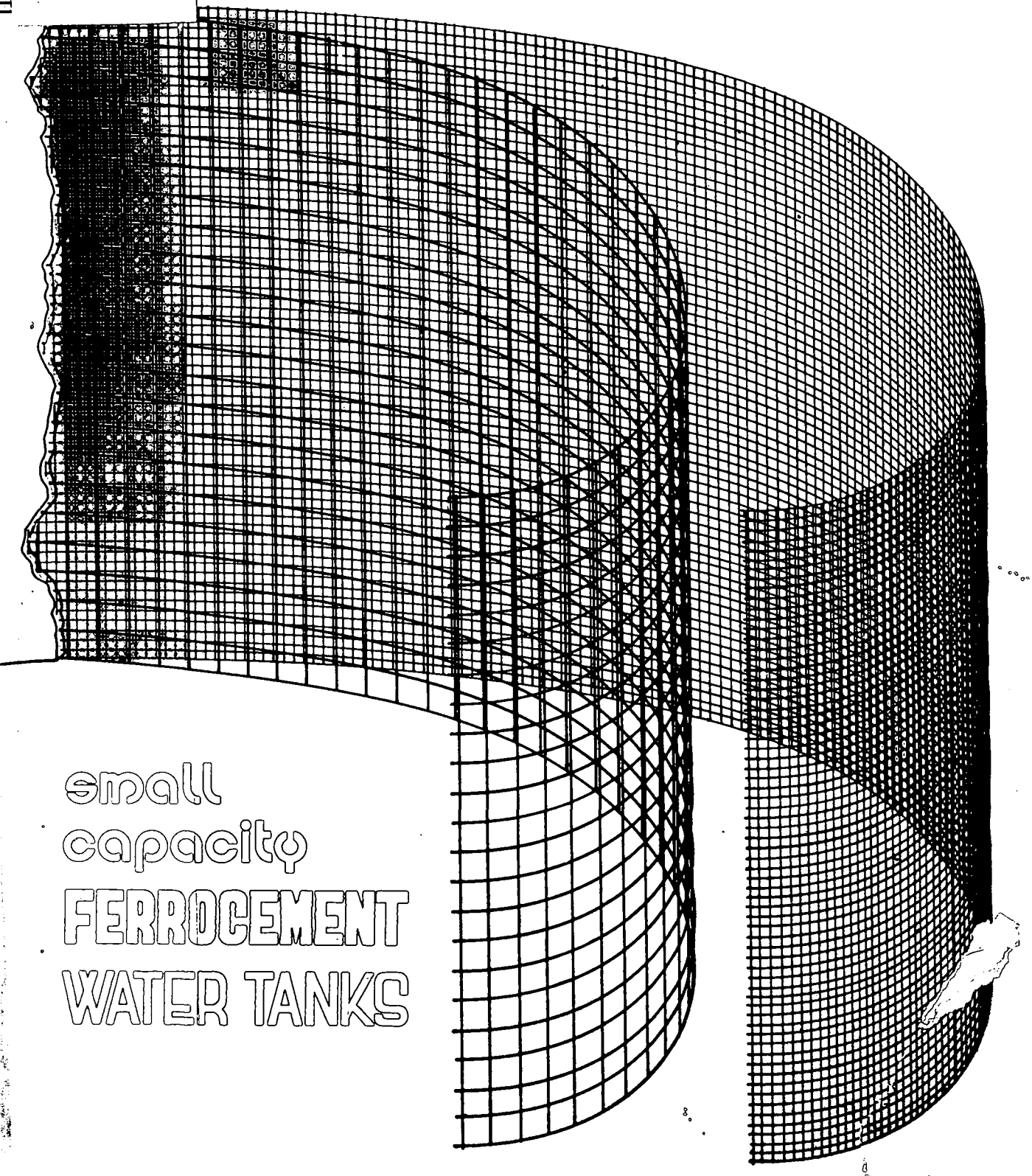


small capacity FERROCEMENT WATER TANKS

STRUCTURAL ENGINEERING RESEARCH CENTRE MADRAS
(Council Of Scientific & Industrial Research)
INDIA

Small Capacity Ferrocement Water Tanks

E. ABDUL KARIM
and
G. PAUL JOSEPH

STRUCTURAL ENGINEERING RESEARCH CENTRE
(COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH)

MADRAS, INDIA DECEMBER, 1978

CONTENTS

Small capacity ferrocement water tanks

1.0 Introduction

Ferrocement is a versatile structural material possessing unique properties of strength and serviceability. It is made with closely-knit wire mesh and mild steel reinforcing bars filled with rich cement mortar (Fig.1). Welded mesh may also be used in place of reinforcing bars. The materials required for making it, namely, cement, sand, wire mesh, and mild steel reinforcing bars, are easily available in most places. It is possible to fabricate in ferrocement, a variety of structural elements which are thin, light, and durable and possess a high degree of impermeability. Ferrocement combines the lightness of steel and mouldability of concrete and can be cast to any shape. The several applications of this material include boats, water troughs and tanks, storage structures, gas holders, pipes, roof and wall elements in buildings, and shuttering for concrete construction. Its application for the fabrication of small capacity water tanks is described in this brochure. They are ideally suited for residential and community uses.

2.0 Advantages

The advantages of ferrocement water tanks over other types are listed below:

—They are thin and light and are amenable to precasting and easy transportation.

—They can be cast by labour having skills required for normal building construction.

—They do not require the use of shuttering.

—They have a high degree of impermeability and resistance to cracking.

—They are economical compared to tanks built with steel, concrete, or brick walls.

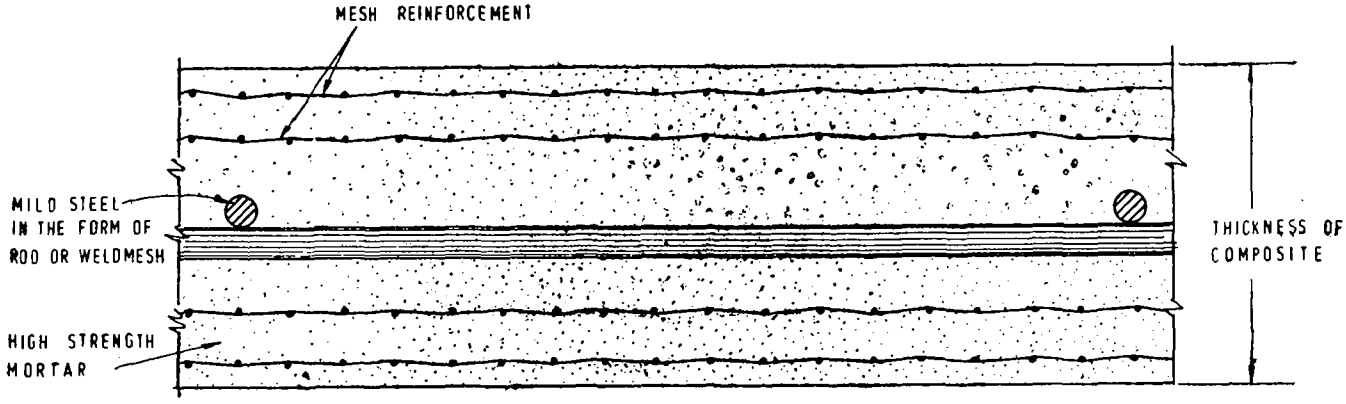


Fig. 1 Typical cross-section of ferrocement element

3.0 Suggested capacities

Tanks of the following capacities are recommended for various uses:

(a) For individual residential houses :	Single tanks of about 800 litres capacity
	1. Rectangular (Type A)
	2. Cylindrical (Type B)
(b) For blocks of flats :	Multiple tanks with compartments of about 800 litres capacity each
	1. Twin rectangular tank (Type C)
	2. Battery of rectangular tanks (Type D)
(c) For community uses :	Single or multiple (interconnected) tanks of 5,000 or 10,000 litres capacity each
	1. Cylindrical (Type E)

4.0 Choice of shape

Adaptability of ferrocement, like concrete, provides unlimited choice in shape. Often, location of tank also decides the shape. Rectangular and circular being the common shapes, they are considered here for ferrocement tanks. Compared to rectangular tanks circular tanks consume lesser quantity of materials and have smaller length of sharp corners.

5.0 Determination of size

The size of the tank depends on the water storage capacity required. The possible sizes for ferrocement water tanks may be selected from Table 1. In circular tanks D/H (diameter/height) ratio of 1.04 is preferred for any capacity.

6.0 Demand

The demand for small water tanks can be estimated to be as large as the demand for the houses themselves. There is also a large demand for community type water tanks in view of the large number of schemes proposed by the Government for providing protected water supplies to the rural areas in the country. Panchayat Raj Departments of some states and some Housing Boards have already shown interest in ferrocement water tanks for use in their water supply and housing schemes.

7.0 Design and developmental work

Designs have been developed at the Structural Engineering Research Centre for tanks of 800, 5,000 and 10,000 litres capacity (Figs. 2, 3, 4, 5 and 6).

The first is suitable for individual houses and the other two for community uses. Tanks fabricated according to these designs were subjected to extensive tests to study their short-term and long-term behaviour. Stresses and deflections were found to be within permissible limits. The tanks exhibited a high degree of impermeability.

For simplicity of construction, the tanks have been designed with a flat bottom. However, for relatively large tanks (Type E, diameter exceeding 2.5 m), a shallow spherical dome has been provided for the base to minimize the deflections. In the battery type rectangular tanks (Type D), the base slab deflection is prevented by the action of vertical grid partitions.

8.0 Economy

The cost analysis made on ferrocement water tanks shows a saving to the extent of 40% in the total cost compared to the traditional, brick-walled water tanks (Appendix 1). Capacity, weight, and cost comparison of ferrocement water tanks are shown in Table 2.

