

# SOME BASIC GUIDELINES IN THE CONSTRUCTION OF "FERRO-CEMENT" FISHING BOATS

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Construction of fishing boats out of steel and cement - "FERROCEMENT", has today gained a greater momentum all over the world, particularly in most of the developing countries. This novel method of boat construction has caught the public admiration due to its cheapness in price, simplicity of construction, durability, strength, water-tightness and resistance to normal wear and tear. Ferro-cement fishing boats reduce the work and worry of constant maintenance that are normally encountered with wooden or steel boats. The boat-building industry in India stands to gain considerably if steel and cement are put to use in the construction of fishing trawlers with greater imagination and skill. During the frequent handling of this new material in connection with the experiments and investigations that are now being carried out at the Central Institute of Fisheries Technology in Cochin, a number of useful results have come to light, some of which are presented in this paper in the form of certain basic guidelines.

In "Ferro-cement" boat construction, reinforcement and cement plaster are the two important aspects involved which requires greater and careful consideration. The internal frame work of reinforcement forms the endo-skeleton while the cement plaster on either side of the reinforcement forms the external layer of protective coating and both of which constitute ultimately the shell of ferro-cement. The reinforcement can be subdivided into (1) the primary reinforcement comprising of bent pipes forming the station moulds transversely as well as longitudinally and (2) the secondary reinforcement of Chicken wire mesh, four layers of which are fastened tightly on either side of the preformed net work of pipes and rods as seen in the accompanying photograph.

Next to reinforcement, the cement mortar is an important variable in the construction of ferro-cement boats. The mortar employed for the external plastering is only an admixture of good quality cement, sharp and fine river sand and fresh-water, well mixed to a

worked out proportion and the resulting mortar is without any coarse aggregates like crushed stones etc. The cement and sand mortar must be workable so that it can be easily forced well through the dense layers of mesh. Eventhough suitable mechanical contrivances are being thought of for the easy and quick application of the cement mortar over the reinforcement, in most of the places the mortar is still applied by hand and is pushed through the hull lay-up and finished from both the sides. Too high a water-cement ratio and also too low a cement-sand ratio will cause excessive shrinkage and severe cracking may

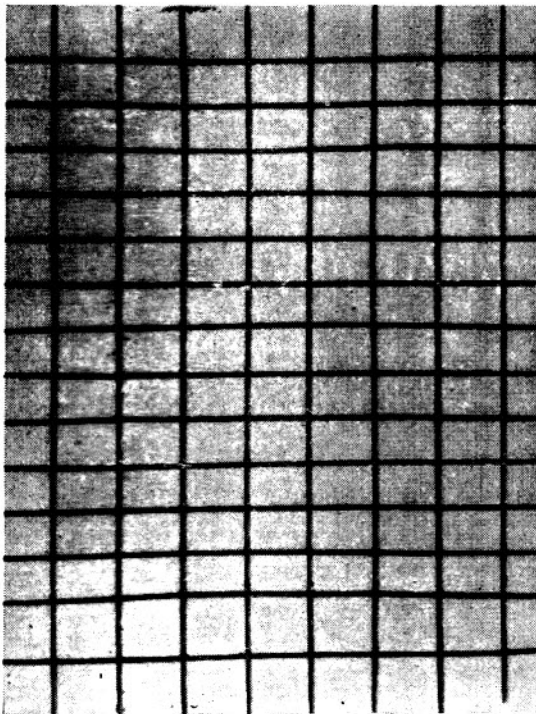


Fig. 1 *Frame work of mild-steel rods welded at 2' x 3' centering.*

occur. The extent of shrinkage and the consequent surface cracking is directly proportional to the quality of the mortar, its careful application and its curing process thereafter.

The rate of steel reinforcement in 'Ferrocement' is greater than in the conventional Reinforced Cement Concrete (R. C. C.) and this additional reinforcement gives a higher strength and higher flexibility both of which are expected of an ideal building material for fishing boats. There must be a large amount of steel in finely divided form dispersed as evenly as possible throughout the cement-sand mortar, (Fig. 3). And yet another important aspect would be, the limiting thickness of the mortar over the mesh. The total shell thickness including the reinforcement, cement plaster and the paint coats progressively increases from  $\frac{3}{4}$ " to  $1\frac{1}{2}$ " (19mm to 38mm) as the over-all length of the boat increases from 40' - 80' (12.5 M to 25 M). The entire 'Ferrocement' hull should have about 20 - 25 percent of steel content (reinforcement) and 75 - 80 percent of cement mortar and should keep the specific gravity of the finished shell at 2.4 to 2.6. The bond characteristics between the reinforcement and the mortar is an important phenomena in 'Ferrocement' construction. The compatibility of steel and cement thus plays an important role as both the materials have a similar co-efficient of expansion and contraction. In spite of the unique and excellent mechanical properties of 'Ferrocement', the reinforcing steel and the cement mortar, if not properly

