



## Ferrocement as a Construction Material

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**Abstract:** Ferrocement construction technology is quite popular throughout the world. Ferrocement is the very old method of construction material as reinforced concrete back in two centuries. Ferrocement, a thin element, is used as a building construction as well as a repair material and it is composed of mortar and galvanized wire mesh. Now a days RCC is very common material in construction whereas ferrocement has its own limitations. This paper attempts to review the literature on ferrocement and bring out the salient features of its construction and properties. This study brings out the importance of using ferrocement in swimming pools and water tanks, silos, corrugated roofs, shell and dome structures, and also in the repair of old/ deteriorated RCC structures. The aim of this paper is to summarize the use of ferrocement with its applications in construction. The study concludes that ferrocement will certainly be one of the best structural alternatives for RCC in the future.

**Keywords:** Cement Mortar, Ferrocement types, comparison to RCC, applications.

### I. INTRODUCTION

Ferrocement invent by Frenchmen Joseph-Louis Lambot in 1848 and construct a Batteau with ferrocement system and showing the resistance power with this system. In this system cement mortar applied over layers of metal mesh, woven expand –metal or metal fibres and closely spaced thin steel rods such as rebar, metal commonly used is iron or some types of steel. With the help of Ferrocement we construct thin, hard and also provides so many different types shapes to the structure such as hulls for boats, shell roofs, decorative parts of the building and water tanks etc. This system use in building construction began in the middle of the 20<sup>th</sup> century in Italy. Presently its application in a large number of fields has rapidly increased all over the world because ferroconcrete has relatively good strength and provide better resistance to fire, earthquake and corrosion than transitional materials, such as wood and any other material. Ferrocement is the arrangement or system of cement mortar applied over layer of chicken mesh or any other type mesh.

#### A. Different Types Reinforcement in Ferrocement System:

Ferrocement is also has other outstanding properties besides its engineering properties compared to normal concrete. Ferrocement exhibits a very easy mold-ability characteristic, that it can be used to produce any desired shape of structure. Besides that due to superior tensile behavior and water tightness, the material is widely used for lightweight

construction and water tight structure as well as for potable structure. Some of the successful application of ferrocement includes boat, sampan, pipes, shell roofs, wind tunnel, modular housing, sandwich pools, permanent form of concrete structure etc.

Table.1

| Wire-mesh reinforcement          |  |
|----------------------------------|--|
| Wire Diameter                    | 0.5mm to 1.5mm   |
| Type of mesh                     | Chicken wire or square woven or welded wire galvanized mesh:expanded metal   |
| Size of mesh openings            | 6mm to 25mm  |
| Number of mess layers            | Up to 12 layers per inch of thickness<br>Or 5 layers per 10mm of thickness   |
| Fraction volume of reinforcement | Upto 8% in both directions corresponding up to 40 pounds of steel per cubic foot of concrete (630 kilograms per cubic meter) |

Table.2

| Typical mortar composition |   |
|----------------------------|---|
| Portland cement            | Any type depending on application   |
| Sand to cement ratio       | 1.0 to 2.5 by weight  |
| Water cement ratio         | 0.4 to 0.6 by weight  |
| Recommandations            | Fine sand all passing U.S. sieve Number 8 and having 5% by weight passing Number 100, with a continous grading curve in |

