 / 10x10 welded wire reinforcing fabric covered with chicken wire on both sides are used to reinforce the walls.

Metal tin sheets are wired on the outside of the reinforcing cage to serve as a backup form while plastering the core wall surrounding the reinforcing. After the core wall is finished, a ½ inch plaster coat is added to the inside and outside walls. Then, the floor of the tank is placed with a regular concrete mix and the base of the wall is built up on the inside and outside.

The completed tank is painted inside with an emulsified asphalt paint.

Design Caution

Because concrete has very little strength in tension, steel reinforcing must be incorporated in the walls to resist the water storage load. This tension is called "hoop tension" and increases with the diameter and depth. Normal reinforced concrete design procedure completely neglects the strength of concrete in tension and is based on a safety factor of two to four times calculated loads.

This particular design involves the maximum economy in both concrete and steel. Theoretical calculations based on the proportional limit of rienforcing steel (a safety factor of one) would require twice as much reinforcing steel as presently used on a 30-foot diameter tank filled to the 6-foot level. Therefore, we must assume that the concrete makes a significant contribution to the tensile strength of the tank.

Research indicates that the tensile strength of concrete can be estimated at 1/10 of its compressive strength, and some texts indicate an ultimate (failure) tensile strength at 270 pounds per square inch after one month's curing. If we assume a plaster concrete compressive strength of 1500 p.s.i. and take 1/10 of this value for its tensile strength, add it to the tensile strength of the reinforcing steel, we calculate that this tank design should fail at about 34-foot diameter. To be sure that this design will stand, we must have a safety factor greater than one.

Reinforcing requirements increase rapidly as the diameter increases and large concrete installations tend to crack due to temperature expansion. The fact that at least three 30-foot diameter tanks in the Kingman area have performed satisfactorily for several years suggests that a 30-foot diameter is the practical limit.

However, a beginner using this construction procedure should not overlook the advantage of construction experience gained by the originators in developing this system. Not only is the construction technique important, but also the quality of the concrete plaster and in particular the quality of the aggregates.

Tank Size

The size of a storage tank for a windmill system depends on the stocking rate, wind frequency, duration, and power. Assuming an average stocking rate, experience in the Kingman area indicates that a 3,000 to 5,000 gallon tank is adequate to serve one or two float-controlled water troughs with sufficient reserve to avoid calm air spells.

The larger sizes have been used for distribution water storage. This type of tank might also be used for catchment water storage. Normally, catchment systems require storage capacities in the range of 50,000 to 100,000 gallons. In this case two or more tanks should be considered.

Tank Construction Procedure

1. Locate and clear site.

Tank should be located so that inlet fills tank by gravity. To avoid shutting off the windmill when the tank is full, an overflow can be installed and connected to drain back into the well casing. (See Figure 1).