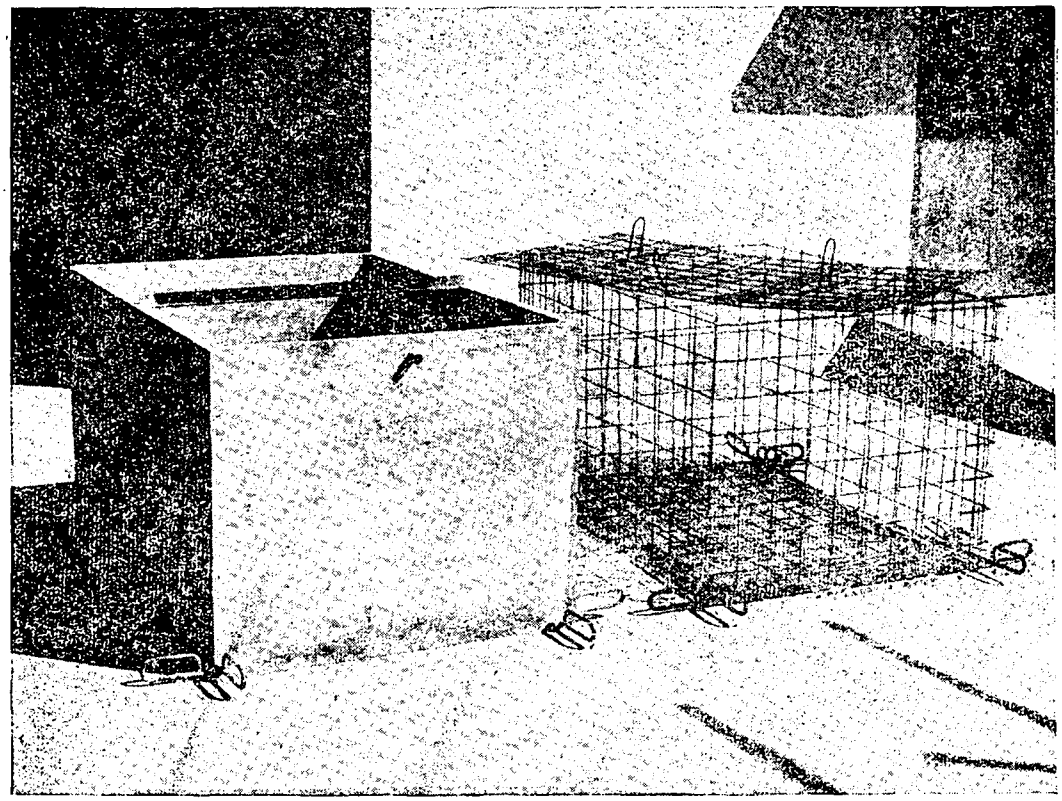


Fig. 2 Ferrocement water tank, 800 litres capacity (Type A)

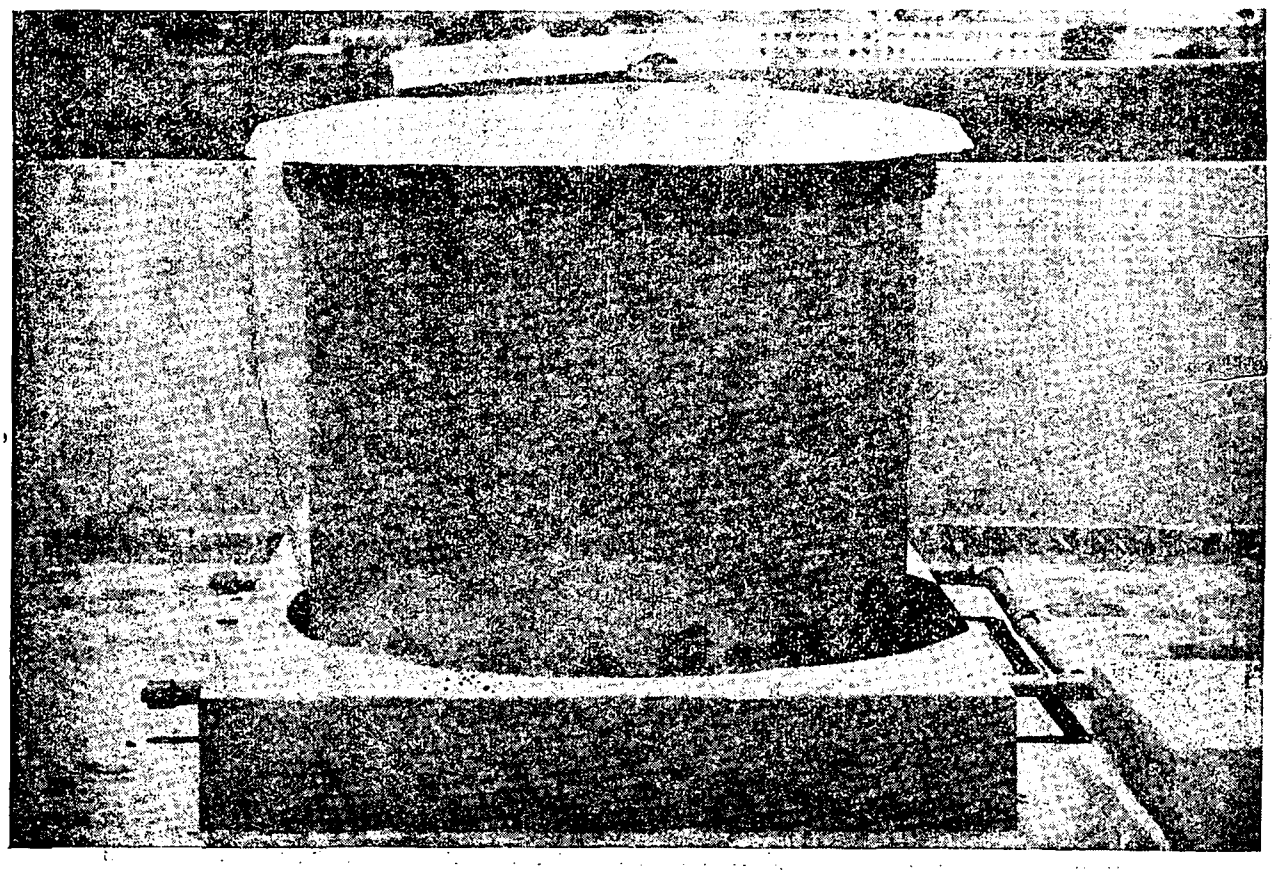


Fig. 3 Ferrocement circular water tank, 800 litres capacity (Type B)

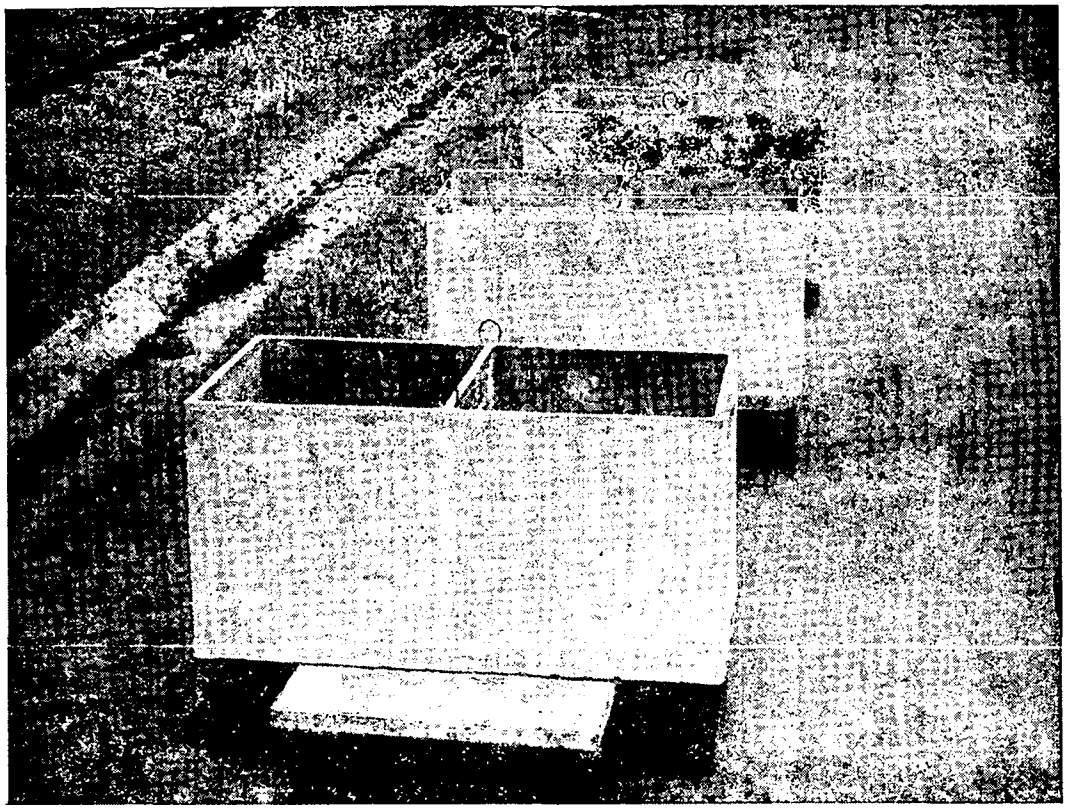


Fig. 4 Ferrocement twin water tank, 2×800 litres capacity (Type C)

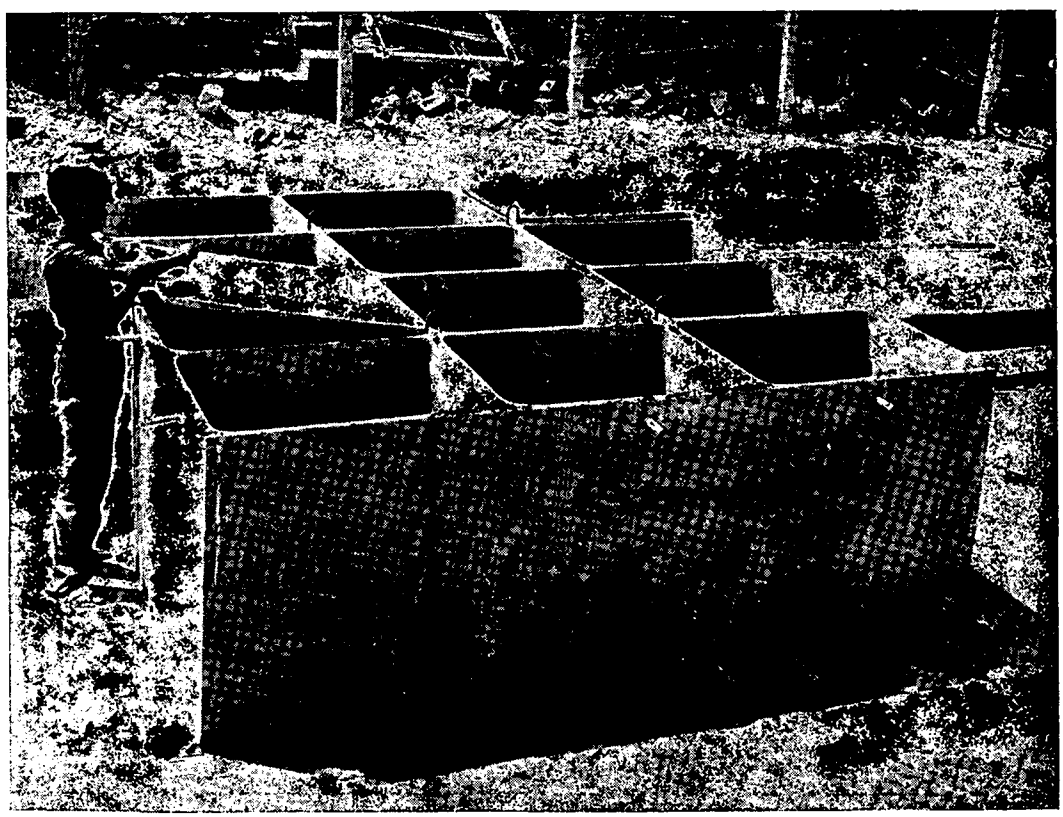


Fig. 5 Battery of rectangular ferrocement water tanks, (625×12) 7500 litres capacity (Type D)

