



# CONCRETE

## INFORMATION

## Underground Concrete Tanks

A satisfactory reinforced concrete tank requires correct structural design, good quality concrete, and careful construction. Design tables and numerical examples illustrating procedures for design of tanks are presented in *Circular Concrete Tanks Without Prestressing\** (IS072) and *Rectangular Concrete Tanks\** (IS003).

**Design.** Tanks should be designed in accordance with ACI 350R-89, *Environmental Engineering Concrete Structures*. Structural design should be in accordance with ACI 318-95, *Building Code Requirements for Structural Concrete*. The reinforcement detailing should be as per *ACI Detailing Manual*, special publication SP-66, 1994.

**Quality of Concrete.** Details of how to make good quality concrete for tanks is given in *Watertight Concrete\** (IS002), also helpful are *Design and Control of Concrete Mixtures\** (EB001) and *Concrete for Hydraulic Structures\** (IS012).

**Forms.** Suggestions for good formwork can be found in *Formwork for Concrete*, special publication SP-4, 6th ed., American Concrete Institute, 1995. Improper and inadequate formwork may result in honeycombed areas. These areas (unless patched properly) are potential spots for seepage, and hence deterioration of the structure. The form ties used should have waterstops—the specific requirement depending somewhat on the liquid pressure to be retained. Ties should not be pulled completely out of the wall. The ends of the tie metal, after breaking, should be at least 1-1/2 in. (38 mm) from the face of the wall. More detailed recommendations are given in ACI 347R-94, *Guide to Formwork for Concrete*.

**Joints.** Leakage through tank walls occurs mostly at joints, so these require special attention. The drawings show construction joints at top and bottom of walls. No other joints should be allowed if they can be avoided. The making of good construction joints is discussed in detail in *Watertight Concrete\** (IS002).

Before backfilling is done or surface treatment applied, the tank should be filled with water to test for leaks. Repairs can be made much easier at that stage. For testing water tightness, reference should be made to ACI 350.1R-93, *Testing Reinforced Concrete Structures for Watertightness*.

Stone pockets or honeycomb should be chipped away to a depth of not less than 1 in. (25 mm), with edges of the chipped-out area perpendicular to the surface. The area is then wetted thoroughly to prevent absorption of water from the patching mortar, which is made without coarse aggregate and with as little water as possible. Patching mortar should be retempered without adding any water by allowing it to stand for 1 hour, during which time it is stirred with a trowel. The mortar is finally compacted into place, screeded off, and cured as prescribed for ordinary concrete.

Leaking joints should be chipped to a depth of at least 1 in. (25 mm), so that a slightly dovetailed groove is provided along the joint, preferably on the pressure side, which is then filled with mortar as described for patching stone pockets.

**Surface Treatment.** Concrete made with the proper type of cement and properly proportioned, mixed, placed, and cured will be dense, strong, watertight, and resistant to most chemical attack. Therefore, under ordinary service conditions, quality concrete does not require protection against chemical deterioration or corrosion.

Corrosive conditions that do require concrete surface protection can range from comparatively mild to very severe, depending on the chemicals used and the domestic and industrial wastes encountered. The type of protection employed against chemical attack also will vary according to the kind and concentration of the chemical, frequency of contact, and physical conditions such as temperature, pressure, mechanical wear or abrasion, and freeze-thaw cycles.

General guidelines for surface treatments are given in ACI 350R-89, while detailed recommendations are included in *Effects of Substances on Concrete and Guide to Protective Treatments\** (IS001) and ACI 515.1R-79(85), *Guide to the Use of Waterproofing, Dampproofing, Protective and Decorative Barrier Systems for Concrete*. Experience shows that surface treatments or admixtures will not correct inadequate design, poor concrete, or faulty construction.

**Mechanical Installations.** Depending on the use for which a tank is to be built, it is advisable to consult local codes, insurance company regulations, and equipment manufacturers in regard to the number, location, and types of manholes, vents, and pipe connections. These and other problems in each individual job require the services of a competent consulting engineer.

