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Development of ferrocement technology for low-cost farm structures

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Abstract

The present study is an attempt to familiarize ferrocement technology for the construction of low-cost structures for farm uses. The selected structures that have been identified for farm uses are storage structure, cattle trough, irrigation and drainage canal lining, and manhole cover. Utilizing locally available materials the design and fabrication of the structures have been made using simple techniques. The cost of construction of ferrocement structures has also been estimated on the basis of present cost of materials and labour. It is hoped that the observations made in this study will bring new idea in achieving wide acceptance of this technology for the construction of low-cost structures for farm uses.

Keywords: Wire-mesh, Skeletal steel, Cement-mortar, Ferrocement

Introduction

Ferrocement is a thin slab of cement mortar reinforced with wire mesh. The very name ferrocement implies the combination of ferrous product i.e. layers of wire mesh or similar small diameter steel mesh with cement mortar (Fig.1). The thickness of ferrocement sections vary from 0.40in to 1.6in (10mm to 40mm). This material which is a special form of reinforced concrete, exhibits behaviour so different from conventional reinforced concrete in performance, strength and potential application that it has been classed as a separate building material. It can be constructed with a minimum of skilled labour and utilizes readily available materials. Its prime attraction lies in its simplicity of construction, flexibility in usages, economically viable, and adoptability to various structural forms (Paul and Pama, 1978).

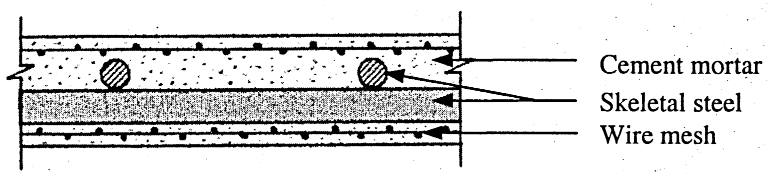


Fig.1 Typical cross section of ferrocement slab element

Since its acceptance as a construction material, its use has vastly been limited to the sector of housing and marine constructions in addition to its application in the manufacture of storage structures. In view of shortage of timber and other building materials ferrocement has been reported to be utilized as secondary structures in rural and urban areas (Ali, 1993; Hussin and Sam, 1993). Research and development work on ferrocement in Bangladesh, however, are not many. Including Bangladesh Agricultural University, only a few institutions like Bangladesh University of Engineering and Technology and Housing and Building

Research Institute in Dhaka have applied ferrocement techniques but mostly limited to demonstration only (Ahmed *et al.*, 1992). Understanding the facts stated above, a study was made in the Department of Farm Structure, Bangladesh Agricultural University, Mymensingh with the following objectives:

1. To identify structures that can be made with ferrocement technology for farm uses.
2. To develop techniques in designing the ferrocement structures using locally available materials.
3. Fabrication and cost estimation of ferrocement structures.

Materials and Methods

Unlike other sophisticated engineering constructions, ferrocement requires minimum of skilled labour and utilizes readily available materials. The basic materials needed for ferrocement constructions are wire mesh, sand, cement, water, and mild steel rod as skeletal reinforcement. A brief description of the constituent materials and construction procedure is given below.

Constituent Materials

Wire mesh

One of the most essential components of ferrocement is wire mesh. Wire meshes either square, hexagonal or expanded metal, are usually 0.5mm to 1.0mm in diameter and spaced at 5mm to 25mm apart (Fig.2). But it is important that they must be easily handled and, if necessary, flexible enough to be bent around sharp corners. The primary function of the wire mesh is to act as a lath providing the form and to support the mortar. In the hardened state it absorbs the tensile stresses on the structure which the mortar, on its own, would not be able to withstand. In this project square woven meshes having 1mm wire diameter with 5mm spacing were used.

