Tensile Strength of Ferro Cement With Respect to Specific Surface

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Abstract— Ferrocement is a term commonly used to describe a steel-and-mortar composite material .Essentially a form of reinforced concrete, it exhibits behavior so different from conventional reinforced concrete in performance, strength, and potential application that it must be classed as a completely separate material. It differs from conventional reinforced concrete in that its reinforcement consists of closely spaced, multiple layers of steel mesh completely impregnated with cement mortar.

The use of ferrocement is a promising technology for increasing the flexural strength of deficient reinforced concrete members. The study reported herein investigates the increase in tension due to increase in contact area between wire meshes and mortar, i.e. increase in specific surface of ferrocement. For achieving higher values of specific surface, No. of Layers of meshes needs to be increased.

So in a beam if we use ferrocement in tensile zone of beam, we will be in a position to replace steel bars used in R.C.C, saving in steel is thus achieved.

Behavior of such Ferrocement is studied which includes following mechanical properties for determining the relations between the tensile strength of ferrocement with respect to the specific surface using various combination of mortar and meshes which is to be used in ferrocement.

1. ***Tensile Strength.***
2. ***Compressive Strength.***
3. ***Split Tensile Strength.***

I. INTRODUCTION FERROCEMENT TECHNOLOGY

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, 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. Ferrocement is such a material that is slim and slender but at the same time strong and elegant which provides a potential solution to roofing problems, with an history of ancient and universal method of building huts by using reeds to reinforce dried mud (ACI Committee 549-R97).

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Small ferrocement tanks of less than 18.9 m3 (5000 gal) capacity were being factory built in New Zealand (Bulletin CP-10, 1968), and elevated water tanks of 47.3 m3 (12500 gal) capacity were successfully constructed in Bangladesh in 1989. Ferrocement silos can hold up to capacity of 10 metric tons (22400 lb) of grain/ food stuffs, fertilizer, cement and pesticide. Ferrocement is more durable than wood/ timber and cheaper than imported steel. Small capacity ferrocement bins 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 and the results have proved that ferrocement bins are less expensive than the bins made of steel, reinforced cement concrete (RCC) or aluminium (ACI 549 R97). Two feasibility studies have shown that the cost of ferrocement is less than that of steel or fiberglass in the construction of wind tunnels (Report JABE-ARC-07, 1976) or hot water storage tanks (Report No.E-40-1-4899, 1976). In 1984, a swimming pool of 25 m X 12.5 m (82 by 41 ft) was built of ferrocement in Vila Loma Jlbacoa beach by the Enterprise Beaches of the East of Havana and its deeper part 1.80 m (5.9 ft) depth, with thickness of 25 mm (1 in.) in the walls were formed with precast panels. The total cost was almost seven times lower than one built with RCC of same size.

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. In ferrocement, cement matrix does not crack since cracking forces are taken over by wire mesh reinforcement immediately below the surface. an underground ferrocement shell structure which was built in 1993 at Ahmedabad, India has not only withstood the 2001 earthquake but also has remained crack-free till date. Such a structure involving complex curvatures can be constructed in a reliable manner using ferrocement technology, giving free reign to architectural expression. Ferrocement construction technology is being popularized throughout the world in countries like Canada, USA, Australia, New Zealand, United Kingdom, Mexico, Brazil, the former USSR, Eastern European countries, China, Thailand, India, Indonesia, and in other developing countries due to its uniqueness and versality. 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; other applications include window and door frames and shutters . Ferrocement can be fabricated into any desired shape or structural configuration that is generally not possible with standard masonry, RCC or steel.

III. PREAMBLE

From the experiments carried out, the main idea was to find out the contribution of tensile strength by bonding in Ferrocement composites. So we have tested the samples accordingly. From this we want to study tension taken by steel mesh, tension taken by mortar, and the increase in tension due to bond between wire meshes and mortar. So our Objective is that for any other type & size of mesh, if the specific surface is known, then its contribution to increase in strength can be calculated.