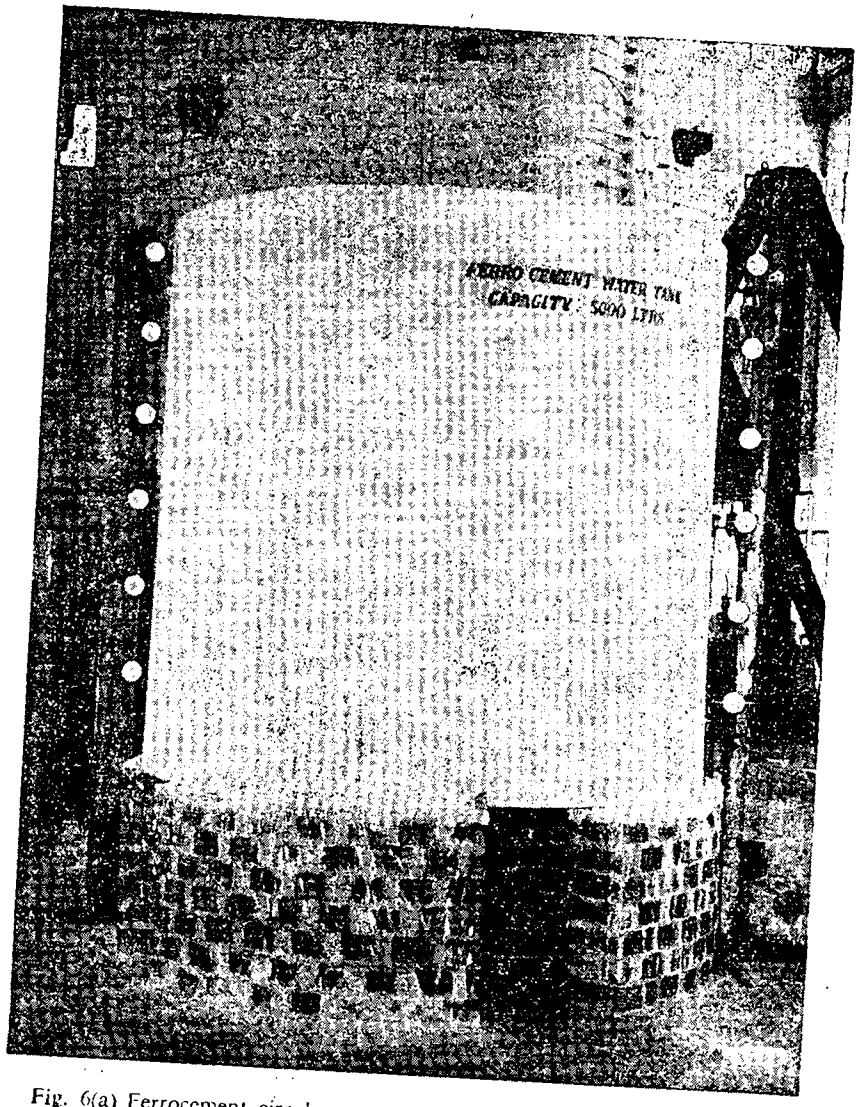


Fig. 6(a) Ferrocement circular water tank, 5,000 litres capacity (Type E), under test

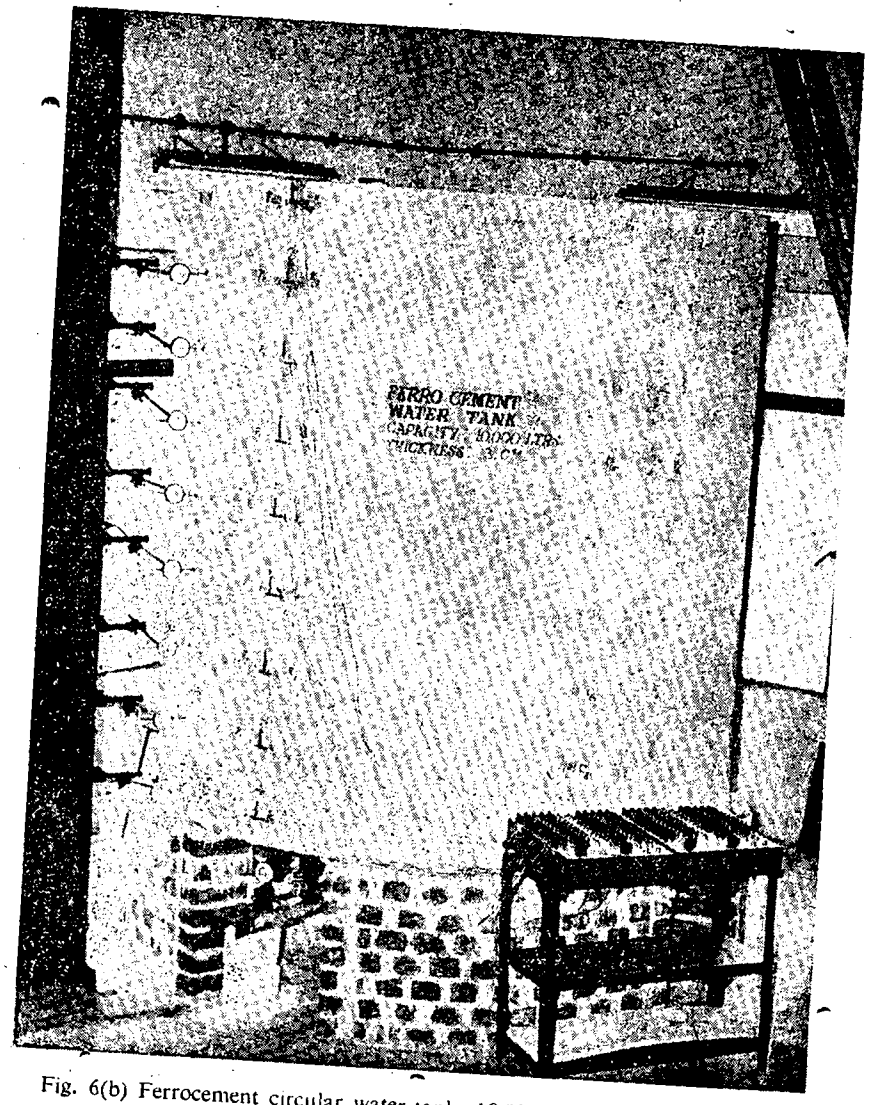


Fig. 6(b) Ferrocement circular water tank, 10,000 litres capacity (Type E) under test

TABLE 1

POSSIBLE SIZES OF FERROCEMENT WATER TANKS BASED ON CAPACITY

Sl. No.	Capacity (litres)	Circular			Square/Rectangular			
		Internal diameter (m)	Height†† (m)	Plan area (m^2)	Inside length* (m)	Inside breadth* (m)	Height†† (m)	Plan area (m^2)
1	300	0.74	0.71	0.430	0.72	0.72	0.58	0.518
2	400	0.81	0.78	0.636	0.80	0.80	0.64	0.640
3	600	0.93	0.89	0.680	0.92	0.92	0.73	0.846
4	800	1.04	1.00	0.850	1.00	1.00	0.80	1.000
5	1000	1.10	1.06	0.950	1.08	1.08	0.86	1.166
6	1500	1.26	1.21	1.227	1.24	1.24	0.99	1.538
7	2000	1.39	1.33	1.517	1.36	1.36	1.09	1.850
8	2500	1.50	1.44	1.767				
9	3000	1.60	1.53	2.010				
10	4000	1.75	1.68	2.405				
11	5000	1.88	1.80	2.776				
12	7000	2.11	2.03	3.497				
13	10,000	2.40	2.30	4.524				

* Suitable rectangular base also can be adopted instead of square

†† Excluding free board

Note : Combinations of the above sizes may be used for multiple and battery type tanks

9.0 Fabrication details

The general fabrication details of ferrocement water tanks of type A, B, C, D and E are given in the Figures mentioned against each type.

Type	A	Fig. 7 (a, b, c)
Type	B	Fig. 8 (a, b, c)
Type	C }	Fig. 9
Type	D }	
Type	E	Fig. 10 (a, b)

9.1 Reinforcement

For making a ferrocement water tank, a welded mesh or mild steel rod cage may be made as per the drawing and covered on either side using chicken mesh or square woven mesh as per the requirement. Both meshes and main mild steel rods should be tied together using binding wire along with the fittings such as scour, inlet, outlet and overflow pipe connections and lifting hooks in the correct positions. Now the cage is ready for casting. Similarly, the reinforcement for top cover slab can be made ready including the necessary lifting hooks.

9.2 Casting platform

Since the cage is made to the required shape, a separate shuttering is not necessary while casting the tank. But, to begin with the casting of base slab a plain and level masonry platform is essential. The casting platform is to be lubricated using mould oil in advance before the casting of the tank.

9.3 Casting

Portland cement and river sand sieved through a sieve with aperture size 2.36 may be mixed dry in 1 : 2 proportion by weight. Water is added to the dry mixed mortar. A water cement ratio of 0.5 may be adopted for the preparation of wet mortar. The mesh cage may be placed on the lubricated level platform and the bottom slab of required thickness may be cast. In the second stage, the vertical walls can be plastered with the cement mortar. A small piece of plywood may be used on the opposite side of the plaster as a backup and the mortar may be forced into the cage from one side, and finished to the required thickness by following the same process from either side. Both the inside and outside surfaces should be finished fine after the initial setting of the mortar.

Cover slab may be cast separately on a level platform and finished fine.