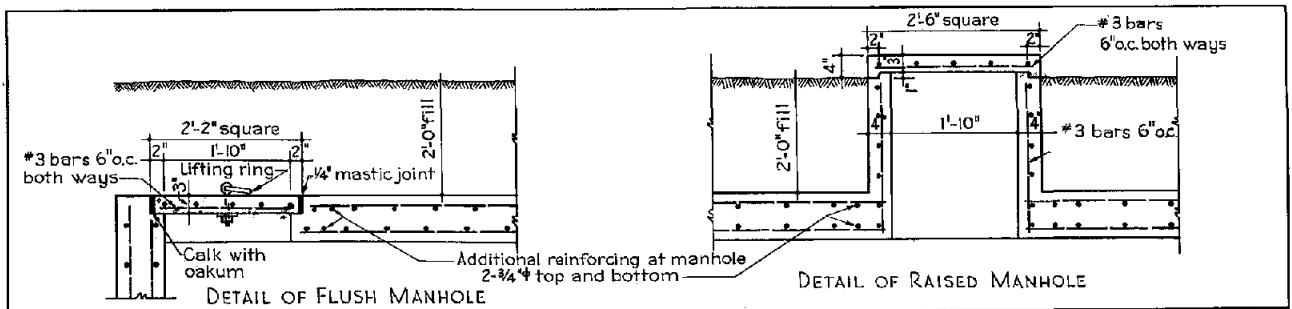
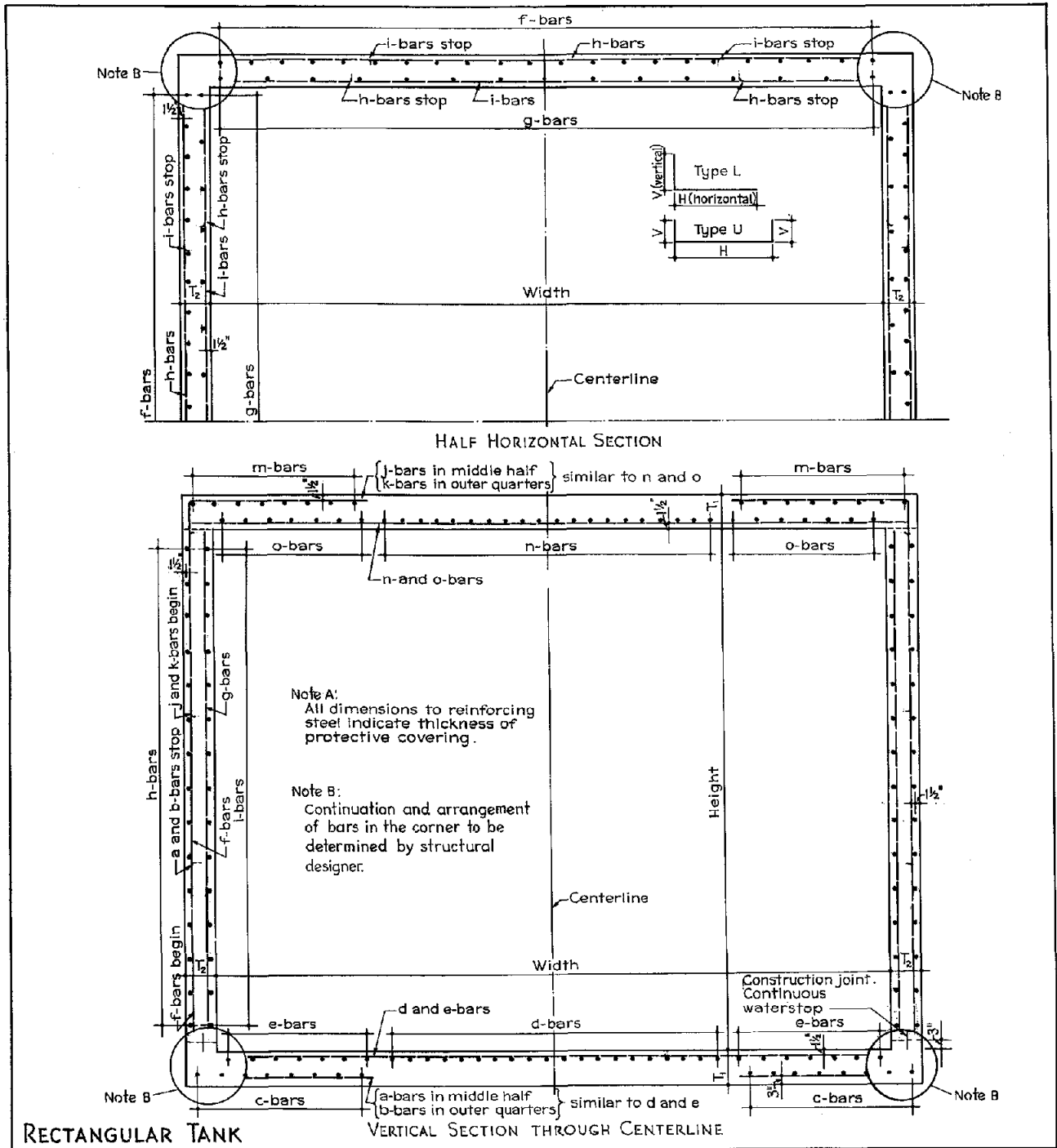
The drawings on the following pages are based on more conservative designs than the current code requirements and are for relatively small capacities only. Since every tank installation involves a separate group of conditions, a competent engineer is needed to make the final design and to supervise the construction. The drawings will help in making preliminary estimates and in drawing final plans. The tanks are designed assuming a concrete strength of 3,500 psi (24.13 MPa) and an allowable stress of 20,000 psi (137.9 MPa) for the reinforcement of members under bending moments. An allowable stress of 14,000 psi (96.53 MPa) is used for the reinforcement of members under direct tension.

