MANUFACTURING AND SPECIFICATIONS OF PREFABRICATED OF FERROCEMENT DOORS

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A ferrocement door is easy to manufacture, the prefabricated door is strong and durable, is resistant against water and requires little maintenance afterwards. Auroville Building Centre has been using the prefabricated technique of casting doors since 1986. The document gives a detailed description of the manufacturing process for prefabrication of ferrocement doors on a small scale. The material and tools needed and details for fixing hinges and locking arrangements.

The advantages of ferrocement doors are:

- The materials required are commonly available
- Manufacturing techniques can be taught to semi-skilled labour.
- Only manual labor is involved in manufacturing the basic ferrocement door panels.
- Ferrocement doors are strong, durable, fireproof, waterproof and termite resistant.
- Ferrocement doors can be made on any flat surface with ordinary mason tools and are easy to transport and install.
- A damaged ferrocement door can be repaired

The disadvantages of ferrocement doors are:

- The weight of a ferrocement door of 12 mm thickness is approximately 30 kg/m2 (as compared to wooden doors weigh approximately 18 kg/m2).
- The hinges and locks have to be installed afterwards which necessitates the use of a powered hand drill and masonry drill bites of various diameters.
- The lock still has to be surface mounted due to the thickness of the door panel, this limits the choice of lock.
- After the casting and initial curing are completed care and experience is required to avoid breaking the thin panel while lifting it off from the casting surface.
- Care has to be taken that no damage occurs during transportation.

MANUFACTURING PROCESS

Manufacturing Aids and Tools for Ferrocement Doors

The following aids and tools are needed:

- A flat and smooth casting surface, (i.e. concrete slab), preferably situated in a shaded area.
- Shuttering oil or waste engine oil and paint brush
- A masonry trowel of medium size
- A square rammer.
- A wire mesh cutter
- A mixing pan
- A string with some chalk powder or paint for marking the dimensions.
- Two wooden or aluminum guides or rulers (screeds) corresponding with the exact required door thickness (we fabricate doors of 12 mms)
- A binding hook
Mesh Preparation

1. Use hexagonal 12 mm x 0.71 mm (22 gauge) galvanized iron (GI) “Chicken mesh” as reinforcement. Use rolls of either 0.90 m or 1.20 m width.
2. With the help of a string dipped in some water based paint, mark the door size on the casting platform. Take care to obtain right angle corners.
3. Cut four separate strips of mesh off with a wire mesh cutter to the door size plus 100 mm all around. Flattened separately on the floor using the square rammer.
4. Then lay the four separate layers of wire mesh on top of each other in alternate layers at right angles to one another. Fold the mesh projecting beyond the door marking so that the final mesh size is 10 mm less all around than the actual door size. This is to allow for cement cover. As an aid for folding the mesh use an aluminum or timber straight edge.

A standard door size of 2.00 m x 0.90 m needs 3 kg of hexagonal 12 mm x 0.71 mm (22 G) wire mesh (4 layers) and 200 g of binding wire. Assuming mesh roll of 0.90 m wide the following sixes will be required: first layer-one of 2.20 m x 0.90 m: second layer – two of 1.10 m x 0.90 m, this is to be placed at right angles to the first layer; third layer – same as first layer and fourth layer same as second layer.

5. Binding wire is used for binding together the 4 layers. The whole steel mat is lightly flattened with the help of a square rammer.

Casting Procedure

1. Oil the portion of the casting platform to be used with a paint brush to ensure easy demoulding. Use waste engine oil for this purpose.
2. Mix the amount of sand, cement and water on a clean surface nearby or even better in a mixing vat.

Mixing ratios are very important and should be strictly followed. The water: cement: sand (W: C: S) ratio for ferrocement doors is 0.40: 1: 1.5 by weight. Sand and cement are first evenly mixed; the required quantity of water is added afterwards. Eg. : for a door of 2.00 m x 0.90 m of 12 mm thickness, the approximate amount of water is 8.1 liter, cement 20.0 kg and sand 30.0 kg (dry).
3. Spread a fine layer of mortar over the oiled surface. The thickness should not be more than 5 mm.

