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SHEAR CAPACITY OF FERROCEMENT PLATES

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ABSTRACT

In order to reduce the in situ construction, now days the modernization and simplification of construction technology and building materials are preferred. The application of newly developed cement based composites for structural applications. Cement based composites perform better than conventional plain concrete.

INTRODUCTION

Ferro cement is one of the relatively new cementations composite considered as a construction material. It is a type of thin walled reinforced concrete commonly consists of cement mortar reinforced with closely spaced layers of continuous and relatively small wire mesh .The closely-spaced and uniformly-distributed reinforcement in ferrocement, transforms the otherwise brittle material into a superior ductile composite. Thus, Ferro cement has been regarded as highly versatile construction material possessing unique properties of strength and serviceability. Its advantageous properties such as strength, toughness, water tightness, lightness, durability, fire resistance, and environmental stability cannot be matched by any other thin construction material.[15] Ferro cement is the promising composite material for prefabrication and industrialization of the building industry.

However, as an alternative material ferrocement has not gained widespread acceptance in both; developed countries in general and developing countries in particular. Its acceptance is hindered mainly due to its small thickness and labour intensive method of production. The technical information available on the behaviour and strength of Ferro cement in shear is limited. The major variables of the study were the shear span-to-depth ratio, the volume fraction of the mesh wires, the strength of the mortar and the number of

mesh wires near the compression face. It is a versatile form of a composite material made of cement mortar and layers of wire mesh or similar small diameter mesh closely bound together to create a stiff structural form. This material which is special from reinforced concrete, exhibits behaviour so different from conventional reinforced concrete in performance, strength and potential application that it must be classed as a separate material. The constituent material in ferrocement are cement , fine aggregate, water, reinforcing mesh of any type like hexagonal , square mesh, diamond mesh galvanised mesh, woven mesh etc

Ferro cement as construction material

Ferro cement is a composite material constructed by cement mortar reinforced with closely spaced layers of wire mesh. Unlike studies on the behaviour of ferrocement elements under flexure very limited research reports are available on the shear behaviour of ferrocement elements. The reason for this may be due to the fact that the span to depth ratio of these elements is very high. But the use of ferrocement is not limited to stress skin elements alone and it finds application in the construction of compound structural sections like I, T, C, L etc. Thus there is a need for the understanding of this material under shear loading.

The behaviour of ferrocement in shear [12]:

The Ferro cement elements such as ferrocement plates, deep beams, rectangular beams having different span to depth ratio having a thickness that is small relative to their span or depth, and being primarily loaded in the plane of the member. They are two dimensional members in a state of plate stress in which shear is a dominant feature. The failure occurs mainly due to flexure shear failure and web shear failure.

Flexure Shear Failure:

In all the specimens, flexure cracks formed first in the span. As the load was increased, additional vertical cracks appeared and were followed by the formation of inclined cracks. In the shear span, an inclined crack developed either as an extension of a previously formed flexure crack or before a flexure crack occurred in its vicinity. The first type of inclined crack is referred to as a “flexure-shear crack” The flexure-shear crack originated as a vertical flexure crack that extended from the tensile surface of the specimen to about one- third of the depth of the specimen, then became inclined and propagated towards the nearer concentrated load.

Web Shear Failure:

The web-shear crack originated at about mid-depth of the specimen and then progressed towards the nearer concentrated load and the specimen support. The first type of inclined crack is referred to as a flexure-shear crack and the second type is identified as a “web-shear crack”. The failure that takes place in

specimen due to web shear crack is called as web shear failure,

Web shears failure. The internal stresses cannot be determined by ordinary beam theory, and ordinary design procedures for determining strength do not apply. Unlike studies on the behaviour of ferrocement elements under flexure very limited research reports are available on the shear behaviour of ferrocement elements.