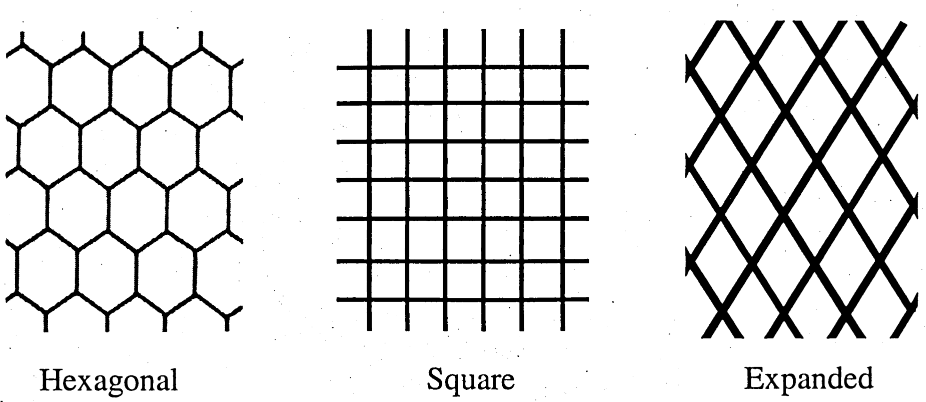


Fig.2 Typical wire meshes.

Skeletal steel

Skeletal steel bar is used for making the frame work of the structure upon which layers of mesh are laid. The rods are spaced from 7.5cm (3in), center to center, to 30cm (12in) depending upon the size of the structure and type of loading that the structure will carry. The size of the rods normally varies from 4.2mm (0.165in) to 9.5mm (3/8in) whereas 6.25mm (1/4in) was mostly used in this study.

Cement

There are several types of cement available commercially of which normal or ordinary Portland cement is the most common. This type of cement is adequate for applications were special conditions do not prevail. In the present study normal Portland cement (ASTM Type I) was used throughout the research work.

Sand

Well graded coarse sand commonly used for making concrete is good enough to prepare mortar for ferrocement work (Anon, 1976). There should not be excess of fine particles, and sand particles porous in nature are not recommended since it affects durability and structural performance of mortar. River borne well graded coarse sand having fineness modulus of 2.3 was used in making mortar.

Mixing water

The quality of water for mixing of mortar has vital importance on the resulting hardened ferrocement. Impurities in water like clay, acids, soluble salts or other organic matters may interfere with the setting time of cement and finally the strength of the structure. Sea water is not at all suitable for mixing the mortar as it increases the risk of corrosion of the mesh and reinforcement. In this study supplied tap water was used for making cement mortar.

Construction Procedure

Making skeletal frame and placement of wire mesh

The ferrocement structures, sketched in Figs.3-6, were fabricated in the Concrete and Material Testing Laboratory. As per dimensions of the structures, the amount of longitudinal and transverse steel was calculated for various segments. After all the steel has been cut to the required length, the skeletal frame was constructed according to the shapes of the structures. The joint connection between steel bars was made by welding. Following the shape of the structures, two layers of wire mesh - one inside and one outside of the steel frame, were placed and tied with steel wire maintaining the thickness as minimum as possible.

Preparation of mortar

It is utmost important that the mixing of mortar should be done in such proportions as to give consistently the desired strength. The proportion of cement to sand generally varies from 1part of cement to 1.5 to 2 parts of sand by weight. The proportion of cement to sand by weight used in the mix was 1:2. The water-cement ratio used was in the order of 0.5 depending upon the dryness of the sand. In the mixing process, sand and cement were firstly mixed uniformly. Water was added part by part in order to obtain required workability of the mortar mix.

Plastering

The strength and durability of a ferrocement structure largely depend on the plastering work. Before plastering a structure, it was ascertained that the reinforcing rods and wire meshes were in proper position; and all the reinforcement was brushed off if there were rust, grease or any other contaminants.

Plastering by hand using trowel has proved to be most satisfactory. The plastering technique employed here was a one-stage method that refers to a single monolithic application of mortar to fill up the wire mesh, finishing both inside and outside surfaces at the same time before the initial set of cement has taken place. For stiff mixes, mortar normally remains in position after placing. For straight and vertical structure like canal/drain lining, plank of wood was used. Storage structure and cattle trough having circular or semicircular shapes were, however, plastered using iron sheet as temporary support to the mortar. Simple sections, say manhole covers were plastered directly on the floor placing polythene sheets.

Curing

The objective of curing is to keep the mortar saturated and to promote the hydration of cement. There are several methods of curing of which moist curing i.e. covering the structures by wet jute mats was followed for about one week.