designed and handled, can be subject to deterioration due to corrosion under aggressive environments like sea-water. Certain acids and dissolved salts in sea-water may attack 'Ferrocement'. Corrosive anions such as chlorides or sulphides in the presence of oxygen and moisture may destroy the protective passivating film and initiate corrosion of steel. The structural properties of this new material are destroyed if the steel reinforcement corrodes. Special precautions must be taken to minimize or eliminate corrosion in 'Ferrocement' structures. To check and minimize the probability of corrosion of steel, proper cement plastering over the reinforcement is thus essential. This external protective cement plaster being very thin in 'Ferrocement' construction, additional protective measures are quite imperative.

The working characteristics of the conventional portland cement can be well improved upon by special additives of pozzolan (such as volcanic ash, powdered burnt clay, fly-ash etc.) to make it more water resistant. Coating the cement surfaces will also reduce migration of salt, oxygen and water to the reinforcing steel where its corrosion may result in the spalling of the cement plaster. Suitable surface preparation followed by generous coats of heavy duty paints like epoxy coal tar, modified cashewnut shell liquid (CNSL) or thermosetting resins, will give the most desired effect. These coatings may act as efficient waterbarriers besides providing the external hull a smooth surface. If water cannot penetrate to any appreciable extent, no deterioration of the reinforcement will ever happen. Most of the conventional boat-building mat-

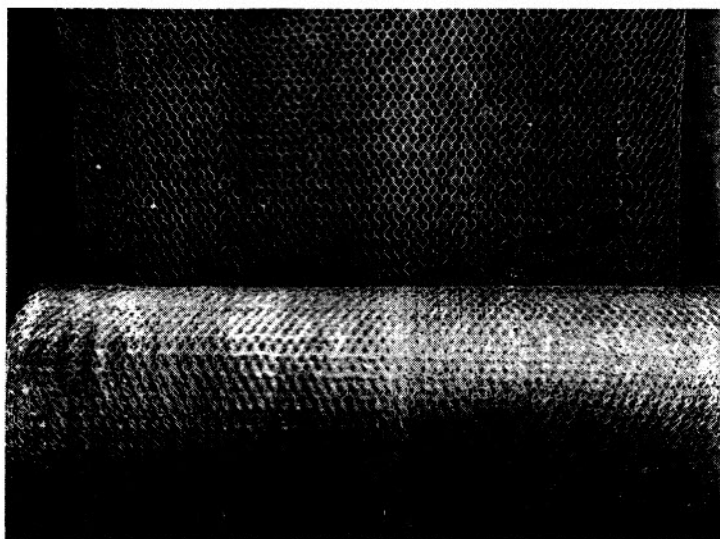


Fig. 2 *G. I. Chicken wire which will form the secondary reinforcement.*

erials deteriorate when they become wet, whereas 'Ferrocement' actually gains strength in water. In fact the sprinkling of cold water during the initial stages of curing of the cement plaster over the reinforcement enhances the strength properties to a considerable extent.

Thus 'Ferrocement' hull is basically a watertight shell, constructed in such a way that it can withstand the stresses and strains to which it is subjected to under rigorous working conditions in sea-water. The steel reinforcement and the cement and sand mortar are there merely to ensure that the outer shell of the boat can withstand such stresses both under static and dynamic conditions as well as light and loaded conditions and still remain watertight. A final coat of suitable antifouling paint applied over the hull below water-line

immediately before launching will take care of the tropical fouling problem almost for a year. In choosing 'Ferrocement' as a new material for the future construction of fishing boats in India, the major problems of marine corrosion and organic deterioration are successfully eliminated and a cheaper and simpler method of boat construction is established.

While further data is being processed for publication in due course, the following are some of the main points for consideration during "Ferrocement" hull construction :

1. Use iron or galvanized-iron water pipes of  $\frac{1}{2}$ " to 1" (13 mm to 25 mm) internal diameter for the station moulds and suitably bend them to shape as per the lofting measurements.