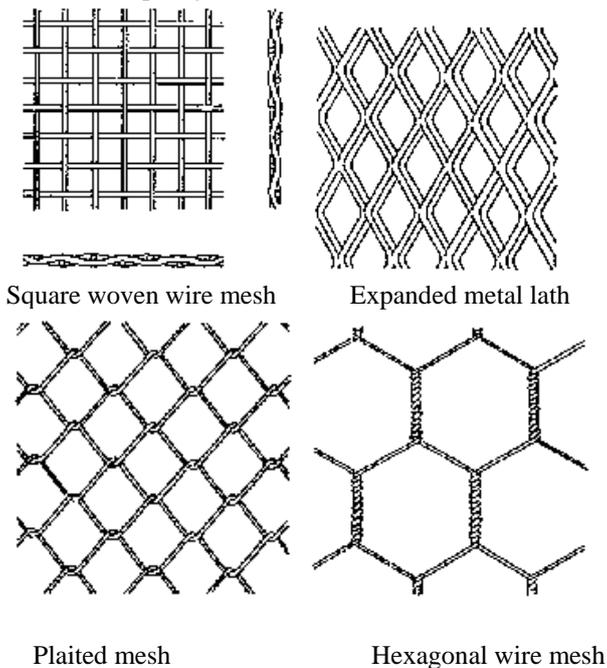
|  |          |
|--|----------|
|  | between. |
|--|----------|

Table.3

| Comosite properties       |                      |
|---------------------------|----------------------|
| Thickness                 | 6 to 50mm            |
| Steel cover               | 1.5 to 5mm           |
| Ultimate tensile strength | 34 Megapascals       |
| Allowable tensile stress  | 10 Megapascals       |
| Modulus of rupture        | 55 Megapascals       |
| Compressive strength      | 28 to 69 Megapascals |

**B. Types of mesh:**

Ferrocement is consist material and it has used many different types of wire meshes (shown in fig), according to their requirement. Square woven wire mesh normal consisting of galvanized form with 1.0mm to 1.5mm diameter at12mm spacing. Woven wire mesh are flexible or high stiffness and easily work with welded meshes and reduces the tensile strength. To provide additional fabric wires with wire meshes to control the cracks. Expanded metal lath made of thin gage sheets and it perpendicularly expanded to the direction of slits. Expanded metal path are also behave like woven wire mesh with approximately same strength. It has good impact resistance capacity.



**C. Method of construction:**

Ferrocement is composite material in the form of closely spaced multiple layers of mesh or small diameter rods completely infiltrated with mortar. Ferrocement construction

thin and light structure and can be easily precast. Ferrocement construction methods have 3 stages. First is to be prepare the skeleton framework of the model with wire mesh is fixed with a thin tie wire as well as welding. In construction process minimum 2 layers of wire mesh required and maximum wire mesh provide according to the design. After prepare the skeleton then we prepare the mixture of cement and this is the beginning of the second stage. Second stage is prepare the mixture of sand, cement, and admixture are carefully proportioned by weighing (first dry mixed and then with water). These are two types of mixing-Hand mixing and Mechanical mixing. Hand mixing is usually satisfactory but mechanical done with uniform mixes, reduces manual efforts and save time. The mix prepare carefully for achieving the final strength and it retains its form and position. Third stage start after checking the stability of the framework and wire mesh reinforcement, the placing or applied the mortar either by trowel or with a hand and plaster on the mesh and fill the voids with cement mortar. This procedure can be done in a single application, that is finishing both sides before initial set takes place. For completion the work two workers are needed to work simultaneously on both sides. Thicker structures can be done in two steps, first is to half section of the model plaster from one side, allowing it to cure for two weeks, after which the other surface is completed. Compaction is achieved by beating the mortar with a trowel or flat piece of wood. Care must be taken not to leave any reinforcement exposed on the surface, the minimum mortar cover is 1.5 mm. Each stage of plastering should be done without introduction, preferably in dry weather or under cover and protect from the sun and wind. As in concrete construction with ferrocement system should be moist cured at least 14 days.



Comparison between Ferro-Cement and Reinforced concrete:

Table.5

| Sr No | Comparison  | FERROCEMENT   | RCC   |
|-------|-------------|---|---|
| 1     | Self Weight | Self-weight of ferrocement is about approximate 50% less than that of RCC.          | Self weight of RCC approximate more than 250% that of ferrocement water tower tank. |
| 2     | Durability  | Ferrocement being crack resistant material, it is very much durable with no repairs | RCC is generally cracked section material. It is deteriorates after 15-20 years.    |