9.4 Curing and transportation

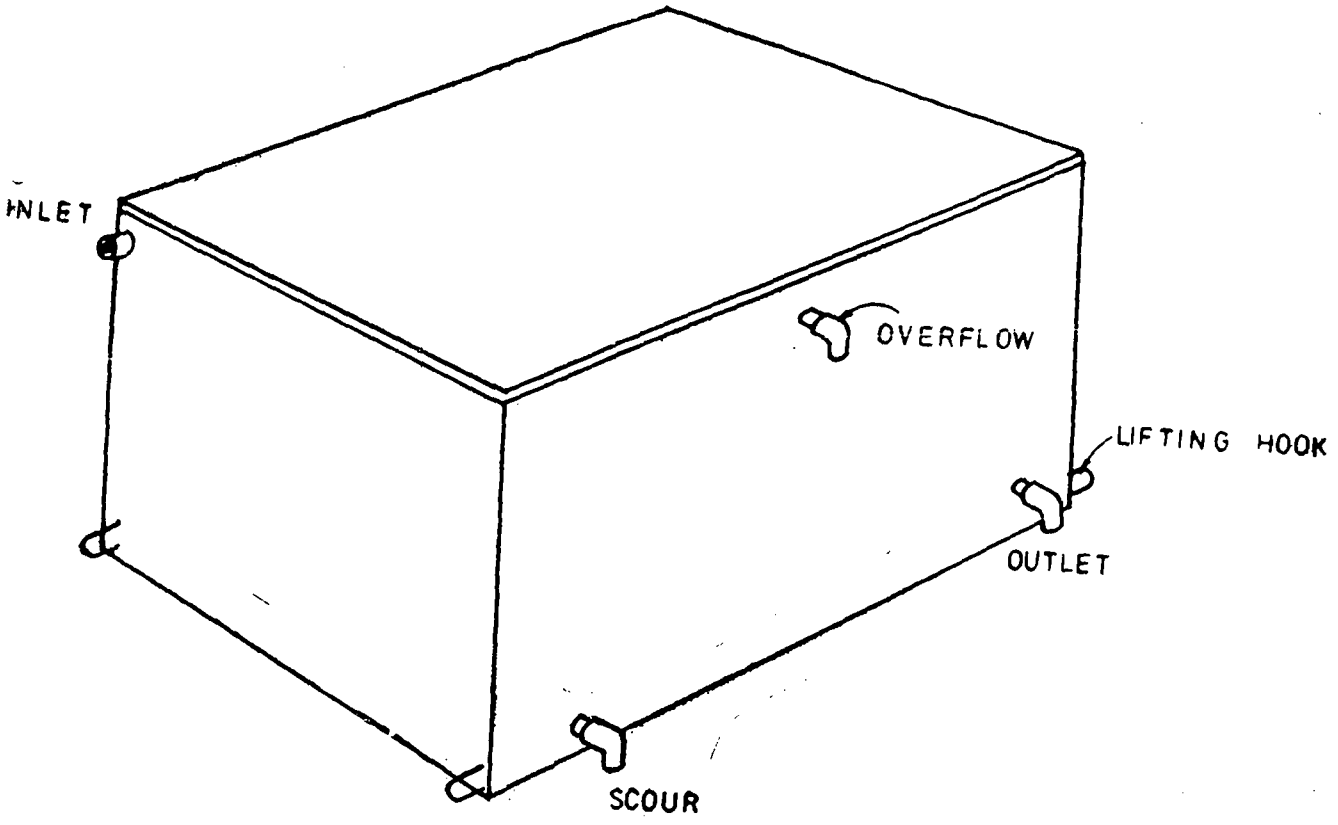
The curing of the tank should be done after 24 hours by using continuous water spray for 7 days. The water tanks will be ready to be handled and transported using lifting hooks by this time.

9.5 Painting

It is always preferable to paint the interior of water tanks using a tankmastic paint of IS-158/8 grade or its equivalent commonly known as drinking water paint. This paint will improve the water tightness.

TABLE - 2 CAPACITY, WEIGHT, AND COST COMPARISON OF FERROCEMENT WATER TANKS

Sl. No.	*Type*	*Description*	*Capacity litres*	*Weight Kg.*	*Cost Rs.*
1	A	Rectangular	800	310	250.00
2	B	Circular	800	300	250.00
3	C	Rectangular Twin	1,600 (800 × 2)	580	470.00
4	D	Rectangular Batteries	7,500 (625 × 12)	3300	2200.00
5	E	Circular	5,000	1500	1200.00
	,,	,,	10,000	2250	2200.00



NOTE :

(a) 1:2 Cement mortar
(b) Wall thickness 2.5 cm
(c) Welded mesh 10 Gauge×10 Gauge - 10cm×10cm
(d) Wiremesh 26 Gauge, 2 layers hexagonal 11.5mm spacing
(e) Suitable lifting hooks are to be provided

Fig. 7(a) Ferrocement rectangular water tank, (Type A) 800 litres capacity

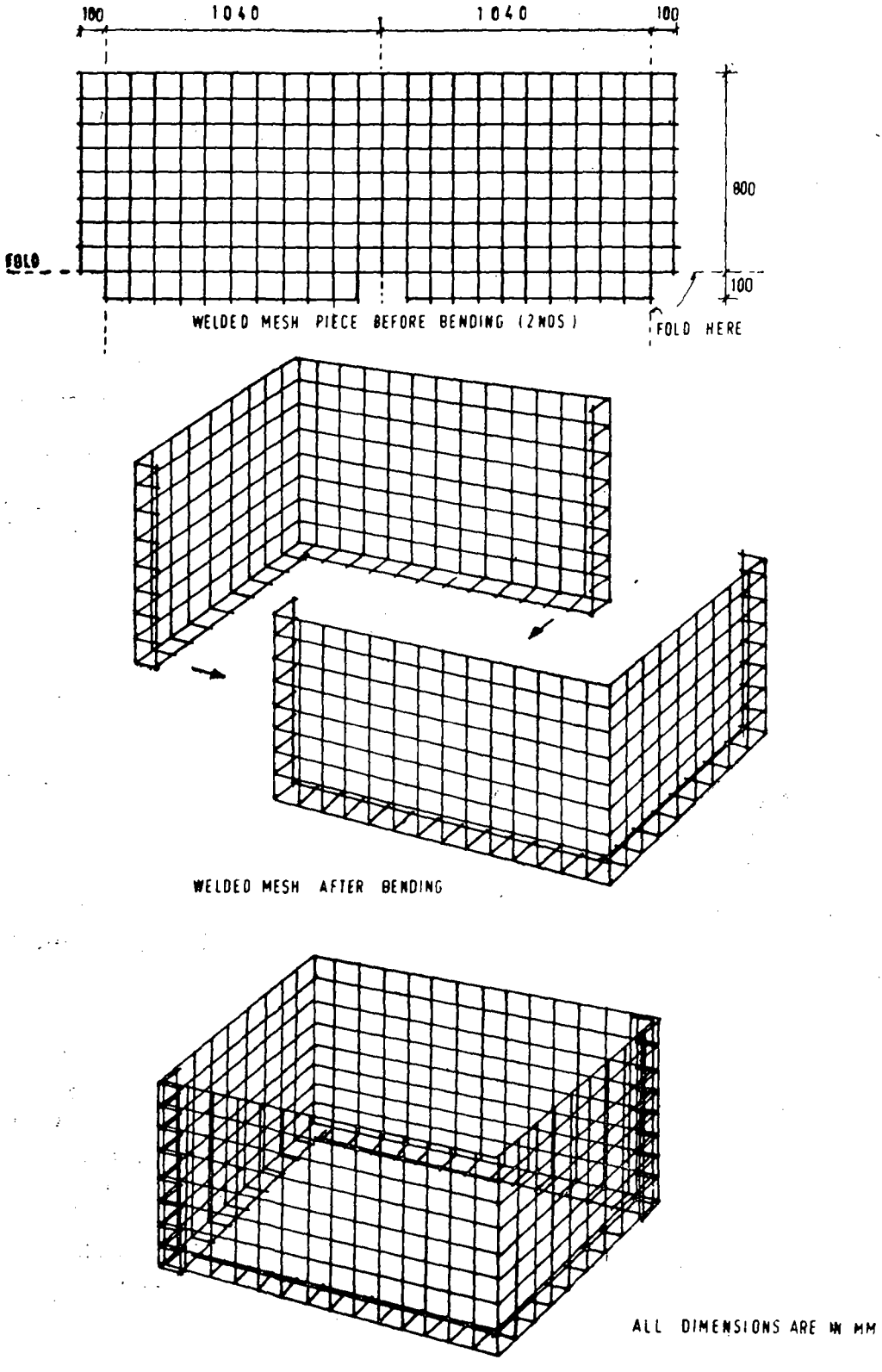


Fig. 7(b) Details of welded mesh for square or rectangular tanks (Type A)

