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FERROCEMENT CONCRETE TANKS FOR RURAL WATER SUPPLY SCHEMES

Compiled by

ENVIRONMENTAL ENGINEERING RESEARCH DIVISION, MERI.

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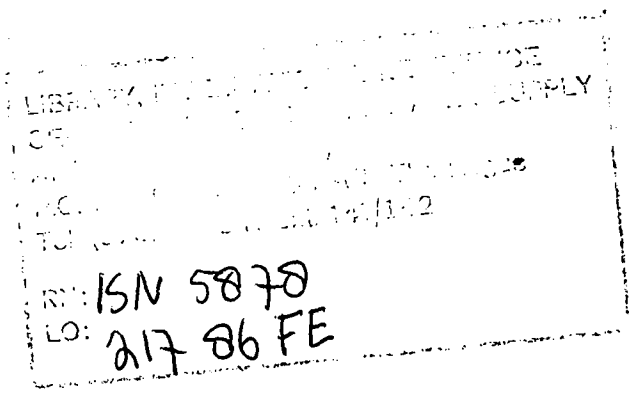
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FERROCEMENT CONCRETE TANKS FOR RURAL WATER SUPPLY SCHEMES

- R. K. KULKARNI

1. Definition of Ferrocement :

Ferrocement is a type of thin wall reinforced concrete construction where usually a hydraulic cement is reinforced with layers of continuous and relatively small diameter mesh.

2. Characteristics of Ferrocement :

2.1 The wire mesh (reinforcement) is much stronger in tension compared to the matrix (mortar). The role of the matrix is to hold the mesh in place, to give a proper protection and to transfer stresses by means of adequate bond.

2.2 Compression strength of this composite is generally a function of the matrix compressive strength, while the tensile strength is a function of mesh content and its properties.

3. Material :

3.1 Cement :

Ordinary Portland cement - fresh cement of uniform consistancy and free from lumps and any other foreign matter.

3.2 Sand :

3.2.1 Particular attention is to be paid to the quality of sand, as it constitutes about 60% of the total volume of ferrocement. Sand should be clean, hard, strong, free of organic impurities and deleterious substances.

3.2.2 Recommended grading is given in Table below -

Sieve size US	Sieve size IS	Percent passing by weight
3/8"	(9.5 mm)	-100
No. 4 - 7/16"	(4.75 mm)	95-100
No. 8 - 7/32"	(2.36 mm)	80-100
No. 16 - 7/64"	(1.18 mm)	50-85
No. 30 -	(600 micron)	25-60
No. 50 -	(300 micron)	10-30
No. 100 -	(150 micron)	2-10

3.3 Aggregate : (for base)

Aggregate should be well graded with maximum size of 10 mm crushed stone/ gravel, strong and non-porous and free from silt or organic matter.

3.4 Water :

Water for mixing should be fresh and free from organic impurities and harmful chemical substances which may lead to deterioration in the properties of water. Sea water should not be used.

3.5 Reinforcement :

3.5.1 Wire Mesh :

The wire mesh reinforcement should be woven or welded square galvanized wire mesh (conforming to ASTM A-185 or equivalent) with a wire diameter not more than 1/16" (usually 18 gauge or 1.3 mm is used) and spacing of about 1/2" (12 mm).

3.5.2 Skeletal Steel :

Steel bars are used for making a frame of the structure over which the mesh is placed. Use of 6, 8 or 10 mm bars conforming to ASTM A-615 and ASTM A-616 (or equivalent) is recommended.

3.5.3 Binding Wire :

For tying mesh layers to skeletal steel, use of annealed (soft) galvanised wires of 24 or 26 gauge is recommended.

3.6 Water Proofing Compound :

Approved water proofing compounds can be used.

3.7 Coatings :

Two coats of any cold, fast setting bituminuous paint are applied to the exterior portion (if desired). Two coats of any non-toxic water tank paint are recommended for the interior side. This helps in filling in any hairline, surface cracks and retards growth of algae.

4. Design and Reinforcement Details :

These have been given in a separate table.

5. Construction :

5.1 Tank supports and foundation should be constructed on soils with adequate bearing capacity and not on uncompacted back fill.

5.2 The bars are cut to specified lengths and bent to proper profile and welded or tied to each other in proper sequence. For tied reinforcement, additional lengths of laps are provided to ensure rigid connections between component bars.

5.3 Cage for roof is fabricated separately and fixed to the base wall unit so that, adequate lap is available between projecting vertical bars of walls and radial bars of the roof.