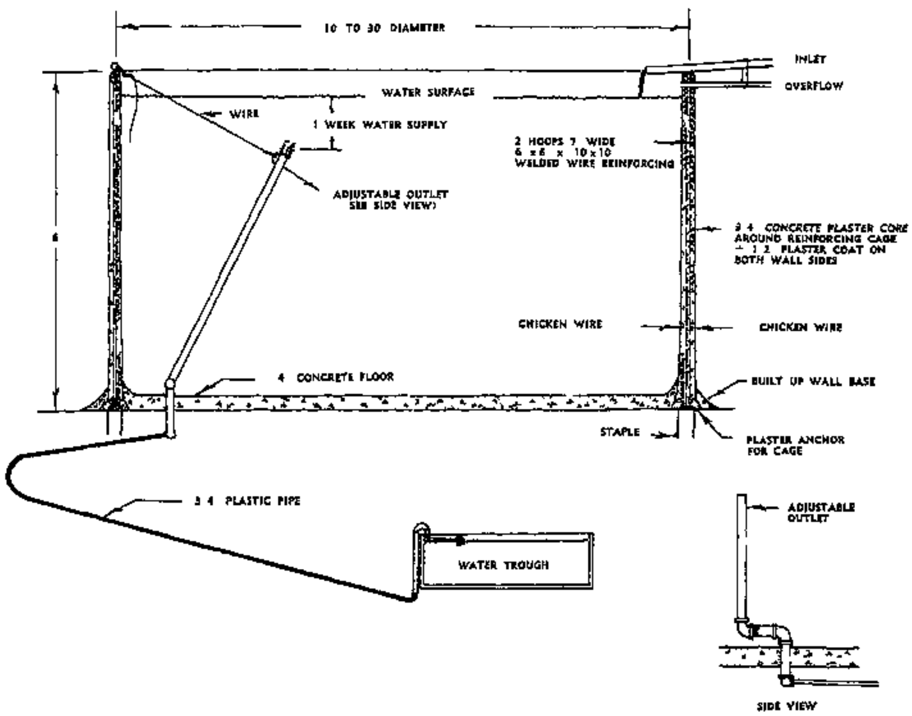


Figure 1. — Section.

2. Transcribe the desired diameter with a marking peg. (Figure 2).

Figure 2. — Marking Scheme.

3. Construct reinforcing cage. Unroll 7-foot wide roll of 6x6 / 10x10 reinforcing wire fabric and cut (bolt cutter preferred) two pieces to desired length. Fold the outside hoop down 12 inches (Figure 3). Fold the inside hoop up 15 inches (Figure 4).

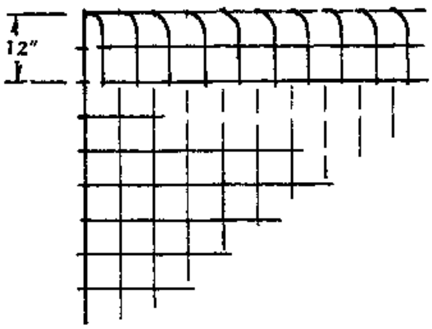


Figure 3. — Outside Hoop Fold.

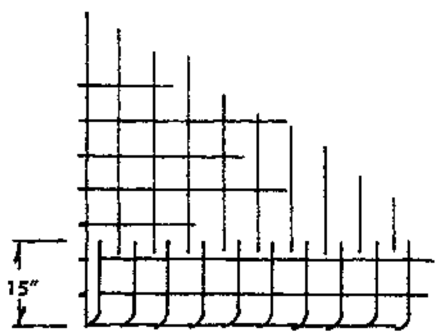


Figure 4. — Inside Hoop Fold.

Re-roll both reinforcing hoops. Cut inside and outside chicken wire hoops. Carry inside rolls to center of the tank site. Set outside reinforcing on end with double section up and temporarily staple the hoop in place on the transcribed circle. Use staples made of ⅜″ reinforcing bar 8 to 12″ long to stake the cage in place.

Four thicknesses of reinforcing fabric at the hoop splice should be avoided by offsetting the inside and outside hoops 6 to 12 inches. (Figure 5).

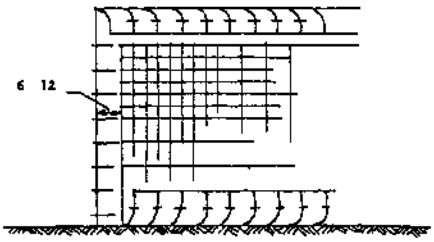


Figure 5. — Overlap Offset at Joint.

Use baling wire to fasten both hoops together. Begin at one end and use as few wires as possible to insure reinforcing alignment. Do not fasten ends together until chicken wire is fastened to the inside and outside of the reinforcing walls. Proceed from one end and wire all reinforcing and chicken wire togther thoroughly.

It may be necessary to remove much of the temporary baling wire fastening from the previously wired reinforcing because of creep. Level the reinforcing cage by digging out the high spots.

4. Make provisions for water inlet.

If the water is supplied by a pressure system, consider frost protection.

5. Make provisions for an outlet system to the stock watering trough.

The storage outlet may be screened and adjustable. (See Figure 1, page 5).

An adjustable pipe extension set about a foot below the water surface (or a week's water supply) has an advantage should the stock trough float valve fail. Only a week's water supply is lost, whereas the entire storage may be lost under other systems.

All water supplies should be checked and adjusted at least twice a week. A recent innovation is to build a continuous stock trough at the base of the storage as illustrated in Figure 6. The construction of the water trough is essentially the same as for the storage tank.