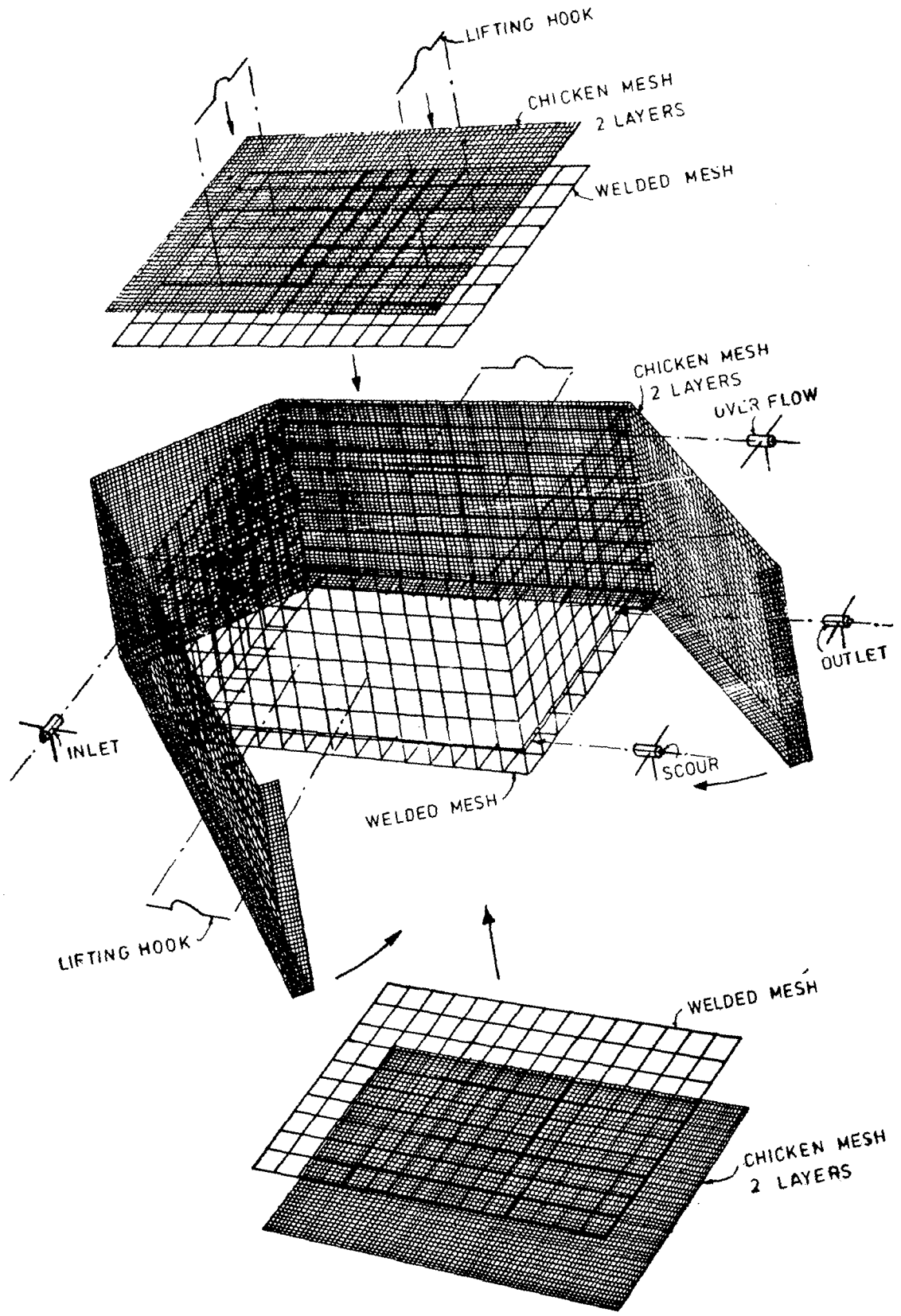
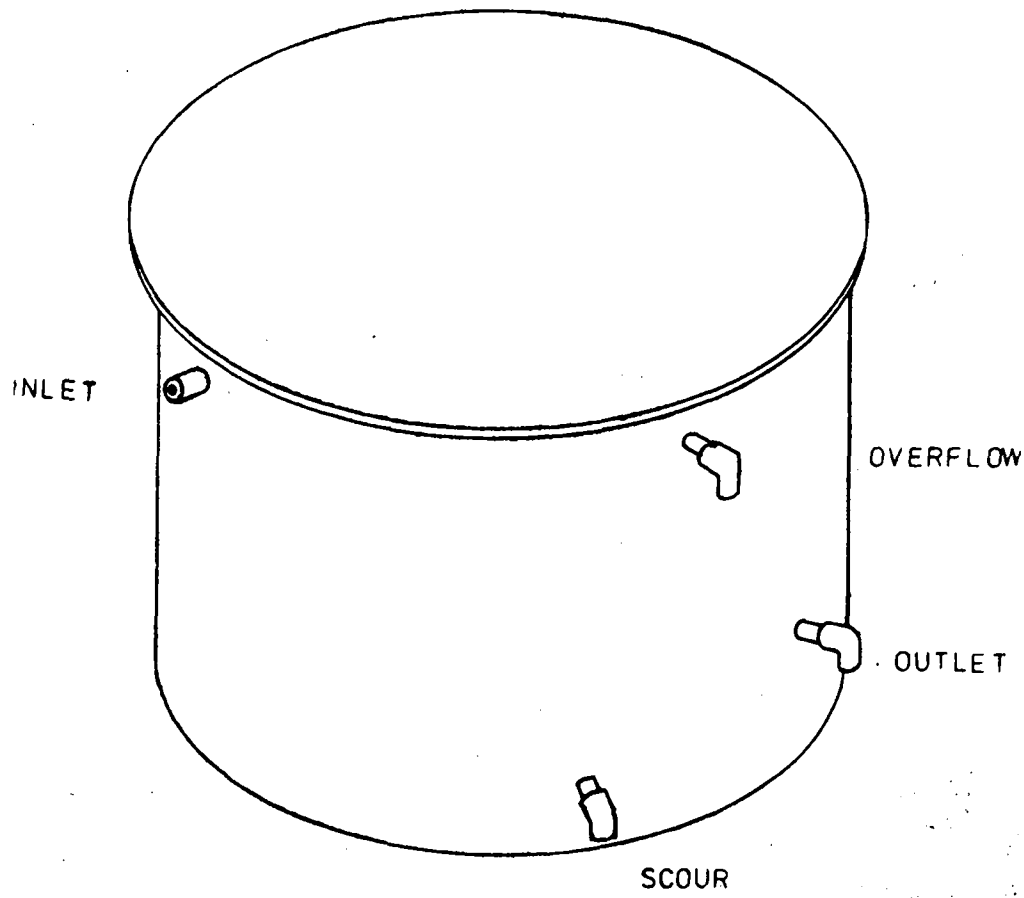


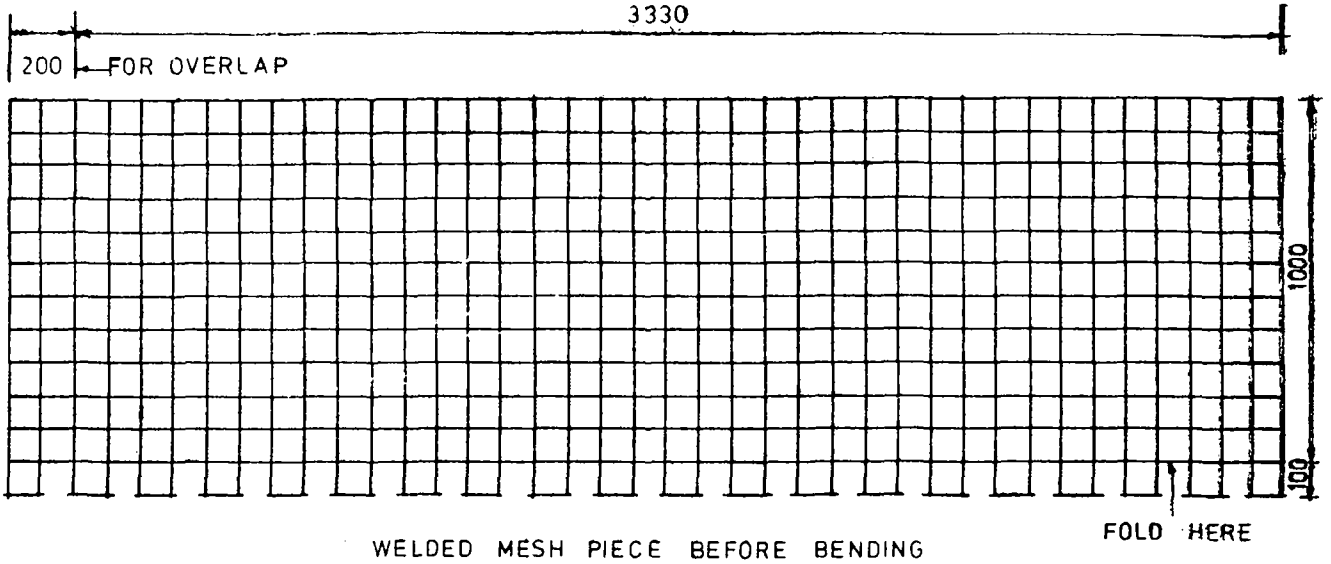
Fig. 7(c) Details of mesh for square or rectangular tanks (Type A)



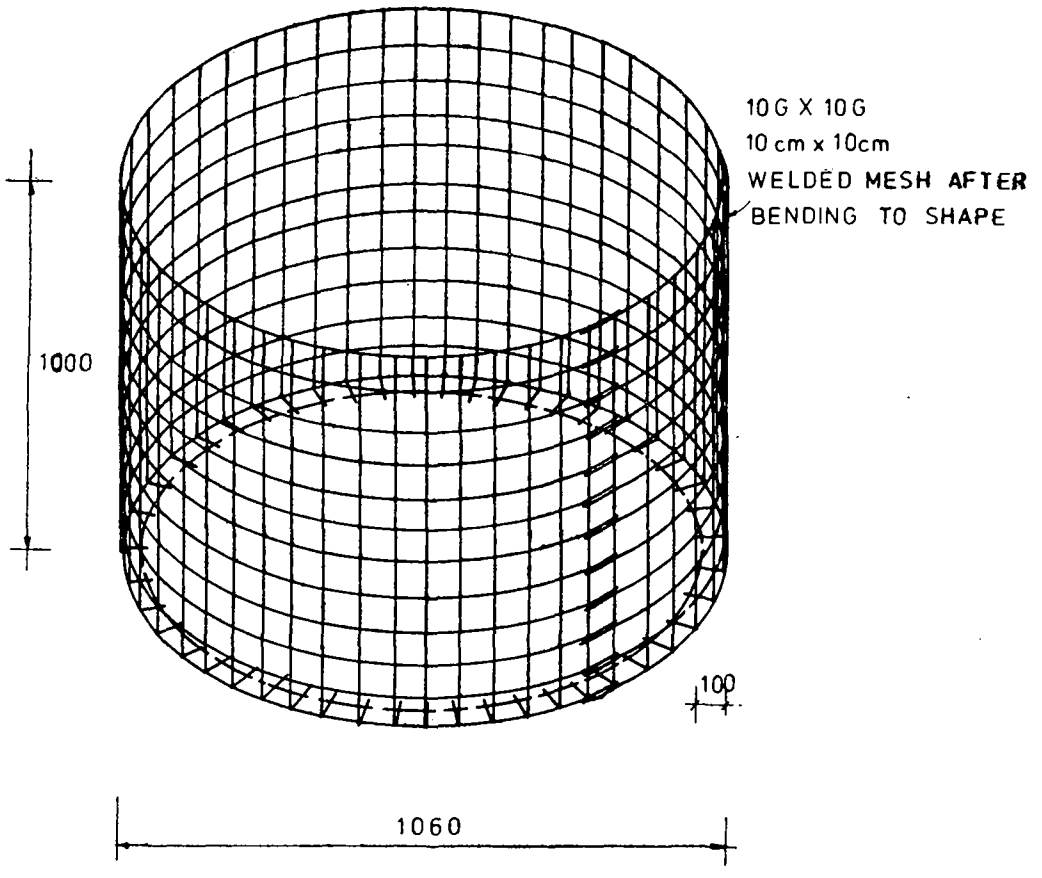
NOTE :

(a) 1 : 2 Cement mortar is to be used
(b) Wall thickness 2.5 cm
(c) Welded mesh 10 gauge×10 gauge - 10 cm×10 cm
(d) Wiremesh 26 gauge, 2 layers hexagonal 12.5mm spacing
(e) Suitable lifting hooks are to be provided

Fig. 8(a) Ferrocement circular water tank, 800 litres capacity (Type B)



WELDED MESH PIECE BEFORE BENDING
(FOR SIDE WALL)



ALL DIMENSIONS ARE IN MILLIMETERS

Fig. 8(b) Details of welded mesh for circular tanks (Type B)

