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Shear behaviour of ferrocement plates

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Abstract*:* Ferrocement members can be used in the form of plates Such as for walling unit, marine structures etc. Such plates are subjected to shear buckling hence shear resistance capacity of plate need to be verified. Various authors have studied shear behaviour on different specimens such as box beams, panels, and plates. The ansys software used for finite element analysis (FEM) of plates. In the present study an attempt is made to observe behaviour of ferrocement plate with various mesh patterns. The results gives that Increasing the volume fraction (VF) of the wire mesh layer subsequently increases the shear carrying capacity of the plate To attain this advantage, supports and loading points should be design and strengthened to prevent local failure, Shear behaviour of ferrocement plates (SBFP).The stress intensity is determined using FEM (Ansys) and compared with the available results. it is observed that stress intensity as well as cracking shear strength of plate depends upon volume fraction. the available equations from literature can be used for analysis of mesh plate.

Keywords- Shear Behaviour of Ferrocement Plates (SBFP), Volume Fraction (VF), Finite element analysis (FEA)

I. INTRODUCTION

Ferrocement is a wire mesh reinforcement embedded with mortar. This is durable and efficient material. Ferrocement deep beams and plates deep, having a thickness that is small relative to their span or depth.ferrocement plates are two dimensional members in which shear is the dominant. The internal stresses cannot be determined by ordinary beam theory, as well as ordinary design procedures do not apply because shear resisting parameter taken into account In the present study experimental analysis as well as FEM (Ansys) analysis is carried for the plates with various mesh pattern to observe the shear behaviour.Many methods are developed for determining shear capacity of plates. The plates which are subjected to transverse loading, two main failure pattern present which are web shear and flexure shear failure. Shear capacity of plates depends upon number of mesh layer.

II. OUTLINE OF THE WORK

To determine the shear capacity of plate experimentation of 10 ferrocement plates are carried out as per the standard code ACI 549[1]. The plates are subjected to transverse loading having size 490x230x20 mm with various mesh pattern The 20mm thick plate with mesh pattern hexagonal, square, diamond and plain mortar plate which acts as reference plate are used to observe the modes of failure. The cracking shear strength of plates is also determined. From experimental analysis the volume fraction, shear span, nodal displacement, mortar compressive strength, cracking loads are calculated. the values are used to model plates in FEM (Ansys) for various plates having thickness 5 to 30 mm.

III. LITERATURE REVIEW

Research work all over the world have carried out for calculation of shear capacity of ferrocement material. It includes the work carried on different parameters for knowing shear capacity. shear strength depends on volume fraction [1], investigated ferrocement concrete composite beams, bearing walls [2], determined the effects of combining reinforcing steel meshes with discontinuous fibers as reinforcement [3], shear behaviour of ferrocement channel beams [4], determined shear behaviour of box
Beams by conducting flexural tests [5] etc. Hence by knowing the previous methods the research can carried to analyse how the shear strength of ferrocement beams, plates depends upon volume fraction of plate.

A. *TESTING PROGRAMME*

The main purpose of the of testing is to get the shear strength of ferrocement plates by conducting the flexural tests, materials mainly used in this procedure is OPC (43 grade) as per code ACI 549[5],sand passing through 2.36 mm sieve water cement ratio is 0.45.the mix proportion is prepared suitably. 10 ferrocement plates are prepared which are having span to depth ratio 2.0[1],the mesh patterns like square, rectangle, hexagonal (chicken mesh) having different volume fraction are used. which are subjected to transverse loading .Therefore, investigation on compressive shear failure behaviour is conducted [1]. The scope of the present test series is limited to investigating the effect of mesh type, volume fraction of web

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reinforcement, and load configuration on the shear capacity of ferrocement plates. Despite these things the bond between mortar and reinforcement which is wire mesh also important factor is taken into account.