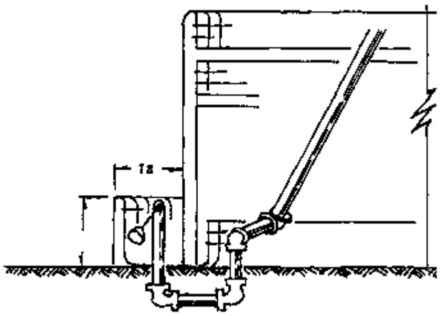


Figure 6. — Stock Trough Scheme.

6. Make provision for an overflow.

7. Fasten the ends of the reinforcing cage permanently.

8. Place enough plaster concrete at the base of the reinforcing cage to anchor the cage. (See Figure 1, page 5).

9. Wire 4-foot wide metal sheets around the outside of the reinforcing cage.

Start by fastening the sheet with the mixer chute hole in the desired mixer location. A 4-inch overlap pattern is adequate. These sheets serve as a backup form for the inside plaster job.

When the inside 3 to 4 feet has been plastered, all metal sheets except the sheet with the mixer chute hole are moved up to the top and rewired. Thus one extra metal backup form sheet is required. (See Figure 7).

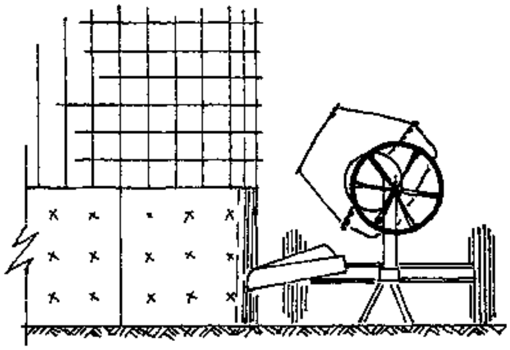


Figure 7. — Sheet Metal Forming. (Note hole in backup sheet for mixer chute.)

10. Plaster the inside of the reinforcing wall with approximately a ¾″ thick coating.

Be sure to cover all of the reinforcing core wall through to the backup sheets. Use wall plaster specifications as follows:

(a) The concrete mortar is mixed using ¼″ maximum sized

Leonard Peterson demonstrates how he plasters the ½″ outside wall coat. He has already finished the inside wall coat in similar fashion.

aggregate. Use Type II cement. Not over five gallons of water per sack of cement should be used if sand is wet. For dry sand, use 6 gallons of water per sack of cement.

Add aggregate to this cement-water mix to the desired consistency. This will be about one part cement to three parts clean and well graded sand. The amount of aggregate may be varied to yield the desired consistency, but the water-cement ratio **should not** be varied.

To improve the workability of the plaster add masonry or "plastic" cement at the rate of one masonry cement to five parts portland cement.

(b) Quality concrete plaster is a must in this system. It is standard practice in the Kingman area to use sand found in arroyos on the range. Nearly all aggregates from such arroyos are relatively silt-free and of excellent quality.

This is probably not true for other areas in the state. Thus a silt test should be run on all aggregates to be used to determine if they contain injurious amounts of finely divided clays or silt particles. (See Appendix for Silt Test).

Likewise, sand sometimes contains harmful amounts of decomposing vegetable matter. If inspection shows evidence of organic matter see the Appendix for Vegetable Matter Tests.

A ¼″ mesh screen should be used on bank run aggregates. Save the larger gravel materials to add to the floor mix later. If tests show excessive silt or vegetable matter the sand should be washed.

(c) The plaster is placed on the wall with a steel or wood trowel. Do not trowel finish.

(d) Curing consists of keeping the surface of the plaster concrete moist. Immediately after initial set it is desirable to cover concrete with moist burlap and keep wet. As each section of the wall is finished, a plastic sheet hung over the sides will reduce water evaporation from the curing concrete.

County Agent Jim McDougal inspects the rough concrete surface of the reinforced cage wall. This honeycombed surface is ideal for outside plaster coat. Mr. Peterson points out that this surface should be remoistened before applying the paster coat.