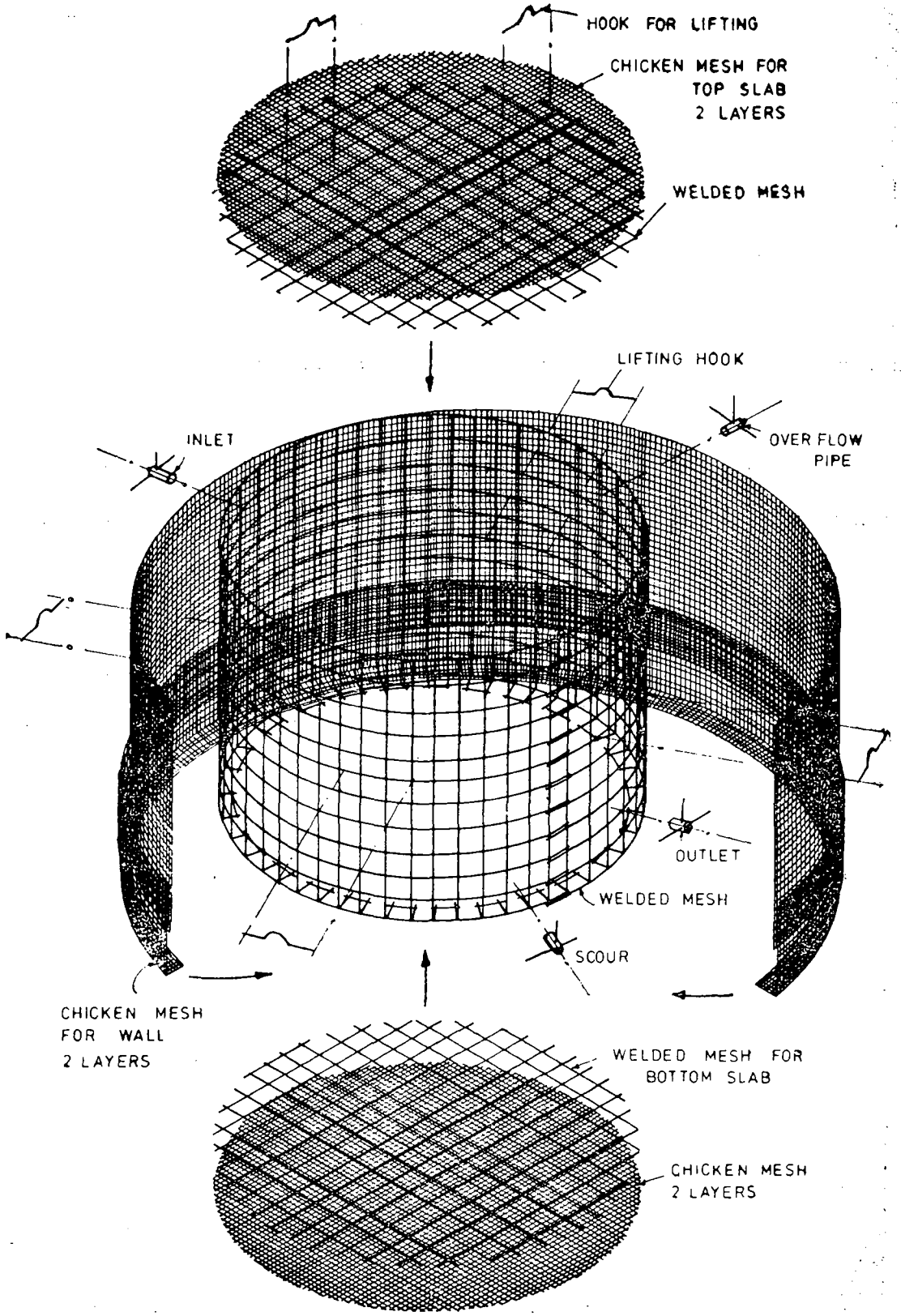
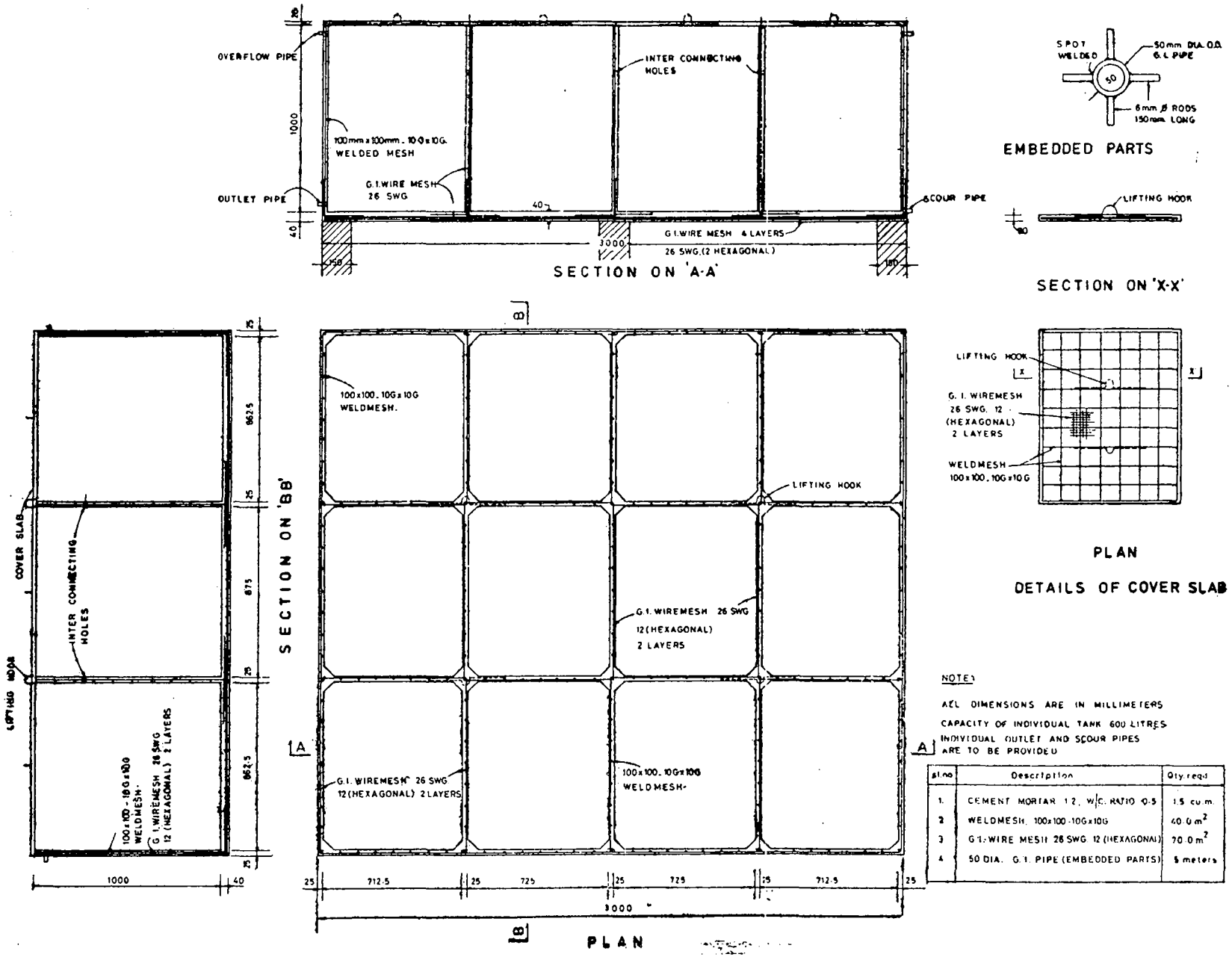
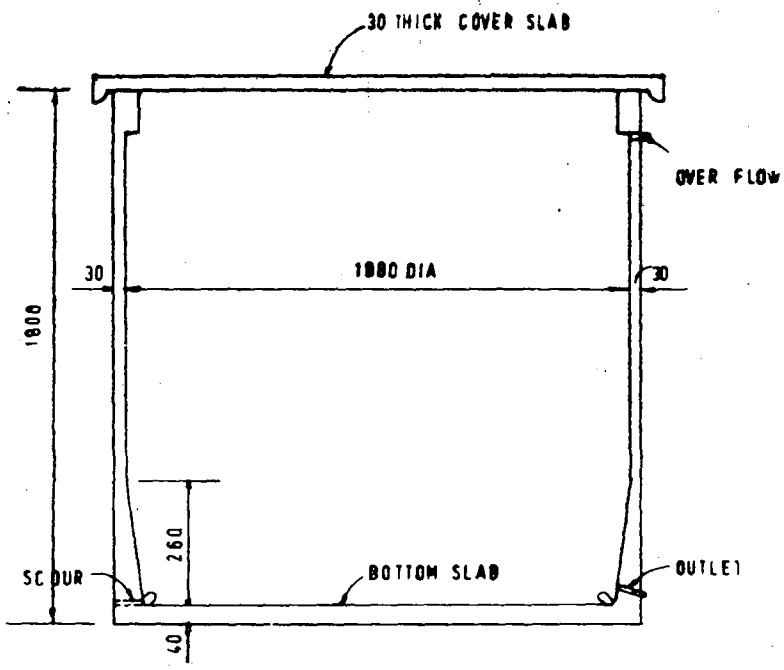


Fig. 8(c) Details of mesh for circular tanks (Type B)

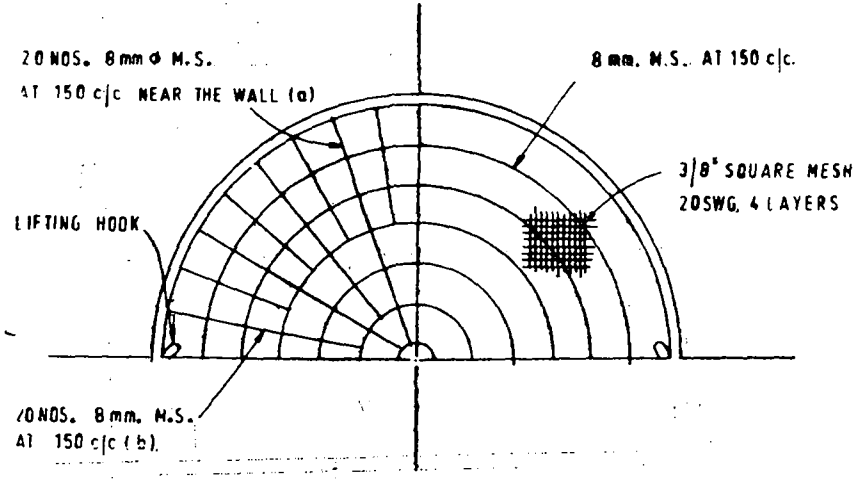


sl.no	Description	Qty. req'd
1.	CEMENT MORTAR 1:2, W/C. RATIO 0·5	1·5 cu.m.
2	WELDMESH, 100x100-10Gx10G	40·0 m^2
3	G.I. WIRE MESH 26 SWG 12 (HEXAGONAL)	70·0 m^2
4	50 DIA. G.I. PIPE (EMBEDDED PARTS)	5 meters

