Ferrocement Construction Technology And It's Applications

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Abstract- *Ferrocement construction technology is quite popular throughout the world. Ferrocement, a thin element, is used as a building construction as well as a repair material. This paper attempts to review the literature on ferrocement and bring out the salient features of construction, material properties and the special techniques of applying cement mortar on to the reinforcing mesh. 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 study concludes that ferrocement will certainly be one of the best structural alternatives for RCC in the future.*

Keywords- ferrocement, pool, tank, RCC, roof

I. INTRODUCTION

Shelter is one of the basic needs of human being. But more than 80 developing countries in the world suffer from housing shortages resulting from population growth, internal migration, war, natural disaster, to mention a few. Most dwellings in rural areas are made of cheap local materials including low quality wood (which is easily attacked by termites), scrap metal, thatch and/or earth products (like clay, mud, sand, rock/ stone) which are temporary and unsafe. There is an urgent need to explore a building material that is structurally efficient but at the same time, should be lightweight, eco-friendly, cost effective and especially the ones that can perform the desired functions (Akhtar et al. 2009). Ferrocement is such a material that is slim and slender but at the same time strong and elegant (PushyamitraDivekar, 2011) which provides a potential solution to roofing problems.Ferrocement is more durable than wood/ timber and cheaper than imported steel (Hago et al. 2005). Small capacity ferrocementbins upto 3 metric tons which are cylindrical in shape, and size of 1.20 m (3.9 ft) in diameter and prefabricated in heights of 1 m (3.28 ft) is analysed and successfully tested in India (Sharma et al. 1979) and the results have proved that ferrocement bins are less expensive than the bins made of steel, reinforced cement concrete (RCC) or aluminum (ACI 549 R97).

II. UNIQUENESS OF FERROCEMENT

Ferrocement is a thin construction element with thickness in the order of 10-25 mm (3/8–1 in.) and uses rich cement mortar; no coarse aggregate is used; and the reinforcement consists of one or more layers of continuous/ small diameter steel wire/ weld mesh netting. It requires no skilled labour for casting, and employs only little or no formwork (Ferro 7, 2001). In ferrocement, cement matrix does not crack since cracking forces are taken over by wire mesh reinforcement immediately below the surface. Ferrocement is being explored as building materials substituting stone, brick, RCC, steel, prestressed concrete and timber and also as structural components—walls, floors, roofs, beams, columns and slabs, water and soil retaining wall structures.Ferrocement can be fabricated into any desired shape or structural configuration that is generally not possible with standard masonry, RCC or steel.

III. FERROCEMENT STRUCTURES WORLD-WIDE

A large rectangular ferrocement flume 35 m (115 ft) long, 2 m (6.6 ft) wide, and 1.3 m (4.3 ft) high has been built in the hydraulic engineering laboratory at the National University of Singapore to conduct model tests under wave action (Paramasivam et al. 1985). The remarkable work done using ferrocement are acoustic panels of ferrocement hung from ceiling in the de Menil Museum in Houston, Texas and ferrocement permanent formwork gracing the ceiling of the Schlumberger building in Cambridge, U.K. (Ferro 7, 2001).

IV. CONSTITUENTS OF FERROCEMENT

Ferrocement is a composite thin element which is constructed of building materials--steel reinforcing mesh, cement, fine aggregate (sand) and water (Naaman, 2000; ACI Committee 549R-97; and Nassif and Najm, 2004) and each of these materials are separately described in this section below.

IV.1. Steel Reinforcing Mesh

Ferrocement uses layers of continuous/ small diameter steel wire/ weld mesh netting (metallic or non-metallic) as reinforcement with high volume fraction of reinforcement (2 to 8%) and the specific surface of reinforcement is considerably higher for ferrocement than for RCC. Also, the reinforcing steel wire mesh has openings large enough for adequate bonding; the closer distribution and uniform dispersion of reinforcement, transform the otherwise brittle mortar into a high performance material distinctly different from reinforced concrete. Skeletal steel rods/wires/strands are used as spacer material and to form the skeleton of the shape of the structure to be built, around which the mesh layers are later attached (Naaman, 2000).

IV.2. Cement

Portland cement is generally used in ferrocement. But the type of cement should be selected according to the need or environment in which the structure is built, for example ASTM cement Type I-V mentions the strength characteristics of cement and its specific use / application (ACI 549, IR 93). Mineral admixtures, such as flyash, silica fumes, or blast furnace slag, may be used to maintain a high volume fraction of fine filler material as well as to enhance the properties at wet and hardened state.

IV.3. Aggregate

Only fine aggregate is used in ferrocement. Coarse aggregate is not used in ferrocement. Normally, the aggregate consists of well graded fine aggregate (sand) that passes a 2.34 mm sieve; and since salt-free source is recommended, sand should preferably be selected from river beds and be free from organic or other deleterious matter (Sakthivel&Jagannathan, 2011). Good amount of consistency and compactibility is achieved by using a well-graded, rounded, natural sand having a maximum top size about one-third of the small opening in the reinforcing mesh to ensure proper penetration (ACI Committee 549R-97). The moisture content of the aggregate should be considered in the calculation of required water (Naaman, 2000).