Roofs of the tanks are assumed to carry a live load of 100 psi (0.69 MPa) and 2 ft (0.61 m) of earth weighing 100 lbs per cubic

\*Available from the Portland Cement Association.

foot (1602 kg/cu m), making the total load 300 psf (14.36 kPa). Tanks are designed for the internal hydrostatic pressure existing when they are full of water. Walls will withstand

ordinary earth pressure, but external hydrostatic pressure is not considered here.



# Rectangular Tanks (SEE PAGE 2)

## Dimensions, Capacities, Estimated Quantities

Tank No.	Area, ft.	Height, ft.	Slab, in. T <sub>1</sub>	Wall, in. T <sub>2</sub>	Capacity, gal.	Steel, lb.	Concrete, cu.yd.
1	18x18	14	11	10	33,930	10,270	58.8
2	14x14	12	10	9	17,590	4,130	34.5
3	11x11	10	9	8	9,050	2,300	20.0
4	9x9	9	8	8	5,450	1,260	13.9
5	7x7	8	7	7	2,930	600	6.1

## Bent Bars, Type U

Tank No.	h-bars					i-bars				
	No.	Size	Spacing	Hor.	Vert.	No.	Size	Spacing	Hor.	Vert.
1	60	#5	11"	18' 4"	4' 6"	60	#5	11"	19' 4"	4' 6"
2	52	#4	11"	14' 4"	3' 6"	52	#4	11"	15' 2"	3' 6"
3	36	#4	14"	11' 4"	2' 9"	36	#4	14"	12' 0"	2' 9"
4	40	#3	11"	9' 4"	2' 3"	40	#3	11"	10' 0"	2' 3"
5	28	#3	15"	7' 4"	1' 9"	28	#3	15"	7' 9"	1' 9"

## Bent Bars, Type L

Tank No.	a-bars					b-bars					j-bars					k-bars				
	No.	Size	Spacing	Hor.	Vert.	No.	Size	Spacing	Hor.	Vert.	No.	Size	Spacing	Hor.	Vert.	No.	Size	Spacing	Hor.	Vert.
1	80	#5	5 1/2"	5' 9"	4' 9"	56	#5	7 1/2"	5' 9"	4' 9"	80	#4	5 1/2"	5' 9"	4' 9"	56	#4	7 1/2"	5' 9"	4' 9"
2	60	#4	5 1/2"	4' 9"	4' 3"	35	#4	7 1/2"	4' 9"	4' 3"	60	#3	5 1/2"	4' 9"	4' 3"	35	#3	7 1/2"	4' 9"	4' 3"
3	40	#4	7"	4' 0"	3' 9"	21	#4	9"	4' 0"	3' 9"	40	#3	7"	4' 0"	3' 9"	21	#3	9"	4' 0"	3' 9"
4	40	#3	5 1/2"	3' 3"	3' 3"	21	#3	7 1/2"	3' 3"	3' 3"	28	#3	7 1/2"	3' 3"	3' 3"	21	#3	9"	3' 3"	3' 3"
5	24	#3	7 1/2"	2' 9"	3' 0"	21	#3	9"	2' 9"	3' 0"	16	#3	9"	2' 9"	3' 0"	21	#3	9"	2' 9"	3' 0"

## Straight Bars

Tank No.	c-bars				d-bars				e-bars				f-bars			
	No.	Size	Spacing	Length	No.	Size	Spacing	Length	No.	Size	Spacing	Length	No.	Size	Spacing	Length
1	32	#3	7 1/2"	11' 0"	40	#5	5 1/2"	19' 3"	28	#5	7 1/2"	11' 0"	88	#5	10"	13' 6"
2	24	#3	7 1/2"	9' 0"	30	#4	5 1/2"	15' 0"	20	#4	7 1/2"	9' 0"	68	#4	10"	11' 6"
3	16	#3	9"	7' 6"	20	#4	7"	12' 0"	12	#4	9"	7' 6"	40	#4	14"	9' 6"
4	16	#3	9"	6' 6"	20	#3	5 1/2"	10' 0"	12	#3	9"	6' 6"	40	#3	10"	8' 6"
5	16	#3	9"	5' 6"	12	#3	7 1/2"	7' 9"	12	#3	9"	5' 6"	36	#3	10"	7' 6"