5.4 Tying wire mesh - One layer of mesh is tied on the inside of the skeletal frame and the other on the outside using tying wires. These mesh

wires should be tied at 20 cms spacing in vertical and circumferential directions stretching the meshes taut. Where the meshes have to be joined 10 cm overlap should be provided. For roof-wall joint, mesh layers should have laps of 10 cms each on wall portion as well as on roof dome. Similar overlap is provided for wall base joint. The two layers of mesh are staggered such that, the effective opening size is reduced to half of the individual mesh opening. This misalignment provides uniform distribution of reinforcement and better bond for the mortar while plastering.

5.5 Plastering :

5.5.1 The recommended mortar mixes to be used are :

Cement : Sand : Water : 1 : 2 : 0.4 (A & B)

Cement : Sand : aggregate : Water : 1 : 2 : 3 : 0.5 (Type B only)

Note : Type A (In Situ) : Type B (Transportable and Mountable).

5.5.2 Water proofing or other similar admixtures should be thoroughly dry mixed with cement and sand before water is added. The mortar is mixed in batches in such a maner that, each batch of mixed mortar is placed within an hour after mixing. Consistency of the mortar mixed should be the same for all batches.

5.5.3 Prior to plastering, it should be ensured that reinforcement cage is in place including auxiliary fittings like inlet, outlet, overflow scour pipes, lifting handles and locking hooks.

5.6 Floor :

5.6.1 Type a (In situ) - The ground is levelled from a circular area of diameter 75 cms. greater than the designed diameter of the tank. Polytheylene sheet is spread over this area. This sheet prevents direct contact of wet mortar with the soil and also facilitates shifting of tank if so decided, at a later date. The reinforcement cage is placed over wet mortar and moved so that, mortar layer penetrates bottom layer of mesh in the tank base and the cage gets an effective cover of 5 mm. Mortar is then spread inside the tank base and levelled as per designed thickness.

5.6.2 Type B (Transportable and mountable on column) - The mesh layer inside the base of the tank is cut at places and temporarily rolled up the wall. A 2 cms. thick layer of wet mortar is placed over a polythylene sheet. The reinforcement cage is placed over this and moved to ensure proper penetration of the mortar onto the base and to maintain clear effective cover of 5 mm. Mortar is now spread inside the hole to just cover the base skeletal grid. A 2 cm thick layer of 1 : 2 : 3 is laid after 16 to 20 tying wires are left projecting from the base skeletal grid. Mortar is plastered on to wall upto 5 cm height, so that, wall-base joint is monolithic. The concrete surface in the base is roughened up with a steel fibre brush and left to harden for 24 hours. After concrete layer is hardened, the inside layer of mesh (which was previously rolled up) is rolled down onto concrete surface. The tying wires left projecting out of concrete surface are used to tie down the inside bars mesh. Cement slurry is brushed over concrete layer and mortar is laid again. the mortar is spread inside the tank base providing a 5 mm cover to the inside layer of mesh.

5.7 Walls and Roof :

Plaster is applied by a mason from the inside pushing mortar onto the layers of meshes with the assistance of another person (helper) holding a sheet of plywood or galvanised iron on the corresponding area outside. The helper shifts the backing of plywood or galvanised iron to adjoining area when the plastering is completed on the earlier region. The mortar should be well compacted and 3 mm cover provided on finishing both the inside and outside surfaces. Special case is necessary while plastering around inlet, outlet, overflow and scour fittings. When first application of mortar on wall and roof are completed, coir brush is used to scrape off excessive mortar built up and making the layer rough to improve adhesion to the finishing layer. The water tank is to be left dry for 24 hours before application of fresh layer. The finishing layer is applied over earlier roughened inside and outside surfaces.

6. Curing :

Curing can be started 24 hours after application of finishing layer and continued at least to 2 weeks. Jute bags soaked in water can be used for this purpose. They are kept moist at all times during entire curing period, with regular spraying of water. Shrinkage cracks will appear on surface of the ferrocement structure if curing is improper.

7. Testing :

The inlet, outlet, overflow and scour fittings are temporarily sealed with plugs and plumbing sealant. (Fibrous white lead paste). Water is filled and exterior surfaces are observed after retaining water for a day. Cracks, pinholes, damp patches are located, if any, and repairs are carried out.

8. Repairs :

8.1 Small damp patches can be repaired by 2 coats of interior and exterior paints.

8.2 Small hairline cracks and pinholes are filled with 1 : 1 (by Wt.) cement sand paste after roughening the crack on pinhole location to ensure adhesion.

8.3 For large cracks and localised damages.

8.3.1 Mortar in and around damaged area is chipped off using fine round head chisel and a small hammer. Mortar in the adjoining area is chipped upto levels where inside and outside wire mesh layers are exposed. Reinforcement is straightened, if necessary.

8.3.2 The adjoining area is coated with a rich cement slurry using a cement brush.

8.3.3 Damaged area is replastered using the same procedure for plastering.

8.3.4 Replastered area is to be cured for 3-4 days before the tank is retested and put to use.

9. Drying and Painting :

9.1 After testing, the tank is dried for 3 to 4 days, avoiding direct sunlight.

Interior and exterior plasters are brushed to ensure removal of loose particles and dust.