The use of ferrocement is a promising technology for increasing the flexural strength of deficient reinforced concrete members. The study reported herein investigates the increase in tension due to increase in contact area between wire meshes and mortar, i.e. increase in specific surface of ferrocement. For achieving higher values of specific surface, No. of Layers of meshes needs to be increased. Many a time, it becomes difficult to force mortar in this layer. The fine diameter wires, with smaller openings pose more problems.

So in a beam if we use ferrocement in tensile zone of beam, we will be in a position to replace steel bars used in R.C.C, saving in steel is thus achieved. Behavior of such Ferrocement is studied in this Literature with respect to the Tensile Strength.

III. DISTINCTIVE BEHAVIOUR OF FEROCEMENT IN TENSION

The behavior of ferrocement in tension is extremely interesting since ferrocement seems to adapt slowly to increasing its extensibility. Typically the tensile strength of ferrocement is directly proportional to specific surface. Numerous experimental studies have observed that, everything else being equal, the tensile stress at first cracking in ferrocement is directly related to the specific surface of reinforcement.

Tensile strength of ferrocement is limited by the tensile strength of its reinforcement taken alone in the direction of loading. The tensile strength of ferrocement also depends on the mesh orientation, and whether the applied load is uniaxial or biaxial. The specific surface of the reinforcement strongly influenced the cracking behavior of ferrocement. The relatively large specific surface for ferrocement may account for the combination of very small width of cracks and high tensile strength.

IV. TENSILE TEST OF FERROCEMENT

A tensile test of ferrocement composite can be used to determine the effective modulus of the mesh system, its ultimate tensile strength, and either its efficiency factor of reinforcement or its yield strength.

Direct tensile tests of ferrocement elements can be undertaken on rectangular specimens satisfying the same minimum size requirements as those set for mesh reinforcements. The test specimens should preferably be additionally reinforced at their ends for gripping. The middle half of the non-gripped (free) portion of the test specimen should be instrumented to record elongations. Drawn load-elongation curves for the readings. The load-elongation leads to the tensile stress —strain curve of the ferrocement composites. Moreover the curve can be used to estimate the ultimate strength. Unlike reinforced concrete, tensile behavior of ferrocement is considerably different. This is mainly because the reinforcement is spaced closer and uniformly than in reinforced concrete and its smaller diameter results in a larger specific surface area. This in turn affects cracking behavior in Ferrocement.

Work indicated that the stress level at which the first crack appeared and the crack spacing were a function of specific surface of reinforcement. The ultimate load of ferrocement specimen was the same as the load carrying capacity of the reinforcement in that direction. The tensile strength of Ferrocement is a result of the volume of reinforcement used in the structure.

A ferrocement member subjected to upwards tensile stress behaves something like linear elastic material until the first crack appears. Beyond this, the member will enter the multiple cracking and eventually continuing to a point where the mesh starts to experience yielding. Once at this stage the number of cracks will continue to grow with the increase in the tensile force or stress. The specific surface area of the ferrocement member or element has been found to influence the first crack in tension, as well as the width of the cracks. The maximum stress at first crack for ferrocement matrix increases in proportion to the specific area. Direct tensile strength of ferrocement using commonly available steel meshes can reach up to 25 MPa. Higher stresses can be achieved with meshes having higher yield strength. Tensile strength of ferrocement is directly proportional to the volume fraction of reinforcement in the loading direction.