Results and Discussion

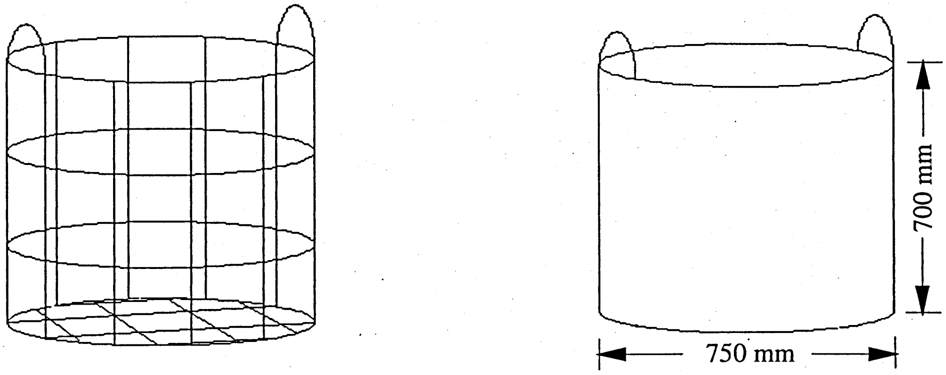
The sketches of various ferrocement structures identified for farm uses are presented in Figs.3-6. The cost of construction of ferrocement structures has been estimated on the basis of cost of materials and labour, and is listed in Table 1

The prototype storage structure (shown in Fig.3) with a capacity of about 0.30 cubic meter (10 cft) can be used for storing either dry or liquid substances. Materials like food grain e.g. rice, wheat, corn etc can be stored in the structure. Due to the provision of two handles, the structure can easily be shifted from one place to other without trouble. According to the need, however, one can make the structure bigger or smaller.

Another item that has been made for farm use is cattle trough. The traditional cattle troughs are made of burnt clay, popularly known as 'chari'. These are neither strong nor suitable for mass use, particularly in dairy farms. Concrete made troughs are sometimes found to be used but these are relatively heavy and expensive. Because of high adaptability to various structural forms, ferrocement technology can be applied in making not only the round shaped cattle trough, shown in Fig. 4 but also be employed in constructing troughs of any shape and size for large scale farm uses.

A good amount of water is lost when water is conveyed through earthen channels for irrigation. The ferrocement water conveying structures (Fig.5) would definitely reduce the loss of water. Also considering the cost of construction, irrigation or drainage canal linings made of ferrocement offer an alternative to the structures traditionally made of concrete or brickwork.

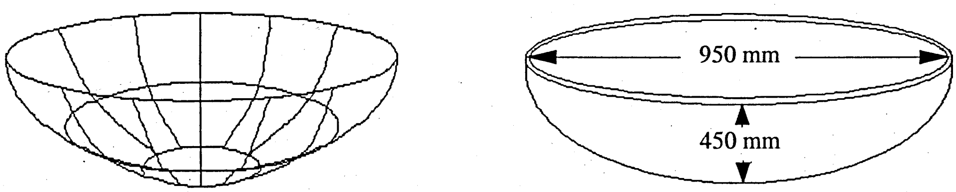
Two types of manhole covers - rectangular and circular were constructed (Figs. 6a & 6b). In comparison to the traditional manhole cover made with iron, these manhole covers are much lighter and cheaper. It is a common phenomenon that because of the greater resale value, the iron-made manhole covers are frequently stolen and the septic tank, inspection box etc are often found uncovered. If such structures are replaced by ferrocement a considerable amount of money can be saved, saving also the environment from pollution.