→

11. As soon as the core wall is finished.

Follow up with a second plaster coat approximately ½″ thick on the inside and outside of the tank wall. If the core wall has dried excessively, remoisten before applying the second plaster coat.

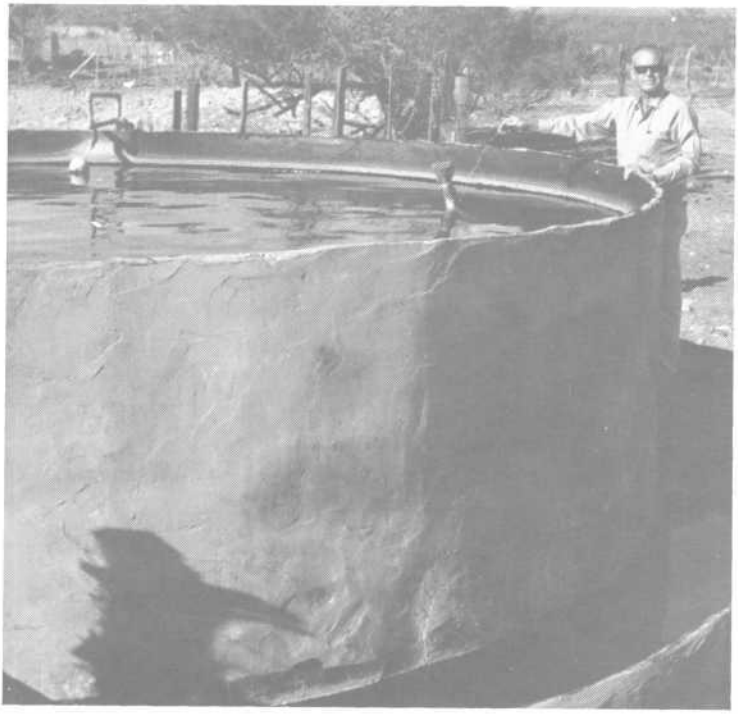
12. Construct the floor and build up the inside and outside base of the wall.

Use the same cement-water ratio prescribed for the plaster. Add sand and gravel to cement-water paste to the desired consistency. As a guide, use two parts sand to three parts gravel (¾″ maximum size). The mix should be quite stiff.

13. Patch the mixer chute hole and paint the inside wall and floor with an emulsified asphalt paint.

→

Leonard Peterson demonstrates how he plasters through the reinforcing steel cage. The concrete plaster covers all of the reinforcing on both sides. Metal back up forms hold the plaster in place until the initial set is firm.



County Agent McDougal demonstrates how the outlet pipe is adjusted about a foot below the water surface. Should the water trough float fail all of the water supply is not lost. He recommends that all range water supplies be visited at least twice a week.

Estimate of Construction Schedule

For Experienced One-man Operation

1. Site location and preparation, materials and equipment preparation — 1 day.

2. Construct reinforcing cage wall — 1 day.

3. Haul sand, screen, mix mortar, and plaster bottom half of tank core — 1 day.

4. Finish top half of tank core — 1 day.

5. Plaster ½″ second coat inside — 1 day.

6. Plaster ½″ coat outside — 1 day.

7. Haul bank-run aggregate mix concrete and pour floor and build up base inside and outside — 1 day.

8. Patch mixer chute hole and paint inside tank — 1 day.

9. Clean up and completion of plumbing connections — 1 day.

APPENDIX I.

Silt Test*

Sand and bank-run gravel may be tested to determine whether they contain injurious amounts of finely divided clay and silt particles as follows:

1. Place 2″ of representative sample of sand in a quart milk bottle or fruit jar.

2. Add water until jar is about full, fasten cover, shake vigorously, then set the jar aside for 24 hours or until the water clears.

3. Measure the layer of silt covering the sand. If this layer is more than 1/8″ thick the sand is unsuitable for use unless washed.

4. A satisfactory washing table can be constructed as illustrated in Figure 8. It consists of a wide, shallow, sloping trough. The material is shoveled onto the high end where it is drenched with water by means of hose or pail, washing out the objectionable materials. Retest after washing to make sure it is clean.

*PcA Handbook of Concrete Farm Construction.