V. GENERAL BEHAVIOUR OF FERROCEMENT IN TENSION

The stress-strain Curves reported are shown below

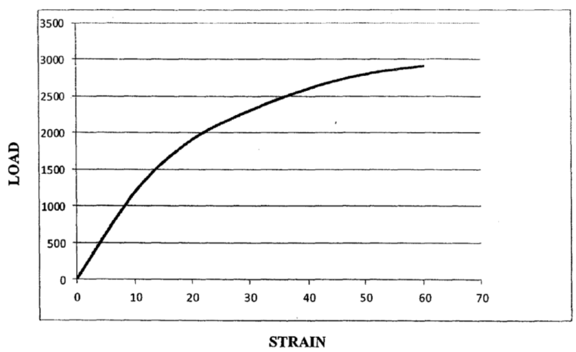

Fig 2.1 - Load vs. strain of ferrocement in axial tension

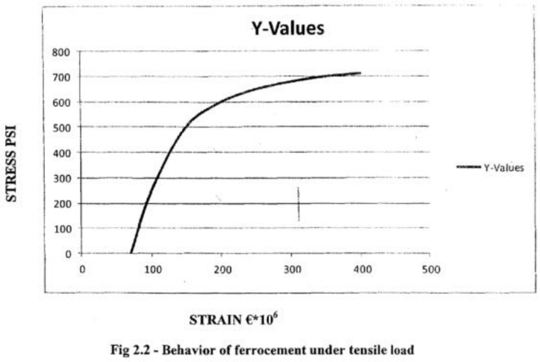

Fig 2.2 - Behavior of ferrocement under tensile load

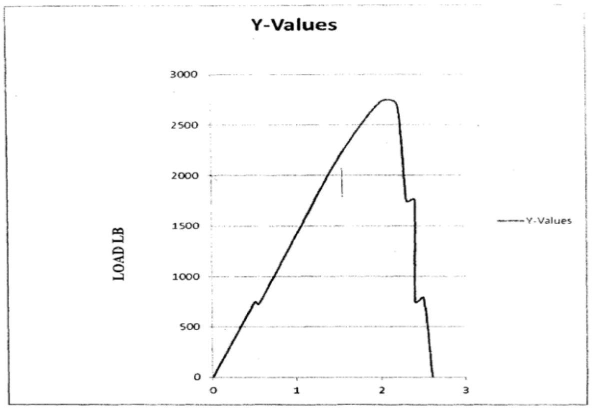

Fig 2.3 - Load vs. Elongation curve showing first crack determination

From this stress-strain curve, following conclusions were made:

When a ferrocement specimen is subjected to increasing tensile stress, the three stages of behavior are observed.

(1) Elastic stage
The stress-strain curve is essentially linear in this stage. No cracking is observed with magnifications up to 70 mm.

(2) Crack formation stage
Stress-strain curve deviates from linearity and an increasing number of cracks is seen with increasing stress. The cracks are very fine in this stage 0.005 to 0.05 mm and increasing mortar strains are due to increase in number of cracks rather than increasing width of cracks.

(3) Crack widening stage
The maximum numbers of cracks that are going to develop have already developed before this stage. Increasing mortar strains are thus mainly due to increasing width of cracks.

Ferrocement specimens have much finer and more numerous cracks than conventional concrete. Considerable amount of research has been done in trying to predict crack widths and number of cracks for conventional R.C.C structures. For these structures, it has been shown that crack width can be reduced by increasing the bond between steel & concrete, by increasing distribution of reinforcement and by reducing cover (crack width is nearly zero at the interface between steel and concrete and increases as you go away from the interface towards the surface of the structure; i.e. the cover, the smaller the crack width). All these factors are favorable for ferrocement. A parameter which combines all these factors is nothing but the specific surface of the reinforcement. It is defined as the total surface area of reinforcement per unit volume of the composite. The tensile strength of ferrocement depends chiefly on the volume of reinforcement and the tensile strength of mesh.

Types of sand, normal weight or light weight, and ratio of sand and water have a little influence on the tensile strength of ferrocement.

VI. EFFECT OF SPECIFIC SURFACE ON FIRST CRACK STRENGTH

It can be observed that the stress-strain at first crack increases with increasing specific surface, up to a certain point. A unique relationship between specific surface ratio and composite stress at first crack was observed. It is clear that the stress at first crack increases linearly with increase in specific surface irrespective of size, type and spacing of the wire mesh.

VII. CONCLUSION

The contribution of tensile strength of ferrocement can be evaluated by bonding with ferrocement composites. From the experiment carried out it can be studied the tension taken by steel mesh only, tension taken by mortar only & tension due to bond between wire meshes & mortar. From the experiment we observe regarding increase in tension due to increase in contact area between wire meshes and mortar i.e. increases in specific surface of ferrocement composite with different compositions.

Thus with this we can find out the relation of increase in tensile strength of mortar with respect to the specific surface. For future works; it will definitely prove that tensile strength of ferrocement is much more than ordinary mortar used so it can be used for various structural members for increasing their tensile strengths.

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