9.2 One coat of paint with vertical strokes is applied followed by second coat of horizontal strokes. It is necessary to alow 2 to 4 hour drying period between the two coats, or as specified by the paint manufacturer.

REFERENCES

1. Ferrocement Materials and Application
Publication Sp - 61 American Concrete Institute
Detroit 1979.

2. Ferrocement Water Tanks and their construction and their applications - S. D. Waft.
Intermediate Technology Publications, London 1978.

3. Ferrocement Water Tank
International Ferrocement Information Centre,
A.I.T., Bangkok 1980.

Ferro Cement :

Reinforced mortar with closely spaced wire mesh reinforcement

Materials :

Cement : Ordinary Portland Cement.

Sand : Clean, hard, strong free of organic impurities.

Sieve (u-s)	Percent passing
3/8" (9.5 mm	100
No.4 (4.75 mm)	95-100
No.8 (2.36 mm)	80-100
No.16 (1.18 mm)	50-85
No.30 (600 µm	25-60
No.50 (300 µm	10-30
No.100 (150 µm)	2-10

Water : Potable water.
Sea water not to be used.

mesh : Woven square mesh 1.3mm (18 gauge)
Spacing 12 mm (1/2")

Skeletal Steel : 6, 8, 10 mm m.s. bars.

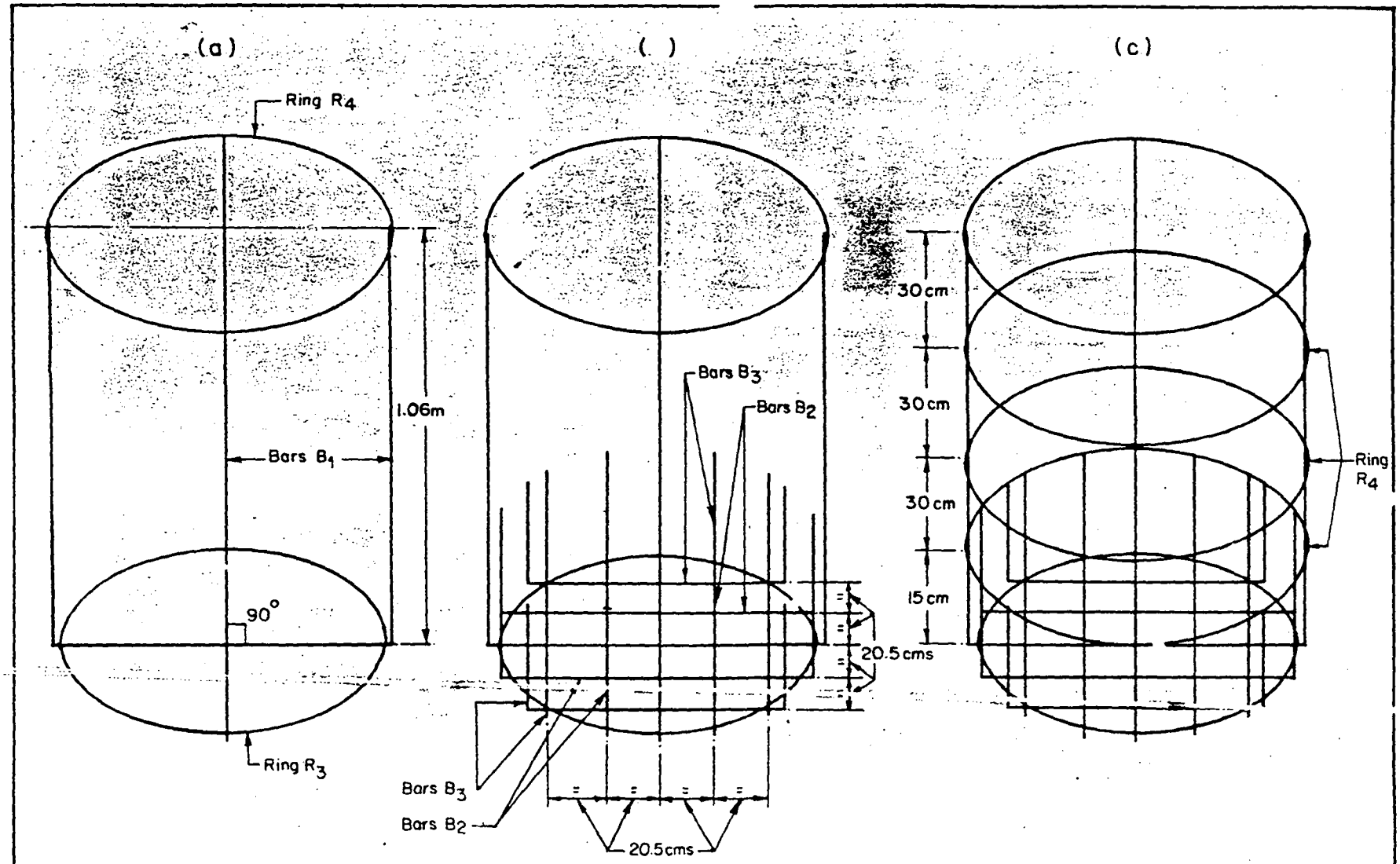
Binding Wire : annealed (soft)
galvanized wire 24/26 gauge.