IV.4. Water

In ferrocement, the water used for mixing cement mortar should be fresh, clean and fit for construction purposes; the water of pH equal or greater than 7 and free from organic matter— silt, oil, sugar, chloride and acidic material (ACI Committee 549R-97).

V. FERROCEMENT CONSTRUCTION PROCESS

Construction sequencing/ process is important for ferrocement construction. Since the ferrocement elements are very thin in the order of 10-25 mm (0.39-1 in.), considerable care is to be taken to maintain minimum cover of 3 mm (1/8 in.).In Ferro cement construction a frame of chicken wire mesh is made. A mixture of cement, sand, and water is spread over the frame. Then the Ferro cement structure is allowed to cure for 28days.

VI. APPLICATIONS

VI.1. Structural Applications

There are various applications of this technology some of them are as follows:

Ferrocement can be used in various structural members subjected to different type of stresses. As a compression member, hollow columns with horizontal stiffners can be cast in ferrocement. Columns or walls in concrete, RCC, stone or brickwork can be encased in ferrocement to increase their strength due to confinement. Members subjected to membrane stresses like shells, domes, pyramids can be cast in ferrocement very easily; and being a homogenous material, full section of member is utilized in resisting the membrane stresses.A greater use could be made of ferrocement in water-retaining constructions and other similar constructions where crack width is a design criterion (Al-Kubaisy and Jumaat, 2000). Because of its very small crack widths under service load and it superior extensibility, ferrocement provides excellent leakage characteristics for applications in water tanks; moreover, should pressure increase, ferrocement stretches to allow higher leakage and acts as a safety valve, thus, it does not fail.

VI.2. Roofing Applications

Ferrocement appears to be an economic alternative material for roofing; and flat or corrugated roofing system is quite popular (ACI Committee 549-R97). Ferrocement roofing materials can be factory mass-produced in prefabricated form, a process best suited to the concentrated demands of the urban area, or it also can be fabricated in-situ in villages. Construction of hundreds of ferrocement roofs for poorer areas of Mexico has been well documented; most of these ferrocement roofs were dome shaped with a span of 3 to 6m (10 to 20 ft); and large ferrocement roofs have also been constructed in Italy spanning 17m (56 ft) with a thickness of 30 mm (1.2 in.). The use of ferrocement as

roofing for large span structures with internal ribs has been successful in many European and South American countries. Domes have been constructed in Jordan using 25 mm (1 in) thick ferrocement with internal ribs (Jennings, 1983).

VII. ADVANTAGES OF FERROCEMENT

- Ferrocement is an innovative material and has a number of structural applications which includes earth-retaining walls, swimming pools, underground and overheadwatertanks .Ferrocement is also used in construction of corrugated roofs, hyperbolic paraboloid shell structures, domes and housing structures. Ferrocement thin elements are used in facades, sunscreens and curtain wall etc.
- Ferrocement elements undergo high deformations before collapse. It has high level of impact and cracking resistance, toughness and ductility.
- The ferrocement structures are thin and light-weight compared to conventional reinforced concrete. Hence there is considerable reduction in self -weight of the structure and saving in foundation cost. Transportation cost is also less, and due to less consumption of building materials and scaffolding items in ferrocement, (as compared to RCC), not much space is required for storing materials
- Ferrocement can be fabricated into any desired shape or configuration. Precasting is suitable for thin ferrocement elements, and mechanised methods can be adopted in case of mass production of ferrocement components.
- Partial or complete elimination of formwork is possible. Hence there is considerable saving in the cost of formwork, particularly for curved or complicated/ complex shapes/ structures, which is not possible with RCC construction.
- Ferrocement is suitable for repair works in boats, water tanks, swimming pools, sewer lines etc. Ferrocement is also suitable for repair or rehabilitation/restoration of ancient or heritage building structures. The repaired elements can withstand long years without cracking.
- In order to prevent corrosion, new meshes manufactured of stainless steel, plastic, PVC, or any other non-metallic mesh reinforcement may be explored as reinforcement in ferrocement. This study also recommends that fibers (such as nylon, poly-vinyl chloride, polyolefin, polyvinyl alcohol, polyethylene and polypropylene) may be added as additional reinforcement in ferrocement into the matrix composition for crack-control and resistance against local loads.

VIII. CONCLUSION

This study has brought out that ferrocement is an innovative material and the ready availability of materials and ease of construction make it suitable in developing countries for housing, and water and food storage structures. Ferrocement is found to be a suitable material for repairing or reshaping the defective RCC structural elements and enhancing its performance. The applications offerrocement are capturing almost all the fields of civil engineering but there is a dirth of research backing and a rationale design base to construction of ferrocement structures. Considering the unique features, ferrocement will no doubt be one of the most important structural alternatives for RCC and a repair material in the future and thus has a great potential for developing and developed countries alike.

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