APPENDIX II.

Vegetable-Matter Test*

Sand and gravel sometimes contain harmful amounts of decomposing vegetable matter. Concrete made with such aggregates may not harden or the resulting concrete may be of low strength. A test to see whether bank-run aggregates are fit for use in concrete may be made as follows:

1. Dissolve a heaping teaspoon of household lye into 1/2 pint of water contained in a 1-pint fruit jar. (Fruit jar should be of colorless glass.)

2. Pour 1/2 pint of representative sample of sand or gravel into the jar containing the lye water.

3. Cover the jar tightly and shake vigorously for 1 to 2 minutes.

4. Set jar aside for 24 hours, then inspect in good light.

5. If the water is clear or colored not darker than apple cider vinegar, the material is suitable for use in concrete. If darker than this, the material should not be used unless washed to remove the objectionable vegetable matter.

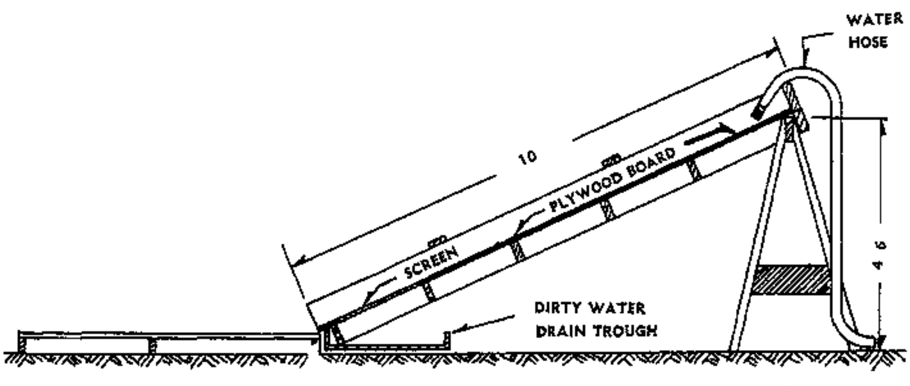


Figure 8. Sloping table for washing bank-run gravel

Storage Capacity and Materials Estimates

Materials	Capacities at 6' Deep, Diameters and Circumferences				
	3,500 gal. **D = 10'** **C = 31.4'**	**5,000 gal.** **D = 12'** **C = 37.7'**	**6,900 gal.** **D = 14'** **C = 44'**	**14,000 gal.** **D = 20'** **C = 62.8'**	**31,000 gal.** **D = 30'** **C = 94.2'**
Portland cement Walls Floor	 12 sacks* 7½ "	 14 sacks* 10 "	 16 sacks* 14 "	 23 sacks* 25 "	 34 sacks* 63 "
Aggregates Wall (⅜" max.) Floor (¾" max.)	 1¼ yards 1¼ "	 1½ yards 1¾ "	 1¾ yards 2½ "	 2½ yards 4¼ "	 3¾ yards 10¾ "
Mixing water	120 gal.**	145 gal.**	180 gal.**	290 gal.**	585 gal.**
7' wide reinforcing fabric 6x6/10x10 (Roll = 200 linear ft., Wt. = 294#, Est. Cost = 10.5¢/#)	2 hoops each 32' long	2 hoops each 38'2" long	2 hoops each 44'6" long	2 hoops each 63'4" long	2 hoops each 94'9" long
6' wide 1" hex chicken wire (Roll = 150 linear ft., Wt. = 83#, Est. Cost = $26/roll)	2 hoops each 32' long	2 hoops each 38'2" long	2 hoops each 44'6" long	2 hoops each 63'4" long	2 hoops each 94'9" long
Emulsified Asphalt Paint, (Est. cost = 70¢/gal.)	2 gal.	2¾ gal.	3¼ gal.	5 gal.	10 gal.

Incidentals include reinforcing bar stapes, baling wire, plumbing fixtures, etc.

* Add 1 sack plaster cement for each 5 sacks Portland cement to improve workability.

** Hauling Estimate.

This publication is issued by the Cooperative Extension Service and the Agricultural Experiment Station of The University of Arizona. See your local County Extension Agent for additional information.