Tank No.	g-bars				m-bars				n-bars				o-bars			
	No.	Size	Spacing	Length	No.	Size	Spacing	Length	No.	Size	Spacing	Length	No.	Size	Spacing	Length
1	60	#5	15"	13' 6"	32	#4	7 1/2"	11' 0"	40	#4	5 1/2"	19' 3"	28	#4	7 1/2"	11' 0"
2	44	#4	15"	11' 6"	24	#3	7 1/2"	9' 0"	30	#3	5 1/2"	15' 0"	20	#3	7 1/2"	9' 0"
3	40	#4	14"	9' 6"	16	#3	9"	7' 6"	20	#3	7"	12' 0"	12	#3	9"	7' 6"
4	44	#3	10"	8' 6"	16	#3	9"	6' 6"	14	#3	7 1/2"	10' 0"	12	#3	9"	6' 6"
5	36	#3	10"	7' 6"	16	#3	9"	5' 6"	8	#3	9"	7' 9"	12	#3	9"	5' 6"

# Circular Tanks (SEE PAGE 4)

## Dimensions, Capacities, Estimated Quantities

Tank No.	Diam., ft.	Height, ft.	Slab, in. T <sub>1</sub>	Wall, in. T <sub>2</sub>	Capacity, gal.	Steel, lb.	Concrete, cu.yd.
1	20	14	10	8	32,900	6,220	44.6
2	16	12	9	7	18,050	3,430	26.4
3	12	10	8	6	8,460	1,350	13.8
4	10	9	7	6	5,290	770	9.6
5	8	8	6	6	3,010	470	6.3

## Circular Bars in Slabs, Variable Length

Tank No.	b-bars			d-bars			g-bars			i-bars		
	No.	Size	Spacing	No.	Size	Spacing	No.	Size	Spacing	No.	Size	Spacing
1	8	#6	10"	5	#3	12"	8	#5	10"	5	#3	12"
2	8	#5	8"	4	#3	12"	8	#4	8"	4	#3	12"
3	6	#4	8"	3	#3	12"	6	#3	8"	3	#3	12"
4	5	#3	8"	3	#3	12"	5	#3	10"	3	#3	12"
5	3	#3	10"	3	#3	12"	3	#3	12"	3	#3	12"

## Circular Bars in Wall

(Two 25-diameter laps included in bar length)

Tank No.	c <sub>1</sub> -bars				e <sub>3</sub> -bars			
	No.	Size	Spacing	Length	No.	Size	Spacing	Length
1	15	#5	3 1/2"	68' 6"	17	#5	6 1/2"	68' 6"
2	10	#5	4 1/2"	55' 0"	11	#5	8 1/2"	55' 0"
3	8	#4	5"	41' 9"	8	#4	9 1/2"	41' 9"
4	10	#3	3 1/2"	35' 0"	9	#3	8"	35' 0"
5	7	#3	5"	28' 9"	8	#3	7 1/2"	28' 9"

## Bars at Center of Slabs

(See arrangement on page 4)

Tank No.	a-bars			h-bars		
	No.	Size	Length	No.	Size	Length
1	10	#6	15' 0"	10	#5	15' 0"
2	10	#5	12' 0"	8	#5	12' 0"
3	8	#4	9' 6"	8	#4	9' 6"
4	10	#3	8' 0"	10	#3	8' 0"
5	6	#3	6' 6"	6	#3	6' 6"

## Bent Bars, Type L

Tank No.	e-bars					f-bars					j-bars				
	No.	Size	Spacing	Hor.	Vert.	No.	Size	Spacing	Hor.	Vert.	No.	Size	Spacing	Hor.	Vert.
1	144	#5	5 1/2"	4' 3"	4' 3"	53	#5	15"	4' 3"	14' 4"	53	#5	15"	4' 3"	4' 3"
2	98	#5	6 1/2"	3' 6"	3' 6"	49	#4	13"	3' 6"	12' 3"	49	#4	13"	3' 6"	3' 6"
3	73	#4	6 1/2"	3' 0"	3' 0"	43	#3	11"	3' 0"	10' 2"	43	#3	11"	3' 0"	3' 0"
4	89	#3	4 1/2"	2' 6"	2' 6"	25	#3	16"	2' 6"	9' 1"	25	#3	16"	2' 6"	2' 6"
5	50	#3	6 1/2"	2' 3"	2' 3"	20	#3	16"	2' 3"	8' 0"	20	#3	16"	2' 3"	2' 3"