Water proofing chemicals : Approved.

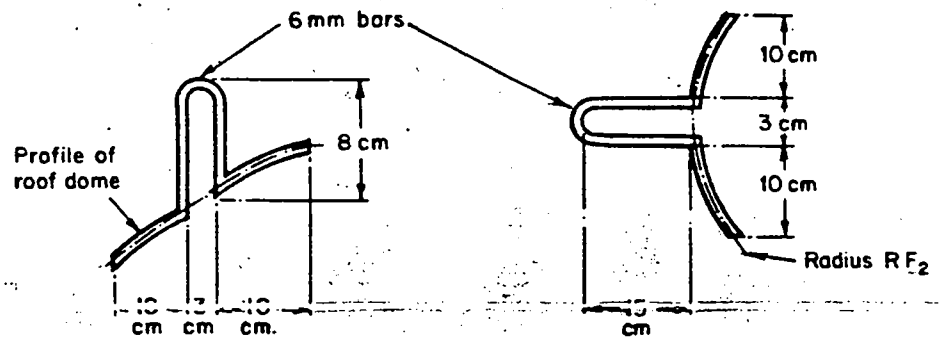
Coatings :

Exterior . 2 coats, cold fast settling bituminous paint.

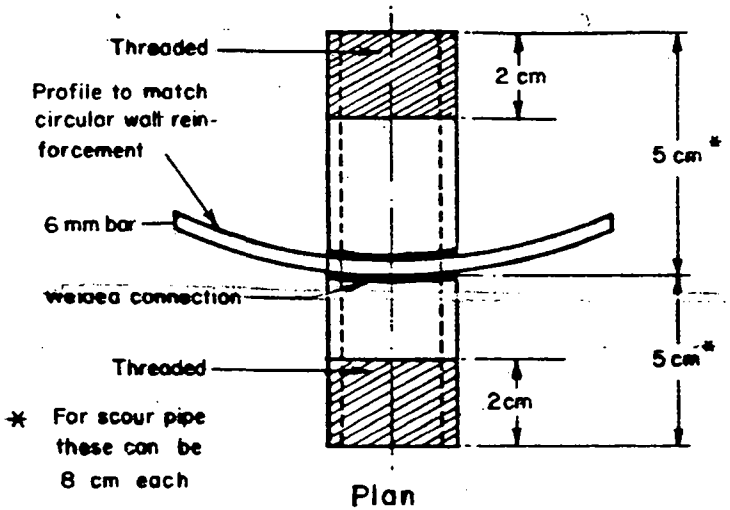
Internal : Non-toxic Water Tank Point.

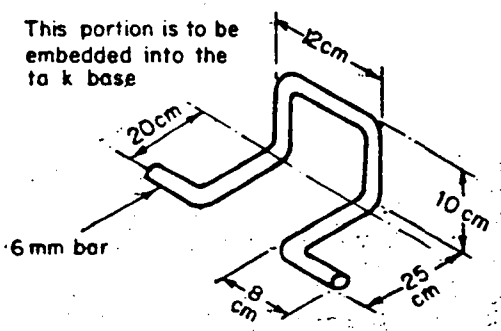


PREPARING THE REINFORCEMENT CAGE (I)



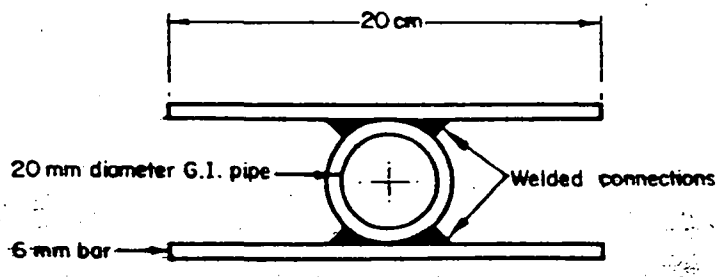
(a) Locking hook profile





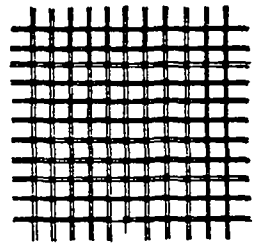
8 mm or 10 mm Bars are suggested for lifting handles of transportable tanks