Aim

The aim of this project is

i. To observe the behavior of ferrocement plates in shear by experimental analysis as well as FEM (Ansys) analysis.

ii. Analyze the shear strength of the ferrocement plate with various mesh patterns

Objective

To observe the behavior of ferrocement plate when

i. Different mesh pattern are used having different volume fraction.

ii. To determine the crack patterns under different loading conditions.

iii. To determine the shear strength, shear stresses developed in ferrocement element, shear cracking load of the specimen.

iv. The stress intensity calculation using equations from literature and compare with stress intensity obtained by FEM (Ansys)

Significance

The ferrocement elements such as beams, plates undergoes shear buckling ,which should be taken into account is the shear resisting mechanism, as the diagonal cracks that develop in the beams are considerably wider than the flexural cracks and the abrupt failure without advanced warning is distinctly different from the failure in flexure. Several attempts have been conducted to study the shear behaviour of ferrocement plates, beams were carried out. Although adequate design information and field experience have been acquired for many types of ferrocement structures, the shear behaviour is still questionable. Hence there is necessity to determine the shear strength of ferrocement element using the parameters like the number of mesh layers or volume fraction consequently lead to an increase of shear capacity.

Researchers all over the world have studied and have testing procedure for calculating shear capacity of ferrocement material.It includes the work on different parameters like shear strength of ferrocement plates depends upon volume fraction of the mesh, load carrying capacity of ferrocement materials, specific surface of reinforcement. Investigation on different types of beams as well as plates. Hence by knowing the previous methods the research carried to analyze how the shear strength of ferrocement beams, plates depends upon the volume fraction.

Following are literature reviews about different test conducted on plates and beams.

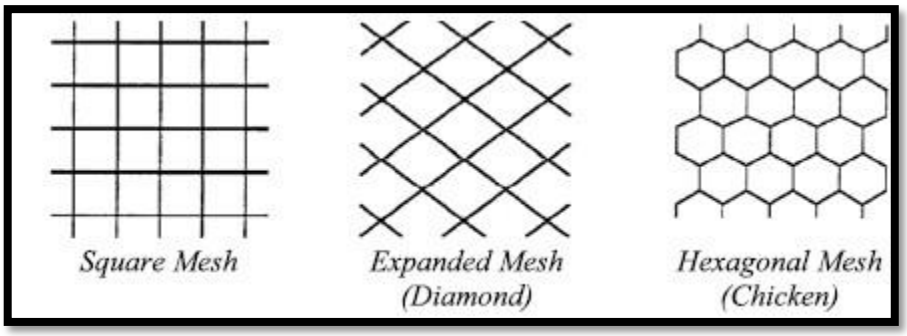
Literature review on plates:

Mansur and Ong [18] studied the behaviour and strength of ferrocement in transverse shear. Tests were performed on ferrocement beams reinforced in tension and compression sides with layers of galvanized square wire mesh under four point load pattern. In a later study they reported test data and the behaviour of ferrocement plates and I Beams reinforced with wire mesh as a secondary reinforcement for web and flanges. The major variables of the study were the shear span-to-depth ratio, the volume fraction of the mesh wires, the strength of the mortar and the number of mesh wires near the compression face. Test results indicated that the diagonal cracking strength of ferrocement increased as the shear span-to-depth ratio was decreased and other parameters were increased. Empirical equations were proposed to predict the diagonal cracking strength of ferrocement. Ferro cement beams were found to be susceptible to shear failure at small shear span-to-depth ratios when the volume fraction of the mesh wires and the compressive strength of the mortar were relatively high.

Chandrasekhar [17] investigated the shear strength of simply supported ferrocement rectangular plates subjected to four points loading. Tested ferrocement elements with varying the shear span to depth ratio and different layers of mesh and they observed that the increase in the volume fraction of the mesh reinforcement (number of layers of mesh) will increase the shear capacity of the member. It is also found that up to shear span to depth ratio 3, shear behaviour is predominant. Beyond shear span to depth ratio 3, the flexural behaviour is predominant and design of the elements based on flexure is sufficient. The in-plane shear is important when ferrocement is used as wall panels or partitions in structures subjected to racking or in plane shear forces due to wind and earthquake loads. Test data for such elements is scant and hence, an experimental study for combined load conditions such as in-plane shear and flexure is needed. Moreover, the localized compressive failure of concrete in ferrocement deep beams remains unsolved and needs to be clarified.