III SPECIMEN DETAILS [1]

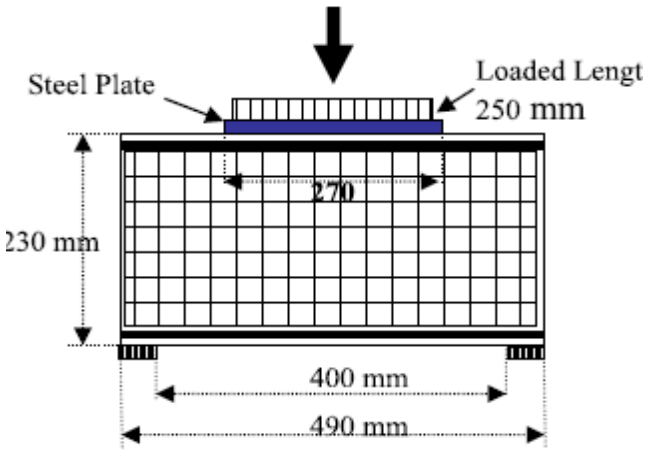

Fig.1 Ferrocement plate Specimen

A total of 10 ferrocement plates of size 490×230×20mm[1] were tested in bending under central in-plane 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 test variables included:

(1) The mesh geometry including spacing of wires forming the mesh (large and small), (2) the volume fraction of wire mesh. The specimens the specimens are prepared using square mesh, hexagonal, diamond mesh and reference beam which is plain mortar [1].

B. *PROCEDURE DETAILS*

The plates were tested under gradually increasing load applied at their Centre in a universal testing machine. For observation of loads load cells are used. LVDT are fixed at centre for calculation of mid span deflection. was fixed at the bottom of beams to measure the mid-span deflection. Initiation and propagation of cracks have been visually detected while the specimens were loaded. The final crack patterns of the beams were recorded [1].the the large part of the load is transferred to the supports directly through compression struts formed directly between the load and the support. This kind of load transfer mechanism generally leads to shear, in the form of splitting tensile failure [1]. The tensile stresses in mortar in the direction normal to ultimate crack are much higher than the tensile strength of mortar, which leads to the crack formation these cracks termed as web shear cracks and flexure shear cracks.

C. PLATE ANALYSIS USING FEM (ANSYS)

FEM (Ansys) is used to check the stresses at which cracking has been initiated; the deflection takes place at different loading condition. The main parameter is at different volume fraction of wire meshes the stress, shear strength is obtained, an elastic finite element analysis was carried using ANSYS Making advantage of the symmetry in geometry and loading, 3 types of wire meshes diamond, square, hexagonal as well as plain mortar plate is analysed.

D.Test Results

All the wire mesh were tested, different crack patterns developed. From the experimental analysis the load at which maximum displacement takes place is analysed. figure shows when wire mesh especially, expanded metal or hexagonal mesh is embedded in a mortar matrix and tends to straighten under tension, the matrix resists the straightening [1]. The

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observed mode of failure which is the diagonal splitting leads to a final shear crack extends between the load and the support, but it grows outwards from mid-depth, having been initiated in a brittle manner.

Fig. 2 Cracks developed on hexagonal mesh

It was detected that the wire steel meshes act like small diameter bars, closely spaced and uniformly distributed, increasing the shear capacity .it shows that percentage increase in shear strength is due volume fraction, number of mesh layers. It is worth mentioning that Hexagonal mesh improves the shear capacity over than that of diamond and square meshes because of it having a higher straight length [1].So diagonal cracks increases strength as compare to other cracks. From these results it is observed that strength depend on volume fraction. So the main purpose is to determine VF of plate. The volume fraction of all mesh types is calculated by formula. for square, diamond, hexagonal mesh the volume fraction is analysed. here one calculation carried to determine volume fraction of wire mesh. Hence for square mesh

$$\mathbf{V}f = \frac{N}{4}\frac{\pi dw^2}{h}\left[\frac{1}{Dl}+\frac{1}{Dt}\right]$$

Where N=No. of mesh layer , $\pi = 3.14$,
dw= Diameter of wire mesh is 1.00 mm
Dl= distance center to center between longitudinal wires
Dt =distance center to center between transverse wires
h= thickness of ferrocement plate is 20 mm
Dl= Dt =D = 13 mm
Volume fraction of plate = 0.0031 or 0.31 % for square mesh.

The volume fraction for other mesh can be analysed for plate size 490 x230x 20 mm. in which hexagonal mesh have 0.0025 or 0.25 % volume fraction, and for diamond it is 0.0028 or 0.28%. The volume fraction for different thickness is also varies hence there is analysis carried for the plates having thickness from 5mm to 30 mm.