(b) Lifting handle profile

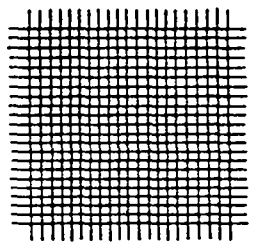


(c) Pipe fitting (inlet, overflow and scour)

AUXIL..RY FITTINGS



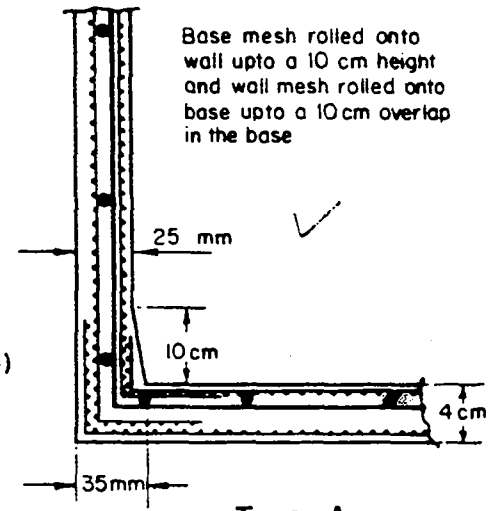
2 Layers of esh not mis-aligned (incorrect practice)



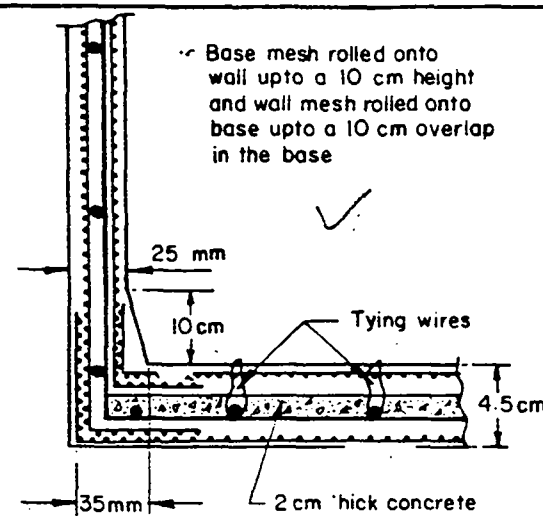
2 Layers of mesh perfectly mis-aligned (correct practice)

Provide ties t 20 cm spacing both ways.