Hassan M.H. Ibrahim [9] investigated that the compressive shear failure is conducted on two groups of ferrocement deep beam specimens with overall depth equal to 230 mm and clear span of 400 mm. The specimens were tested under either a concentrated patch load at mid span (group A) or a uniform distributed load (group B) in which the loads cover nearly 10% and 67.5% of the clear span respectively. By using a single mesh layer as a web reinforcement, the present study adopt the US Naval Laboratory tests which demonstrated a remarkable increase in strength-to weight ratio where one mesh is used. The experimental programme contains total of 18 ferrocement plates of size 490×230×20mm were tested in bending under central in-plane patch

loading. The plates were designed to fail in shear and reinforced with flexural steel of 1ϕ10 mm deformed bar positioned at the midway of the cross section with a cover of 10 mm. The web is reinforced with a single layer of wire mesh reinforcement. The test variables included: (1) the mesh geometry including spacing of wires forming the mesh (large and small), and (2) the volume fraction of wire mesh. The specimens are identified using two abbreviated terms: the first term represents the wire mesh reinforcement type D for Diamond (i.e., expanded), S for Square, C for Chicken (i.e., hexagonal), and R for reference beam (i.e., plain mortar); and the second term represents the mesh opening size (L for large and S for small).



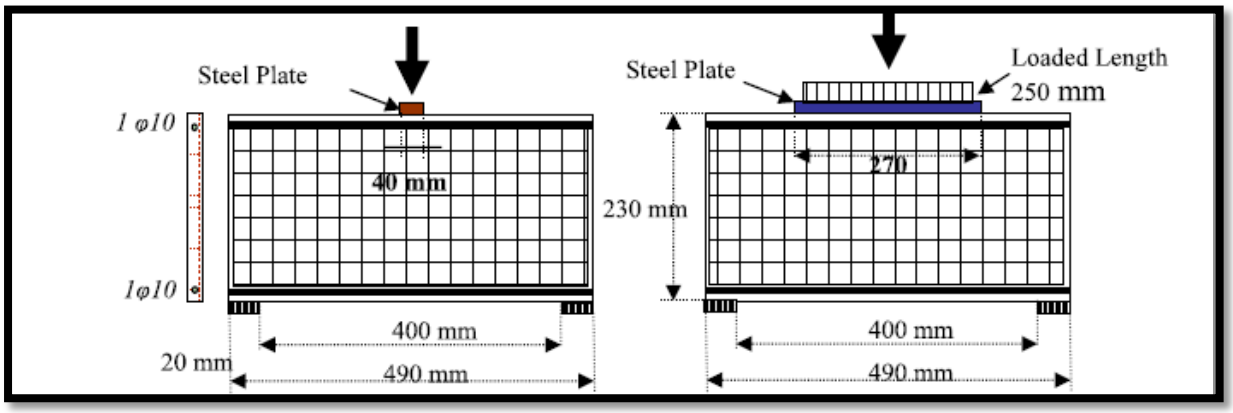


Figure 2.1 Details of Group A and B

The mortar matrix consisted of Portland cement, sand passing through 2.36mm sieve and water to cement ratio is 0.45. At the time of casting, six companion cube specimens of siz 70.6 × 70.6 × 70.6 mm were also cast to determine the ultimate compressive strength of the ferrocement mortar all specimens were cured under wet conditions for 28 days and tested for compressive and flexural tensile strengths. The average compressive cube strength was35 MPa. The experimental program consisted of two groups of deep beams according to the load and support configuration. Group A is tested under concentrated patch load while group B was tested under uniform load. Each group consists of testing twelve deep beams.

Figure 2.2 Types of wire mesh used

Summary

From the above literature reviews it is observed that there are various applications of ferrocement elements are available such as ferrocement laminates, ferrocement plates etc. The analysis of all literatures involves shear capacity, durability and maximum crack width determination. The shear behaviour of ferrocement members depends upon various factors such as volume fraction, span to depth ratio, and different modes of failure. For analysis some best fit equations are proposed which analyse the cracking shear strength, shear stress of the ferrocement members.