4. Softly press the steel mat onto the spread out mortar layer, care must be taken to position it correctly. Place two wooden or aluminum rulers along the two longest sides of the door to facilitate the filling up of the second layer of mortar and to stay within the exact dimensions of the door.

5. Then spread the second and last layer of mortar over the steel mat, using the two rulers as a guiding level for the appropriate dimensions and also the final thickness of the door.

6. Obtain a smooth finish by sprinkling a handful of cement and rubbing it in with a mason’s trowel in a circular manner. Special care is taken to finish the top, sides and edges of the door neatly. The average thickness of a ferrocement door should be around 12 mm. The rulers have a similar dimension which helps in maintaining this thickness. Vibration is not required.

7. Leave the finished door untouched until the next day (about 12 hours). Precaution has to be taken to make sure that nobody steps on it. If needed, lay a plastic cover over it to give some protection against the hot sun.

**Curing Procedure**

Curing is a necessary phase in order to obtain a properly manufactured ferrocement product. Since the ferrocement units are usually much thinner than normal concrete products, a properly carried out curing procedure is even more important.

Curing is the action by which the water trapped in the freshly cast structure is released slowly over a period of time. This should take place slowly in order to prevent cracks which would weaken the product. For this purpose, leave the freshly cast door in place on the casting platform. Then spread a sand or coir dust layer evenly over the door and sprinkle water several times a day and never allow the curing material to dry out. The sand or coir dust should be kept moist for about 15 to 21 days. One can also demould from the casting platform after two days and cure elsewhere.

**DEMOULDING PROCESS**

After a minimum of 20 days, the curing time for a ferrocement door is over and the mortar mixture has attained its full structural strength.
For demoulding the ferrocement door, carefully insert a large mason’s trowel under one of the long sides of the door and move it slowly under the whole length of the door to separate the ferrocement plate softly from the casting platform. The oiled ensures that no bond has taken place with the mortar during the casting and curing period.

Once the ferrocement door panel is loosened, two or three person lifts it quickly up on one of its long sides. The door is now ready for the fitting and locks.

**ASSEMBLING AND FINAL PHASE**

Use 300 mm to 460 mm (18 in.) steel T-hinges, tower bolts, aldrops and rim locks. For a door of 2.00 x 0.90 m, use three T-hinges of 460 mm (18 in.) to hand the door directly on to a brick wall, a pillar or even a wooden frame. The holes should be premarked for hinges and locks. Use an electric power drill with a small diameter masonry drill bit to drill the required holes. Afterwards use a bigger size masonry drill to enlarge the holes to the required size. Attach the three hinges with bolts, nuts and washers. Fit tower bolts, aldrops and rimlocks in the same way.

Several holes are drilled next to each other for making a keyhole, this until the appropriate shape is obtained.

**PAINTING, INSTALLATION AND MAINTENANCE**

Where appearance is important, a smooth finishing of the two surfaces is recommended. Remove hinges, handles and locks for this purpose. Prepare a mastic paste made from chalk powder and white cement primer paint and apply on the two surfaces. After the mastic has dried, sandpaper the door properly and apply the final paint coat.

Ferrocement doors can be installed without door frames. Fix hinges with plugs in a brick pillar of wall. Add a cement border afterwards to act as a door rebate. It is even possible to install a ferrocement door inside an existing wooden doorframe, provided a carpenter makes the necessary adjustments on the frame for fitting the hinges.

**Extra Care**

Ferrocement doors need extra handling care. Stack properly after curing so that they do not slide down. During installation avoid circumstances where they might be dropped or topple over. Transport is best done by placing them upwards on the largest side against each other.
Damage

If breakage occurs, repair the ferrocement door by removing cement around the cracks. Then clean the exposed wire mesh properly with a wire brush and place the door on a flat surface, then cement the cracks with the mortar mixture ratio. Cure the repaired section for the required number of days. A repaired ferrocement door is as strong as the origin one.