(a) Mis-aligning during laying of meshes

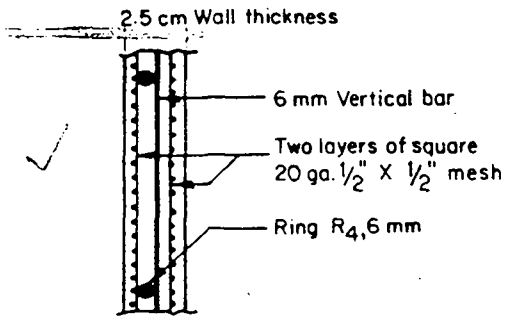


Type A

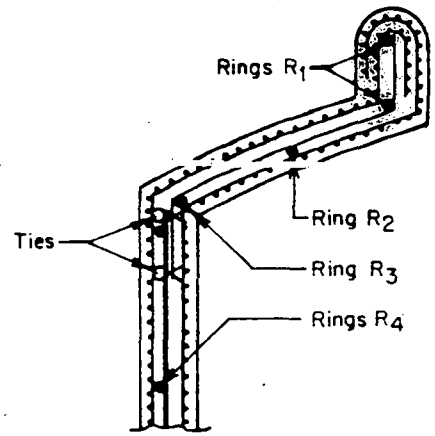


Type B

(c) Wall – base joint



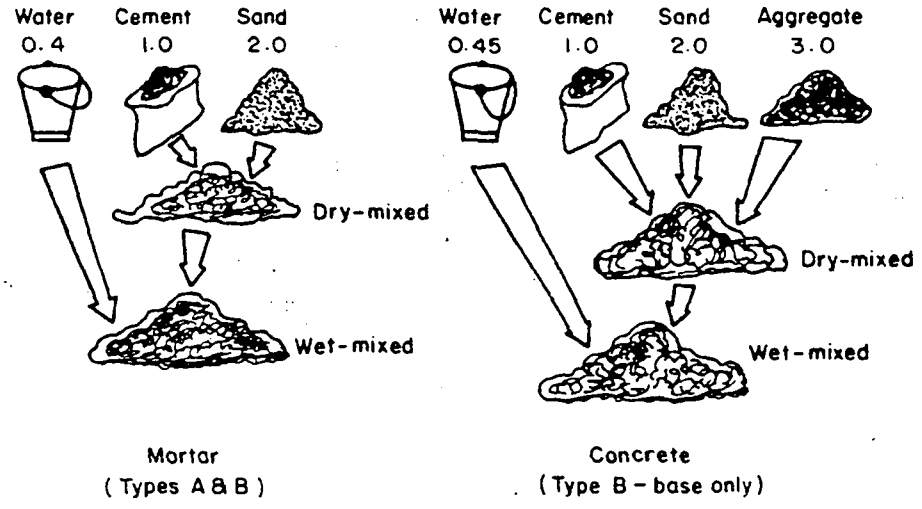
(b) Typical wall section



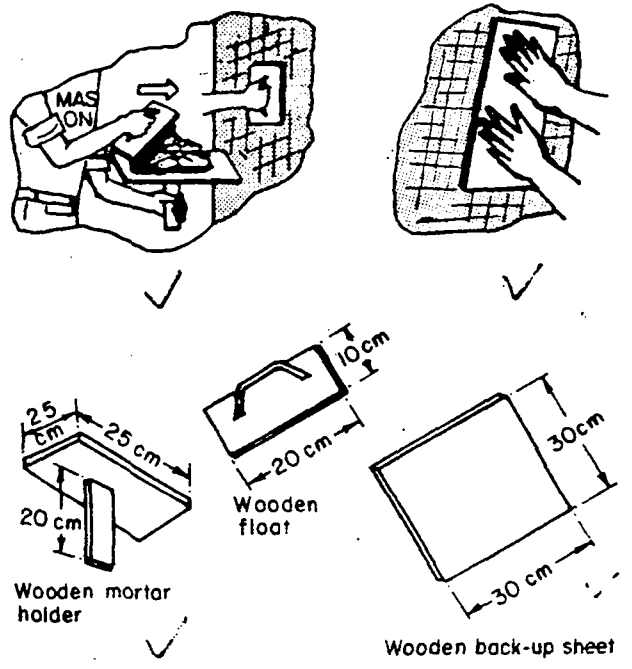
Inside mesh is taken over to the outside upto the base of the manhole rim. Outside mesh is also similarly taken inside upto the base of the manhole rim

(d) Roof – wall joint

MESH LAYUP

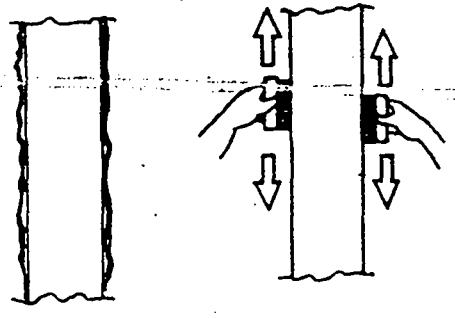


(a) Mix proportions by weight for mortar and concrete mixes that are required to be prepared.



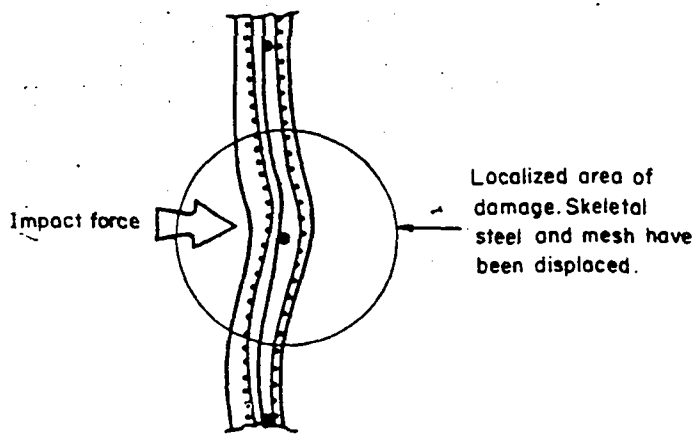
(b) Plastering technique and simple equipments that make plastering an easy task. Mason impregnates mortar from the inside of the tank while the helper holds a back-up sheet on the outside

(c)

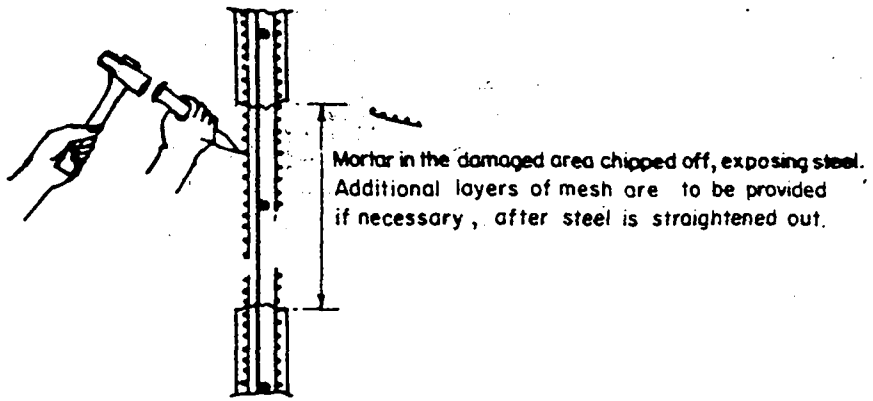


Scraping out excessive mortar build-up. This also improves adhesion of finishing coat.