SCHEDULE OF THE PROJECT

Activity	Jan	Feb	Feb	Mar	Mar	April	April	April
Topic selection								
Collection of research paper								
Study of research paper								
Methodology								
Design of component								
Implementation								
Test result								
Conclusion								

Theory:

With the growing demand for stronger and lighter materials, composite have become very important for structural applications. An important design criterion typically used is the prevention against shear buckling. The shear behavior of ferrocement plates in shear is also important factor. Ferro-cement is a building material with some similarities to reinforced concrete. Indeed, both materials have the same source. Ferro-cement is produced by applying cement mortar composed of fine aggregate and cement onto wire reinforcement using plasterer techniques. As a result the property of Ferro-cement distinguishes it from reinforced concrete. While of similar durability, it is more elastic than reinforced concrete. Ferro cement can be used as plates, Ferro-cement beams, thin webbed sections, box beams.

For shear behavior of composite plates it has been acknowledged that a flat plate supported at its boundaries can carry considerable amount of load beyond its buckling load a lot of work has been performed in buckling of metal plates. The stress –strain relations for composite materials can be obtained from simple tests. In the case of unidirectional fiber composites, there are two orthogonal planes of symmetry in which one is parallel to the fibers and the other is transverse to the fibers. Several tests were performed to determine the mechanical properties, the linear portion of the stress – strain curve is used to determine the constants. Hence from all the analysis following stress strain relations are obtained [21].

$$\epsilon x = \frac{1}{Ex} . \sigma x \qquad [4.1]$$

Where E_x =Longitudinal young's modulus

σ_x = longitudinal applied stress

ϵ_x =Longitudinal strain

With the symmetry, the number of independent constants in a unidirectional composite is reduced to four. If the material is square symmetric, where the mechanical properties are the same in x and y directions , the number of constants is reduced to the three, since $E_x = E_y$ Finally for an isotropic material , only two constants are independent and shear modulus is function of both of them.

ADVANTAGES AND DISADVANTAGES

Advantages of ferrocement construction over R.C.C. construction

- It is highly versatile and can be formed into almost any shape for a wide range of uses.
- Thin elements and light structures, reduction in self weight.
- Reduction in expensive form work so economy & speed can be achieved.
- Only a few simple hand tools are needed to build any structures.
- Structures are strong and have good impact resistance.
- Structures are highly waterproof.
- Higher strength to weight ratio than R.C.C.
- Suitability for pre-casting.
- Flexibility in cutting, drilling and jointing.
- Very appropriate for developing countries; labor intensive.

Disadvantages of ferrocement construction

- Structures made of it can be punctured by collision with pointed objects.
- Corrosion of the reinforcing materials due to the incomplete coverage of metal by mortar.
- It is difficult to fasten the ferrocement element with bolts, screws, welding and nail etc.
- Large no of labors required.

Tying rods and mesh together is especially tedious and time consuming.

6.1 Conclusion

After all the experimental and analytical analysis it is observed that shear capacity of ferrocement plates depends upon the volume fraction. The cracking and ultimate strength of plate depends upon the span to depth ratio of the plate. The important modes of failure in the ferrocement plates are web shear failure and flexure shear failure, from the failure modes the shear stresses that develops in the plate can be calculated using the equations from the available codes and literatures. From the available literature the volume fraction of plate, cracking shear strength, stress intensity of plate are determined and the values are compared with results obtained in FEM (Ansys) analysis.

1. Two types of shear cracking and failure, namely, those due to flexure-shear & web- shear were observed.
2. The flexure shear cracking & flexure occurred at a lower shear stress than that at which the web-shear failure

occurred for uniformly distribution mesh layout

increasing the volume fraction of wire mesh layer subsequently increase the shear carrying capacity of the plate. To attain this advantage, supports and loading points should be designed and strengthened to prevent local failure.

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