DEVELOPMENT AND APPLICATIONS

The described construction technique is for the small scale production of ferrocement doors. Once this technique is mastered, several improvements can be undertaken such as:

- Commercial plasticizer can be used to augment the workability of the mortar mix and to reduce the water content thus enhancing the mortar strength.
- Do away with visible hinges. A technique for incorporating plate hinges in the ferrocement door was developed at the Auroville Building Centre.
- If a micro-enterprise is envisaged in the manufacture of ferrocement doors, speed up production by using a plate vibrator to cast the doors. This would reduce the manufacturing time, allow for a larger production and ensure a better production and ensure a better finished product. A small plate vibrator for this purpose has been developed at the Auroville Building Centre.
- Lastly, cure in a natural way by using solar energy with a curing tunnel, at present being used at CSR – Biogas Technology for the manufacture of ferrocement biogas plants and water tanks. Another improved way of curing is by using steam. Doors can be cured and ready within a few days employing this technique.

Ferrocement doors can be used in a variety of applications:

- They can replace steel doors in industrial settings and low-cost wooden doors for housing projects because of their strength, durability and economy.
- They can replace asbestos panel doors in bathrooms, because they are waterproof and do not pose health or environmental hazards.
- They can be used as balcony or back doors because of their durability, waterproof and non-warping qualities.
- They can be used as double doors for larger openings.
- They can be manufactured in different shapes and styles for different applications and can be decorated with plaster of Paris ornaments for a superb finish.

CONCLUSIONS

A ferrocement door is an alternative for a wooden and steel door. What makes it attractive is that it can fulfill the needs of urban as well as rural houses and other buildings. The use of the above described technique is not restricted to doors alone; it can also be used to produce window shutters, small shelves, covers for water tanks, fixed louvers, and other similar structures.
### PREFABRICATED FERROCEMENT DOOR

#### Element Profile

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>2 mtrs</th>
<th>1 mtr</th>
</tr>
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<tbody>
<tr>
<td>Height</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C / S / W ratio</td>
<td>1/2/0.40</td>
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</tr>
<tr>
<td>Manufacturing time</td>
<td>6 hours</td>
<td></td>
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<tr>
<td>Curing period</td>
<td>21 days</td>
<td></td>
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<tr>
<td>Thickness</td>
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<tr>
<td>Weight</td>
<td>72 kg</td>
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#### Design Features

![Diagram of door dimensions]

#### Manufacturing:

1. Raw materials:

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<th>Material</th>
<th>Quantity</th>
<th>Unit price</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Mesh: GI Hex 22 G x 1/2&quot; (kg)</td>
<td>4.5</td>
<td>85</td>
<td>383.00</td>
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<tr>
<td>Binding wire (kg)</td>
<td>0.5</td>
<td>30</td>
<td>15.00</td>
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<tr>
<td>Cement (kg)</td>
<td>23</td>
<td>3.5</td>
<td>80.00</td>
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<tr>
<td>Sand (kg)</td>
<td>34</td>
<td>0.35</td>
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<tr>
<td>Water (ltrs)</td>
<td>11</td>
<td>0.25</td>
<td>3.00</td>
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Sub-total: **493.00**

2. Consumables:

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<th>Material</th>
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<td>Used engine oil (ltrs)</td>
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<td>Water for curing (ltrs)</td>
<td>200</td>
<td>0.25</td>
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Sub-total: **54.50**

3. Labour cost for manufacturing process

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<th>Labour Process</th>
<th>Labour</th>
<th>Time</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Mesh preparation</td>
<td>M + H</td>
<td>2 hrs</td>
<td>60.00</td>
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<tr>
<td>Casting</td>
<td>M + H</td>
<td>4 hrs</td>
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<td>Demoulding</td>
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<tr>
<td>Curing</td>
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Sub-total: **235.00**

Total: **Rs. 782.50**

C / S / W = Cement / Sand / Water ratio

Professional qualification: M = Mason;  H = Mason Helper