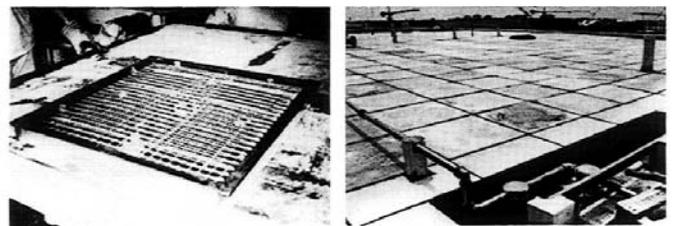
|   |                                  |   |  |
|---|----------------------------------|---|--|
|   |                                  | requirement up to 50years.  |  |
| 3 | Strength                         | Ferrocement has high strength to weight ratio.  | RCC has much low strength to weight ratio as compared to ferrocement.  |
| 4 | Foundation in Ferrocement System | Cost of foundation of ferrocement system like water tank is less than that of RCC. Foundation of ferrocement frame is convenient on weak soil.  | Cost of foundation is higher than that of ferrocement. Weak soil requires costly foundation such as pilling or any other.            |
| 5 | Pre-gunited Structures           | Ferrocement system has surface of beams, columns, floors, require approximate 5mm wire mesh reinforcement layers. The arrangement of this system has wire mesh reinforcement is of small diameter and at close spacing. Therefore it resists crack formation very efficiently. There are at least 2 or 3 layers of wire mesh. | There is no such arrangement in the case of RCC frame. RCC sections generally being cracked by the effect of weathering or external. |
| 6 | Waterproofing                    | Many Ferrocement systems does not require any waterproofing treatment for example water tank.   | Waterproofing of walls and floor has to be exclusively carried out.  |
| 7 |                                  | Ferrocement   | RCC structures   |

|   |                                |   |   |
|---|--------------------------------|---|---|
|   | Earthquake and wind resistance | system has a ductile property. The earthquake and wind forces are very low. | earthquake and wind forces are very high.     |
| 9 | Cost                           | Cost of ferrocement system is less than that of RCC.                        | Cost of RCC is more than that of Ferrocement. |

II. FERROCEMENT SYSTEM USED IN BUILDINGS

A. Ferrocement in Slabs:

- Reinforced concrete is commonly used for the protection of structure. The concrete structure subjected to a combination of blast and fragments loads, when these structures are subjected to dynamic loads due to explosion. The structure will shake, vibrate, serve crushing of concrete occurs and crater forms in front of the concrete when the fragments and blasts influence the structures forming small charges is used.
- The ferrocement is used as reinforcement to concrete slab which enhance the perforation resistance and reduce the heat transfer through the thinner thickness of the steel mesh reinforced cement grid. As compare to the non tested slabs the fire tested ferrocement slabs gives the less resistance and penetration. The ferrocement layers generally having the good stiffness and impact resistance.



B. Ferrocement for Structural Beam Rehabilitation:

- Due to the attacks of carbonation, chlorides etc, a large number of civil infrastructures around the world are in the condition of serious deterioration. The overloading causes the structures to a serious damage. Hence, the most of the civil structures are no longer considered safe due to these over loadings or due to the lack of quality control. For obtaining the good structural results, the older structures must be strengthened, so that they fulfill the requirements of the structures in the present and in future. ferrocement is very versatile material which is used not only for housing, industry but its potentials are