Skeletal steel

Completed structure

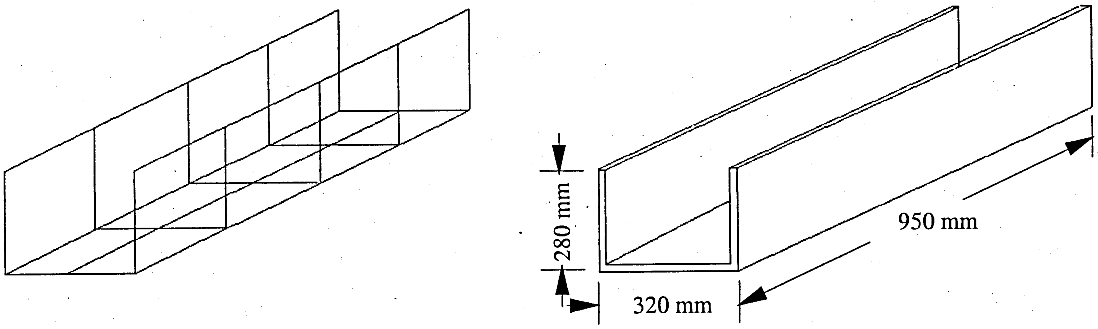
Fig.3 Sketches of the storage structure



Skeletal steel

Completed trough

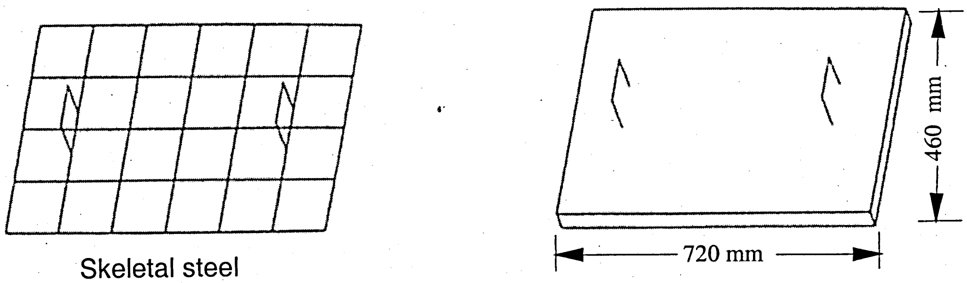
Fig.4 Sketches of the cattle trough



Skeletal steel

Completed channel

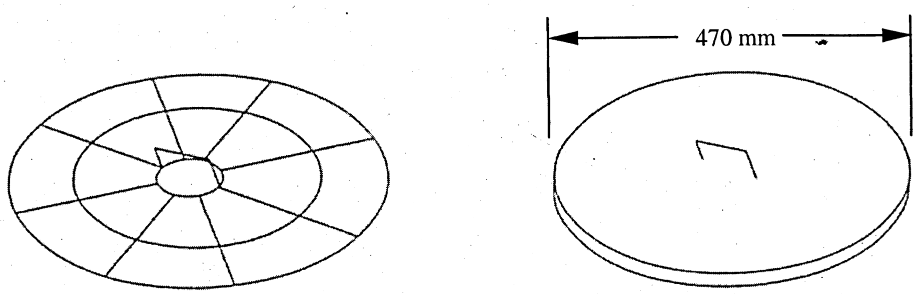
Fig.5 Sketches of the irrigation/drainage canal lining



Skeletal steel

Completed manhole cover

Fig.6a Sketches of the rectangular manhole cover



Skeletal steel

Completed manhole cover

Fig.6b Sketches of the circular manhole cover

Table 1. Estimated cost of various ferrocement structures*

Type of Structures		Cost of Materials (Tk)	Cost of Labour (Tk)	Total cost (Tk)
Storage structure		545	400	945
Cattle trough		350	250	600
Irrigation / drainage canal lining		255	100	355
Manhole cover	Rectangular	130	100	230
	Circular	80	100	180

*Detail dimensions of the structures have been shown in Figs. 3-6

Table 1 summarizes the cost of various ferrocement structures estimated on the basis of cost of materials and labour. Though it has not been the prime objective of the studies to compare the cost of construction of ferrocement structures with other varieties of materials, it can however be emphasized that ferrocement structures are relatively cheaper than those made with traditional materials like timber, steel and such other materials.

Conclusions

Structures that have been identified and made in this project are some of many that can be constructed for farm uses using ferrocement technology. The results obtained have demonstrated that utility and economy can both be achieved using very simple techniques utilizing readily available materials. It is expected that the observations made here in this research will bring new concept in gaining wide acceptance of ferrocement for the construction of low-cost but strong and durable structures for farm uses.

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