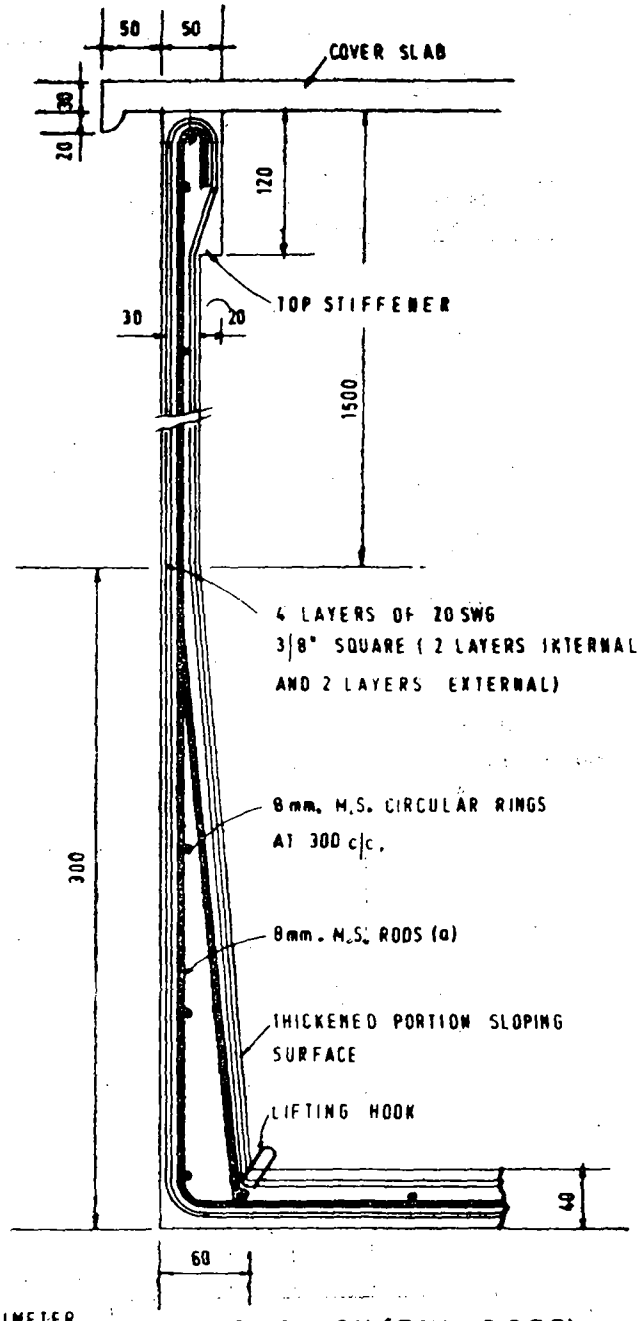
Fig. 9 Battery of rectangular ferrocement tanks (Type D) 7500 litres capacity (12×625 litres approx.)



SECTION ON 'A-A'



PLAN



NOTE: ALL DIMENSIONS IN MILLIMETER

SECTION (ENLARGED)

Fig. 10(a) Ferrocement water tank, 5,000 litres capacity (Type E)

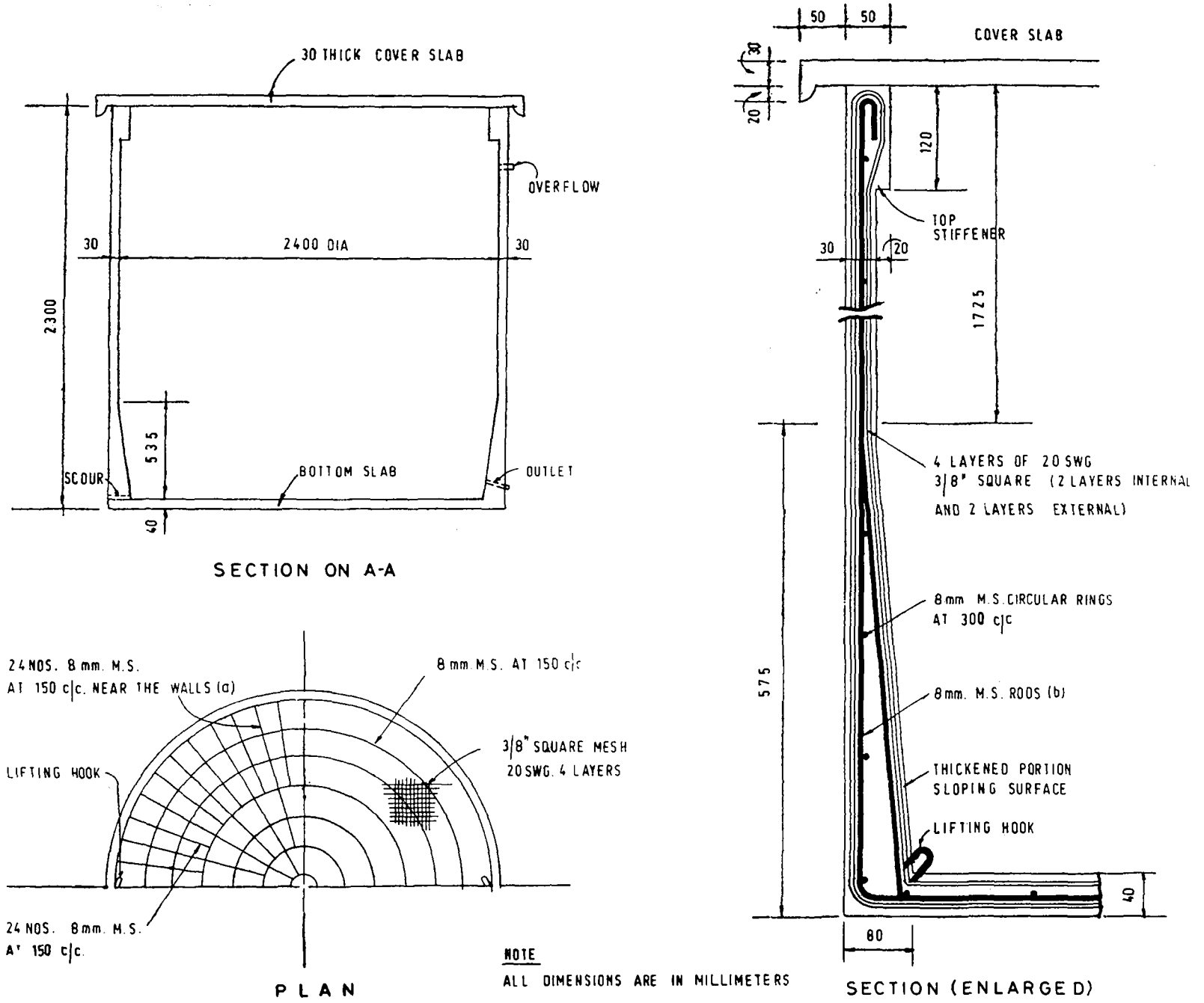


Fig. 10(b) Ferrocement water tank, 10,000 litres capacity (Type E)

APPENDIX 1

I. COST OF FERROCEMENT WATER TANKS OF 800 LITRES CAPACITY

Rectangular (Type A)

Clear size 1.00m × 1.00m × 0.8m (h)

1. Qty. of welded mesh 10 gauge × 10 gauge — 10cm × 10cm

Base slab	= 1.00 × 1.00 =	1.00 m^2
Side wall	= 4.20 × 1.00 =	4.20 m^2
Cover slab	= 1.00 × 1.00 =	1.00 m^2
		6.20 m^2
Add for wastage		0.80 m^2
Total		7.00 m^2

2. Chicken mesh 20 gauge - spacing 1.25 cm

Base slab	= 2 × 1.00 × 1.00 =	2.00 m^2
Side wall	= 2 × 4.20 × 1.00 =	8.40 m^2
Cover slab	= 2 × 1.00 × 1.00 =	2.00 m^2
		12.40 m^2
Add for wastage		0.60 m^2
Total		13.00 m^2

3. 6 mm M.S. rod

For hook - 2 × 0.6m × 0.22	= 0.30 Kg
Fins of fixtures 4 × 0.15m × 3 × 0.22 =	0.40 Kg
	0.70 Kg

4. Cement

Volume of cement mortar 1 : 2

Base slab	= 1.04 × 1.04 × 0.03 = 0.034 m^3
Cover slab	= 1.08 × 1.08 × 0.03 = 0.035 m
Side wall	= 4.08 × 0.80 × 0.02 = 0.065 m^3
	0.134 m^3

Quantity of cement required

0.134 × 720	= 97.00 Kg
Add for wastage	= 13.00 Kg
Total	110.00 Kg

5. Sand

Sand required	= 0.134 m^3
Wastage etc.	= 0.013 m^3
	0.147 m^3

6. Labour L. S.

7. Welding L. S.

COST

		Rs. P.
1	Weld mesh 7.00 m^2 at Rs. 8/m^2	= 56.00
2	Chicken mesh 13.0 m^2 at Rs. 6.00/m^2	= 78.00
3	6 mm M.S rod 0.7 Kg at Rs. 2472/M.T.	= 1.69
4	Cement 2.2 bags at Rs. 21/bag	= 46.20
5	Sand 0.147 m^3 at Rs. 35/m^3	= 5.15
6	Labour L.S.	= 40.00
7	Welding of fins for outlets and scour	= 10.00
8	Oil, grease, mixer, etc. L.S.	= 12·00
	Total	= 249.04
	Say	= 250.00

Cost per litre = Rs. 0·31

Cost per gallon = Rs. 1.42

II CONVENTIONAL WATER TANK WITH BRICK WORK, 800 LITRES CAPACITY

Size of the tank = 4'0" × 3' 0" × 2'4½"

1. **Cement concrete 1 : 1½ : 3 for RCC base slab**

Base slab = 1 × 5'6" × 4'6" × 0'4" = 8.25 cft or (0.233 m³)

2. **Brick work in CM 1 : 3 using stock bricks :**

Wall alround = 1 × 17'0" × 0'9" × 2'4½" = 30.28 cft (0·857 m³)

3. **Plastering with CM 1 : 3, ½" thick mixed with water proofing compound**

Bottom 1 × 4'0" × 3'0" = 12.00 sft
Inside 1 × 14'0" × 2'4½" = 33.25 sft

Total 45.25 sft (4.20m²)

4. **Plastering with CM 1 : 5, ½" thick**

Outside 1 × 20'0" × 2'10½" = 57.50 sft (5.34 m²)

5. **Providing form work**

Bottom of base and cover slab 2 × 4'0" × 3'0" = 24.00 sft

Side of base slab 1 × 20'0" × 0'4" } = 10·00 sft
1 × 20'0" × 0'2" }

34.00 sft

Total (3.16 m²)

6. **Cement concrete 1 : 2 : 4 for RCC cover slab**

Cover slab: 1 × 5'6" × 4'6" × 0'2" = 4·13 cft
Deduct for manhole cover: 1 × 1'6" × 1'6" × 0'2" = 0·38 cft

Net Total 3.75 cft) (0·106m³

7. **Fabrication of mild steel : 2·3 × 9 = 20·7 Kg**

8. 18" × 18" **G.I. manhole cover fan** 1 × 1 = 1 No.