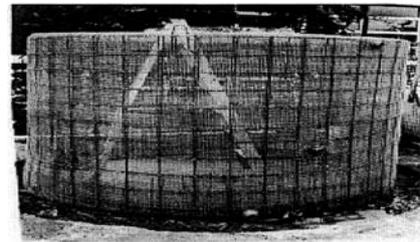
commonly used in retro fitting and strengthening of destroyed structural members. The ferrocement is constructed of hydraulic cement mortar, which is reinforced with closely packed layers of relative small wire diameter mesh. It has been mentioned that the ferrocement is the type of reinforced concrete, a per ferrocement model code. That mesh is made up of metallic or other suitable materials. To obtaining the proper strength, cracking control, ductility and impact resistance by using the ferrocement in thin walled, it is important to adjust the material properties to the construction type and forces acting on the structures. To improving the material properties of mortar some water soluble polymer dispersions are often used. Because of the good performance, the polymer mortars are used as a popular construction material to inhibit the wet corrosion of reinforcing bars in concrete structures, the use of polymer modified mortars are recommended as repairing and finishing materials. But in practical the powered polymer mortars can be used in the same manner as those of the polymer modified mortar. We can improves the water retention of powered and polymer-modified mortars, but the improvement is depends upon the type of cement modifiers used. The large volume of air voids often forms. When the cement mixtures are mixed with polymer. Jae-Ho-Kim introduced a technique at 1997 in involves pre-wetting the cement and sand with plain water before adding the polymer solution or dispersion. The wet cured polymers are assumed to have lower bond strength than the dry cured polymer mortars. The polymers can be filled into the micro cracks, pores and cracks. With the increase in the addition of polymer the water adsorption decreases remarkably when the polymer cement ratio is small. But on exceeding the polymer cement ratio 10%, the change may become unnoticeable. Where the external reinforcement subjected to mechanical and environmental damage, this technique becomes attractive for flexural strengthening.

#### C. Ferrocement in Water Tank:

- Ferrocement tanks are lighter in weight (wall thickness of 500 liter is one cm) and higher in strength as compared to reinforced concrete tanks. It involves minimum skill, lesser project cost for fabrication, maximum utility and service-ability. Ferrocement tanks can replace costly steel/mild steel tanks. As compared to PVC and steel tanks, ferrocement tanks are Eco-friendly and the quality of these tanks is that here the water gets less heated in summer.
- Ferrocement tank have diversified applications in addition to water tanks such as grain storage silos,

septic tanks, animal feed, cup-boards, boundary wall, door shutters, segmented roofing sheets, man-hole covers (light, medium and high duty), irrigation channels, ferrocement earth quake resistant houses, flower pots etc. All these products can be fabricated in the same unit with the use of different molds.

- While tanks up to 1000 L capacity could be fabricated at factory premises higher capacity tank could be fabricated casting the cylindrical surface in four segments which are later joined together with base in situ. These segments are transported in trucks carrying the material for large number of tanks.



#### D. Ferrocement Applications:

We are Civil Engineers, specialized in FERROCEMENT construction techniques. Our activity is largely concentrated on ferrocement tanks for storage of water, oil chemical, petroleum products etc, containers, elevation treatment, sloping roofs, domes, resort structures, water proofing treatments, manhole covers, heavy duty floors wall cupboard systems. Low cost houses, anti-corrosive treatment, rehabilitation works, site cabins, etc. Ferrocement structures have advantage over the conventional materials like RCC steel, wood and plastic as these are durable strong, waterproof and also competitive in price generally. Ferrocement structures are constructed using ferrocement plates made on machinery set up. These plates are joined suitably to make different components such as footings, columns, beams, floors walls, roof, dome structural plates other structures such as tanks, containers, silos, floating dock etc are constructed. The Quality of ferrocement works are better assured because the components are manufactured on machinery set up. Moreover, the execution time at work site is reduced, contributing least shutdown. Maintenance cost of ferrocement structures is almost negligible.

### III. CONCLUSION

The conclusion of this review paper is the properties and uses of ferrocement. Ferrocement is an old technique; it has observed that the little use until recent decades. Ferrocement can compete with other materials as a economical manner depending on the type and site location. Ferrocement is similar with RCC and its composition is cement mortar with wire mesh, as opposed to steel bars and concrete. The behavior of ferrocement system is different as compared to RCC. RCC have good compressive strength, ferrocement has excellent tensile and flexural strength. However, innovative structures in different parts of the world have clearly indicated the unique, unmatched properties of this material and therefore the vast potential waiting to be explored. Uses of Ferrocement include boats, water tanks, design a

earthquake resistant buildings and improve structural configurations etc.

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