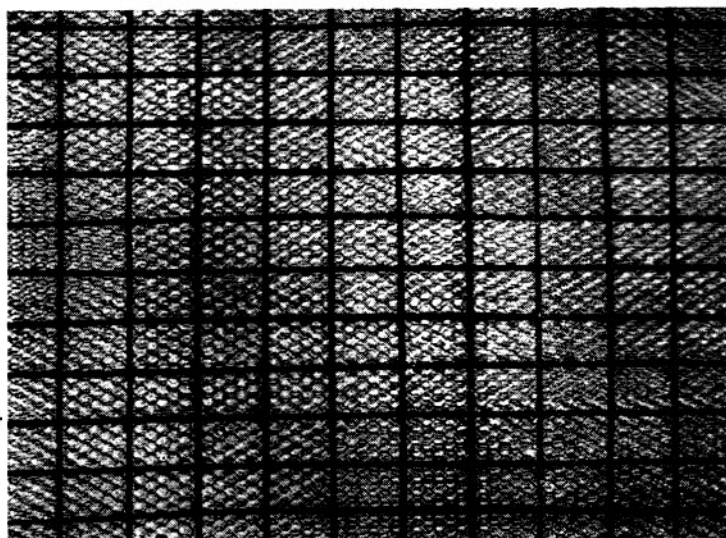


Fig. 3 4 layers of chicken wire mesh fastened on either side of the mild steel rod frame work.

2. Use  $\frac{1}{4}$ " to  $\frac{3}{8}$ " (6 mm to 10 mm) mild steel rods and weld them on to the outside mould frames of pipes with 2" to 3" (50 mm to 75 mm) centering. They may even be tied together with iron wire of 19 to 20 S. W. G.

Extra stringers may be necessary in the form of flats or pipes in the case of bigger boats beyond 50' OAL. Avoid any distortion and maintain a true ship-shape at all points.

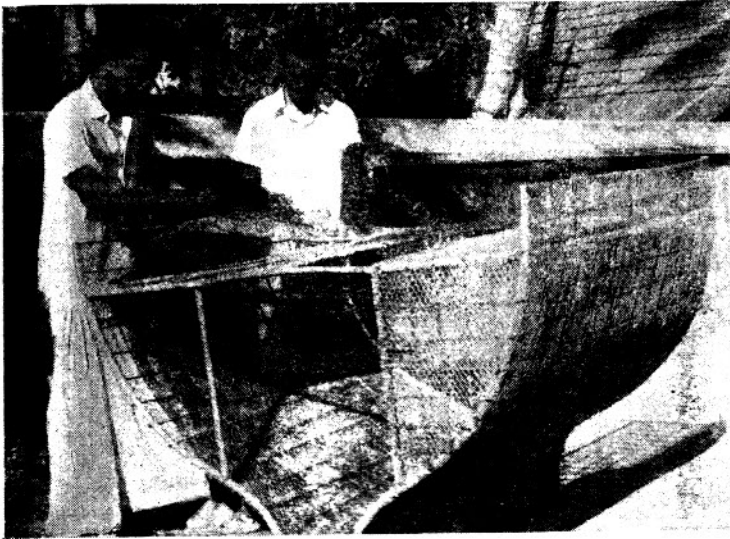


Fig. 4 *Mock-up model of a 'Ferrocement' boat hull receiving the fourth and final layer of wire mesh.*

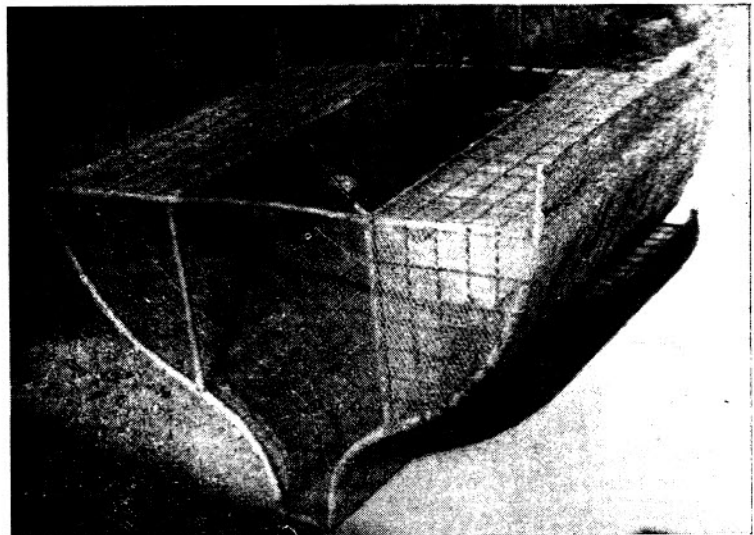


Fig. 5 *The mock-up model is complete in its reinforcements (endoskeleton) ready for plastering.*

3. Use machine woven galvanized iron chicken wire mesh of 20 S.W.G. with  $\frac{1}{2}$ " (12mm) mesh. Use 4 layers of them on either side (total 8 layers) of the frame-work of reinforcement. Galvanized wire of 19-20 SWG may be used for fastening and lacing them tightly to the frame work. Check with battens and fair the lines. Once this basic frame-work is completed to perfection, cement plastering may commence.