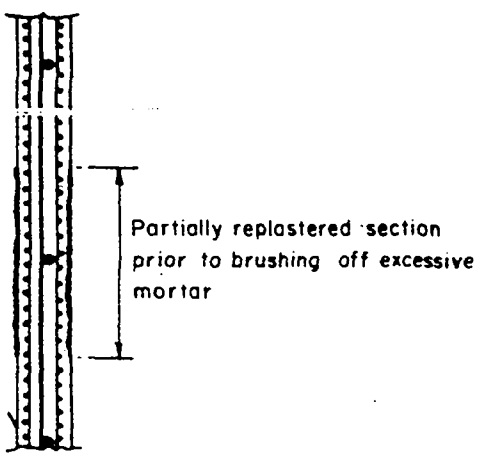
MORTAR MIXING AND PLASTERING



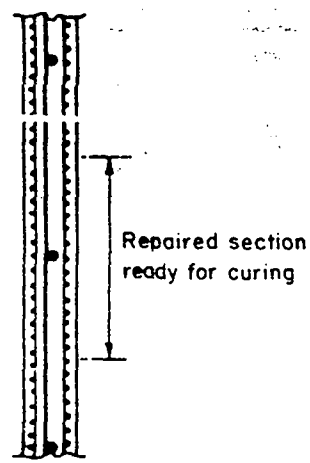
(a) amaged ferrocement section



(c) Chipping mortar and straightening steel



(b) Repair partially complete



(d) Completed section

STAGES IN REPAIRING A DAMAGED SECTION

Dimensional and Reinforcement Details of Cylindrical Ferrocement Water Storage Tanks