ABSTRACT

	Rs. P.
1. C.C. 1 : 1½ : 3 for base slab excluding cost of steel and formwork 0·233 cum at Rs. 265·92/cum	61·96
2. Brickwork in CM 1:3, 0·857 cu.m at Rs. 138·87/cum	119·01
3. Plastering with CM 1:3, ½" thick mixed with W.P.C. 4.20 sq.m at Rs. 6·00/ sqm	25·20
4. Plastering with CM 1:5, ½" thick 5.34 sqm at Rs. 3.95/m²	21.09
5. Formwork 3.16m² at Rs.14·32/m²	45·25
6. C.C. 1:2:4 for RCC cover slab 0·106 cum at Rs. 224.85/m³	23·83
7. Mild steel cost including fabrication charge	51·17
8. Manhole cover fan with erection charge	32·00
Total	379·51
Say Rs.	380·00

Cost per litre Rs. 0·48

Cost per gallon Rs. 2.16

REFERENCES ON FERROCEMENT WATER TANKS

"Ferrocement Tanks and Utility Buildings", New Zealand Concrete Construction, July 1968, pp.110-114

Geolite, T.N. "Polymer impregnated ferrocement storage tanks", *Report No.* 4, Catalina National Inc., No. 1557, 24 pp.

Guerra,A.J., Naaman, A.E., and Shah, S.P.," Ferrocement cylindrical tanks, cracking and leakage behaviour", *ACI Journal,* January 1978

Naaman,A.E. and Shah, S.P., "Evaluation of ferrocement in some structural applications", *Proceedings of IAHS Symposium*, Atlanta, Georgia, USA, May 24-28, 1976, pp,1069-1085.

NAS, "Ferrocement—Application in developing countries", *A Report of an Ad-hoc Panel of the Advisory Committee on Technological Innovations*, Bostid, National Academy of Sciences, Washington D.C., February 1973, 90 pp.

LIST OF REFERENCES ON FERROCEMENT (GENERAL)

Abdulkarim, E., and Paul Joseph, G., "Investigation on the flexural behaviour of ferrocement and its application to long span roofs", *Journal of Ferrocement*, AIT-IFIC, Bangkok, Thailand, January 1978.

ACI, ACI Committee 506, "Shotcreting" ,*ACI Publication SP*-14, 1966, 223pp.

ACI, ACI Committee 506, "Recommended practice for shotcreting", *ACI Standard* 506-66, 1966, 26pp.

Bigg, G.W,, "An introduction to design for ferrocement vessels", *Project Report No.* 52, Industrial Development Branch, Fisheries Serivce, Dept. of Environment, Ottawa, January 1972.

Calder, W.W., "Chart for the resistance moment of concrete slabs reinforced with expanded metal", *Illustrated Carpenter and Builder,* Vol. 146, 4162, June 1957, p.142.

Cassie W.F., "Lambot's boats.—A personal rediscovery", *Journal of the Concrete Society, Concrete*, Cement and Concrete Association, Vol. 1, No. 11, November 1967, pp. 380-382.

CCAA, "Ferro-cement Boats", *Concrete Information Bulletin*, C—39, Cement and Concrete Association of Australia, pp.9.

Chiang, F.P., and Narayanan, T., "On pure bending of ferrocement beams", *Report No.* 223, Dept. of Mechanics, College of Engineering, Staff University of New York, Stoney Brook, March 1972.

Collen. L.D.G., and Kirawn, R.W., "Some notes on the characteristics of ferrocement", *Civil Engineering and Public Works Review*, London, England, Vol. 54, No. 631, February 1959, pp. 195-196.

Desayi, P., And Jacob, A.K., "Strength and behaviour of ferrocement in tension and flexure", *Proceedings, Symposium on Modern Trends in Civil Engineering ,Vol.* 1, University of Roorkee, November 1972, pp. 274-279.

Gopalakrishnan, R.J., "Ultimate moment and flexural Rigidity of ferrocement folded plate beams", *Proceedings of Symposium on Ultimate Load Design of Concrete Structures,* PSG College of Technology, Coimbatore India, 1967, pp. 83-89.

Greenius, A.W., and Smith, D., "Ferrocement for Canadian fishing vessels, Vol. 2", *Project Report No.* 48, Industrial Development Branch, Fisheries Service, Department of Environment, Ottawa, January 1972

Harris, A.J., " Concrete boat building", *Concrete Quarterly*, No. 83, October-December 1969, pp. 26-28.

ICJ., "Small ferrocement ships for inland water transport", *Indian Concrete Journal*, Vol. 30. No. 11, November 1956, pp. 358-360.

Kelly, A.M., and Mouat. T.W.," Ferrocement as a fishing vessel construction material", *Conference on Fishing Vessel Construction Materials,* Montreal, October 1968.

Khaidukov, G.K., "Development of armocement structures.," *Bulletin of the International Association for Shell structures*, No. 36, December 1968, pp. 85-97

Lachance, L., and Fugere, P., "Ferro-shotcrete for thin shell structures", *Bulletin of IASS*, No. 44, December 1970, pp. 13-18

Logan, D, and Shah S.P. "Moment capacity and cracking behaviour of ferrocement in flecture", *Journal of the American Concrete Institute*, Proceedings, Vol. 70, No. 12, December 1973, pp. 799-804.

Lorman, W.R., " Engineering properties of shotcrete" *ACI Publication, SP-14A*, 1968, pp.53.

Mahaffey, P.I., " *Ferrocement - Technical Memorandum*", Cement and Concrete Association of Australia, May 1970.

Muhlert,H.F., "Analysis of ferrocement in bending", *Report No.* 043, Department of Naval Architecture and Marine Engineering, University of Michigan, January, 1970.

Naaman, A.A., and Shah, S.P., "Tensile tests of ferrocement", *Journal of the American Concrete Institute*, Proceedings, Vol.68, No. 9, September 1971, pp.693-698

Nervi.P.L., "*Ferrocement—Its Characteristics and Potentialities*," Cement and Concrete Assocaition, London, England, Library Translation, No. 60, 1956.

Nervi,P.L., "Naval Construction in Ferrocement", *L'Industries Italiana Delcements (Rome)*, Vol. 20, No. 7-8, July-August 1950, pp. 163-166.

Nervi, P.L., "*Structures*", Translated by Giuseppina and Mario Salvadori, F.W. Dodge Corporation, New York, 1956.

Rajagopalan, K., and Parameswaran, V.S., "Analysis of ferrocement beams", *Journal of Structural Engineering*, Vol. 2, No. 4, January 1975. pp. 155-164,

Rajagopalan, K., and Parameswaran, V.S., "Cracking and ultimate strength characteristics of ferrocement in direct tension and in pure bending", *Indian Concrete Journal*, Vol. 48, No. 12. December 1974. pp. 387.

Rao.,A.K., and Gowder,G.S.K., " A study of behaviour of ferrocement in direct compression", *Cement and Concrete*, India ,Vol.10, No. 3, October-December, 1969, pp. 231-237

Rao. A.K., and Gowder, G.S.K., "A study of the behaviour of ferrocement in flexure," *Indian Concrete Journal*, Vol. 45, April 1971, pp. 178-183.

Romualdi, I.P., and Batson, G.B., "Behaviour of reinforced concrete beams with closely spaced reinforcement", *ACI Journal*, June 1963.

Romualdi, J.P., and Mandel, J.A., "Tensile strength of concrete affected by uniformly distributed and closely spaced short lengths of wire reinforcement, *ACI Journal*, Proceedings, Vol. 61, No. 6, June 1974.

Scott, W. H. (Editor), "Ferrocement for Canadian fishing vessels", *Project Report No.* 42, Industrial Development Branch, Fisheries Service, Dept. of Environment, Ottawa, August 1971.

Shah, S.P., and Key, W.H., " Impact resistance of ferrocement", *Journal of Structures Division*, Proceedings of American Society of Civil Engineering, Vol. 98, STI, January 1972, pp. 111-123.

Thomas, G., "Ferrocement boats", *Indian Concrete Journal*, Vol. 45, No. 8, August 1971, pp. 178-183.

Thurston, T.G., "On the design and construction of self propelled sea-going cargo steamer, now building in Great Britian", *Transactions of INA*, Vol 60, 1918.

Van Riel, A.C., Beranek, W.J., and Bouma, "Test on shell roof model of reinforced mortar", *Proc. of Second Symposium on Concrete Shell Roof Construction*, Oslo, 1-4, July, 1957.

Viswanath, C., Mhatre, R.P., Seetharamulu, K., "Test of a ferrocement precast folded plate", *Journal of Structural Division*, Proceedings of ASCE, Vol. 91, No.6, December 1965, pp. 239-245.

Walkus, R., "State of cracking and elongation of ferrocement under axial tensile load 2", *Bulletinul Institutui Politechnic*, DIN IASI, Tomul XVI (XX), FAC. 3-4, SECJIA V, Construcji Hydrotechnica, 1970.

Walkus, R., and Kowalski, T.G., "Ferrocement-A Survey", *Concrete (London)*, Vol. 5, No. 2, February, 1971 pp. 13-18

For further details, please contact :

Director
Structural Engineering Research Centre
CSIR Campus,
Adyar, Madras 600 020.

Scientist (Liaison & Information)
Structural Engineering Research Centre
CSIR Campus,
Adyar, Madras 600 020.

Telephone : 412139
412343

Grams : SERCENTER

Telex : MS 363

Cover design
P. A. Fredric

Photographs
T. N. Gangadharan

Drawings
R. Ramanujam
P. A. Fredric

Editing and Publication
N. Balasubramanian
C. C. Ravindran

PRINTED AT
St. Louis Institute of Printing for the Deaf,
Adyar, Madras-600 020.