Fig. 6 *The reinforcement is filled and covered with cement and sand mortar.*

4. Use special pozzolana cement in combination with good quality fine and sharp river sand and uncontaminated fresh-water in the ratio of 1 : 1.5 : .4/.5 and work them well into a paste. A combination of ordinary portland cement with fly-ash at 85:15 will give the required pozzolanic effect at a cheaper price. Plastering may be done both from inside and outside using simple trowels and floats. Ensure perfect and deep penetration of the mortar into the network and evenly cover up the wire-mesh with the barest minimum thickness of plaster. Level up with a straight edged batten and remove extra lumps of mortar. Round off corners and crevices. Unnecessary extra layers of mortar will only increase the dead weight. According to the overall size of the boat, the hull thickness should be kept within  $\frac{3}{4}$ " to  $1\frac{1}{2}$ " (19 mm to 38 mm).

5. Once plastering is completed, it should be allowed to set hard. 15 to 20 days of curing has to be allowed under shade with frequent sprinkling of cold water. The hull must be kept fully wet without getting quickly dried up either by direct sun or hot breeze.

6. The hull surface must be thoroughly dry and clean before painting is attempted. Use 2 generous coats of

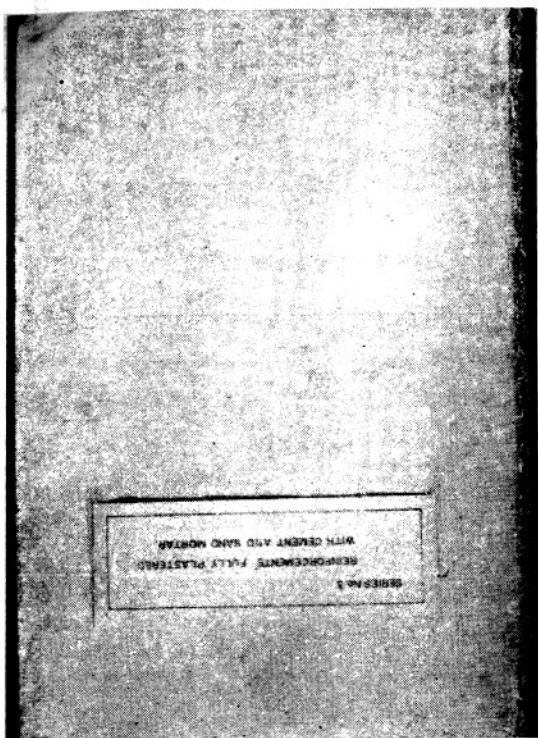


Fig. 7 Reinforcements filled and fully plastered with cement and sand mortar which has undergone 20 days of curing.

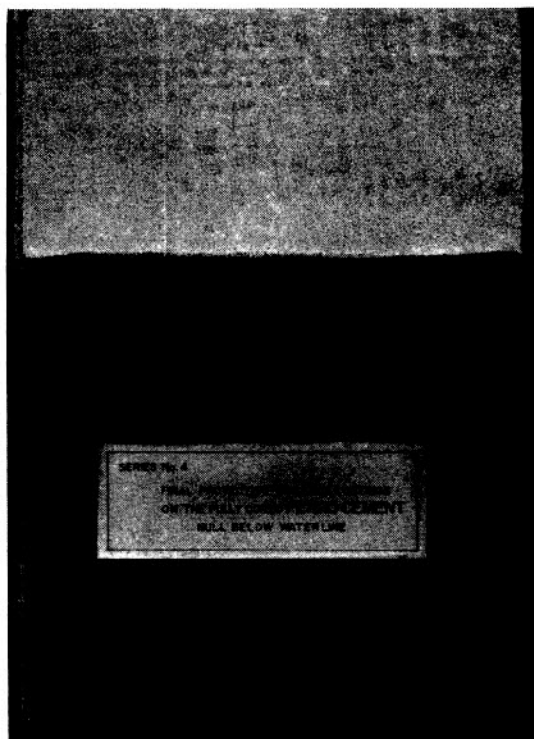


Fig. 8 Painting schedule on the finished "Ferro-cement" hull after thorough curing.  
 (a) Surface preparation  
 (b) Epoxy coal-tar and  
 (c) Antifouling paint.

either epoxy coal-tar, or modified CNSL resin or heavy duty bitumastic paint. On the hull below water-line give one or two coats of antifouling paint just before launching. Above water-line, may be given any

top coat of paint to owner's choice.

7. Use coir or rubber fenders on the outside bulwarks while at the jetty or along side other boats.

Note:- A  $\frac{1}{2}$  ton mock-up model of 'Ferrocement' hull is available for inspection and study at the Central Institute of Fisheries Technology, Cochin-11.