No	Capacity		Diameter (m)		Plan Area (m^2)	Height (m)		Tank	Base		Wall		Roof	
	m	Lit	ternal	External	(inside)	Inlet	Overflow	Type	Thickness(cm)	Reinforcement	Thickness(cm)	Reinforcement	Thickness(cm)	Reinforcement
1	0.6	600	0.90	0.95	0.64	0.95	1.05	A	4.0	1 No. 6 mm Ø Ring R_3	2.5	8 Nos. 6 mm Ø Vertical 4 Nos. 6 mm Ø Rings R_4 (both equally spaced)	2.5	6 Nos 6 mm Ø Radial 2 Nos. 6 mm Ø Ring R_1 1 Nos. 6 mm Ø Ring R_2 1 Nos 6 mm Ø Ring R_3
								B	4.0	6 mm Ø at 18.5 cm				
2	1.0	1000	1.20	1.25	1.13	0.79	0.89	A	4.0	1 No. 6 mm Ø Ring R_3	2.5	12 Nos 6 mm Ø Vertical 4 Nos. 6 mm Ø Rings R_4 (both equally spaced)	2.5	6 Nos. 6 mm Ø Radial 2 Nos 6 mm Ø Ring R_1 1 No 6 mm Ø Ring R_2 1 No 6 mm Ø Ring R_3
								B	4.0	6 mm Ø at 20.5 cm				
3	1.2	1200	1.20	1.25	1.13	0.96	1.06	A	4.0	1 No. 6 mm Ø Ring R_3	2.5	12 Nos. 6 mm Ø Vertical 4 Nos. 6 mm Ø Rings R_4 (both equally spaced)	2.5	6 Nos 6 mm Ø Radial 2 Nos 6 mm Ø Ring R_1 1 No 6 mm Ø Ring R_2 1 No 6 mm Ø Ring R_3
								B	4.0	6 mm Ø at 20.5 cm				
4	1.5	1500	1.20	1.25	1.13	1.23	1.33	A	4.0	1 No. 6 mm Ø Ring R_3	2.5	12 Nos. 6 mm Ø Vertical 5 Nos. 6 mm Ø Rings R_4 (both equally spaced)	2.5	6 Nos 6 mm Ø Radial 2 Nos 6 mm Ø Ring R_1 1 No 6 mm Ø Ring R_2 1 No 6 mm Ø Ring R_3
								B	4.5	6 mm Ø at 20.5 cm				
5	2.0	2000	1.20	1.25	1.13	1.70	1.80	A	4.0	1 No. 6 mm Ø Ring R_3	2.5	12 Nos. 6 mm Ø Vertical 6 Nos 6 mm Ø Rings R_4 (both equally spaced)	2.5	6 Nos. 6 mm Ø Radial 2 Nos. 6 mm Ø Ring R_1 1 No. 6 mm Ø Ring R_2 1 No 6 mm Ø Ring R_3
								B	4.5	6 mm Ø at 20.5 cm				
6	2.5	2500	1.20	1.25	1.13	2.10	2.20	A	4.0	1 No. 6 mm Ø Ring R_3	2.5	12 Nos 6 mm Ø Vertical 8 Nos. 6 mm Ø Rings R_4 (both equally spaced)	2.5	6 Nos. 6 mm Ø Radial 2 Nos 6 mm Ø Ring R_1 1 No 6 mm Ø Ring R_2 1 No 6 mm Ø Ring R_3
								B	4.5	6 mm Ø at 20.5 cm				
7	2.5	2500	1.50	1.56	1.77	1.31	1.41	A	4.0	1 No. 6 mm Ø Ring R_3 6 mm Ø at 20.0 cm	3.0	16 Nos. 6 mm Ø Vertical 8 Nos. 8 mm Ø Rings R_4 (both equally spaced)	2.5	8 Nos. 6 mm Ø Radial 2 Nos. 6 mm Ø Ring R_1 1 No. 6 mm Ø Ring R_2 1 No 6 mm Ø Ring R_3
								B	4.5	1 No. 6 mm Ø Ring R_3 8 mm Ø at 20.0 cm				
8	3.0	3000	1.50	1.56	1.77	1.66	1.70	A	4.5	1 No. 6 mm Ø Ring R_3 6 mm Ø at 20.0 cm	3.0	16 Nos. 6 mm Ø Vertical 8 Nos. 6 mm Ø Rings R_4 (both equally spaced)	2.5	8 Nos. 6 mm Ø Radial 2 Nos. 6 mm Ø Ring R_1 1 No 6 mm Ø Ring R_2 1 No. 6 mm Ø Ring R_3
								B	5.0	1 No. 6 mm Ø Ring R_3 8 mm Ø at 20.0 cm				
9	4.0	4000	1.50	1.56	1.77	2.16	2.26	A	4.5	1 No. 6 mm Ø Ring R_3 6 mm Ø at 20.0 cm	3.0	16 Nos. 6 mm Ø Vertical 8 Nos. 6 mm Ø Rings R_4 (both equally spaced)	2.5	8 Nos. 6 mm Ø Radial 2 Nos. 6 mm Ø Ring R_1 1 No 6 mm Ø Ring R_2 1 No 6 mm Ø Ring R_3
								B	5.0	1 No. 6 mm Ø Ring R_3 8 mm Ø at 20.0 cm				
10	5.0	5000	1.70	1.77	2.27	2.10	2.20	A	4.5	1 No. 6 mm Ø Ring R_3 8 mm Ø at 22.0 cm	3.5	16 Nos. 6 mm Ø Vertical 8 Nos. 6 mm Ø Rings R_4 (both equally spaced)	2.5	8 Nos. 6 mm Ø Radial 2 Nos. 6 mm Ø Ring R_1 1 No 6 mm Ø Ring R_2 1 No. 6 mm Ø Ring R_3
								B	5.5	1 No. 6 mm Ø Ring R_3 8 mm Ø at 18.5 cm				
11	5.0	5000	1.80	1.87	2.55	1.87	1.97	A	5.0	1 No. 8 mm Ø Ring R_3 8 mm Ø at 18.5 cm	3.5	16 Nos. 8 mm Ø Vertical 8 Nos. 8 mm Ø Rings R_4 (both equally spaced)	2.5	8 Nos. 8 mm Ø Radial 2 Nos. 8 mm Ø Ring R_1 1 No 8 mm Ø Ring R_2 1 No 8 mm Ø Ring R_3
12	10.0	10000	2.00	2.07	2.47	3.85	4.00	A	5.0	1 No. 8 mm Ø Ring R_3 8 mm Ø at 18.0 cm	3.5	20 Nos. 8 mm Ø Vertical 10 Nos. 8 mm Ø Rings R_4 (both equally spaced)	3.0	10 Nos. 8 mm Ø Radial 2 Nos. 8 mm Ø Ring R_1 1 No 8 mm Ø Ring R_2 1 No 8 mm Ø Ring R_3
13	10.0	10000	2.20	2.27	3.80	2.53	2.63	A	5.0	1 No. 8 mm Ø Ring R_3 8 mm Ø at 16.0 cm	3.5	20 Nos. 8 mm Ø Vertical 10 Nos. 8 mm Ø Rings R_4 (both equally spaced)	3.0	10 Nos. 8 mm Ø Radial 2 Nos. 8 mm Ø Ring R_1 1 No 8 mm Ø Ring R_2 1 No 8 mm Ø Ring R_3