Finally all the test results used for calculating the cracking shear strength of the plate analytically [4]. The following empirical formula is proposed here to predict the cracking shear strength of ferrocement plates which are having different volume fraction and different mesh pattern.

$$\vartheta_{cr} = (0.27 + V_f^{0.65}) \text{ x } (\text{f 'c x } \frac{h}{a})\text{^ } (0.65).....[4]$$

V_f= volume fraction of mesh.
f' c= Mortar compressive strength is 35 MPa.
a= shear span is 75mm,
h= Overall beam depth is 230mm.
a/h ratio = 0.326

From this formula cracking shear strength for the mesh of plate size 490x 230x 20 mm are as follow
Square mesh = 7.38 MPa
Hexagonal mesh= 7.34 MPa
Diamond mesh = 7.41 MPa

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These are cracking shear strength obtained. The cracking strength as per volume fraction the shear strength is calculated for different ferrocement thickness. The volume fraction of ferrocement plate is important factor for analysing shear strength, the stress developed on plate can be analysed using the experimental values. The stresses can be govern by using the best fit equations. In ferrocement plates modes of failure are web shear failure and flexure shear failure. the shear cracking load from experiment analysis for all plates obtained which is for hexagonal mesh plate it is equal to 17.33 KN, diamond mesh plate 20 KN , square mesh plate it is 19.10 KN. These are values obtained from all the experimental as well as analytical analysis.

E. ANALYSIS OF FERROCEMENT PLATE USING FEM (ANSYS)

The analysis of plate involves FEM (Ansys) method. the mesh plate 490x230x90 mm for all wire mesh is analysed. The model is prepared, then key points are plotted for generation of line .the material properties of steel and concrete are defined. solid 65 is used for the analysis. Then stress strain is calculated from the values which are obtained from experimental data, from which modulus of elasticity is calculated. The nodal displacement is provided. non linear analysis of plate is carried. in different steps. the final analysis gives displacement of plate, the crack pattern developed on the plate. The stress intensity is evaluated for every plate. figure shows analysis of square mesh plate which shows the nodal displacement.

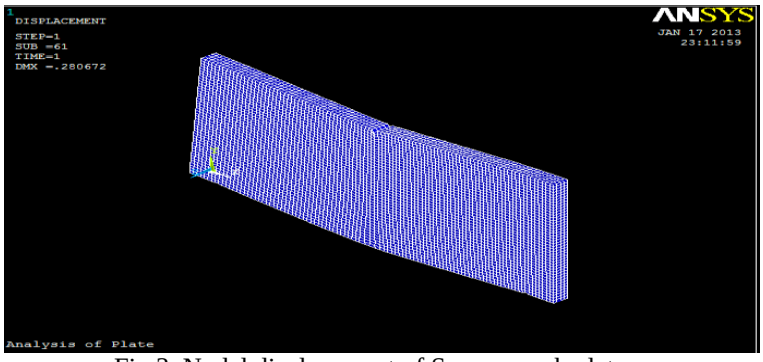
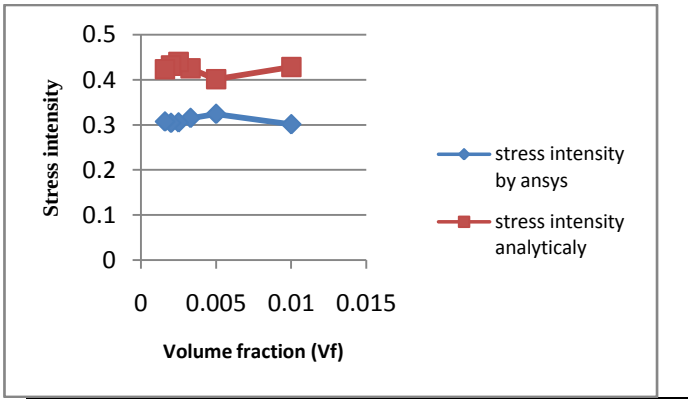


Fig.3. Nodal displacement of Square mesh plate

The figure shows the nodal displacement of square mesh plate which gives 0.28 mm displacement .the stress intensities for all types of plates are evaluated. The stress intensities of mesh plate having different volume fractions are calculated. This shows variations in the stress intensities. The stress intensities analytically and by ansys is analysed which is having very minor difference. The graph is plotted against volume fraction of wire meshes and the stress intensities.



Graph 1.stress intensity of square mesh plate

The graph is plotted for diamond as well as hexagonal mesh plate. which gives details of stress intensities for all mesh patterns.

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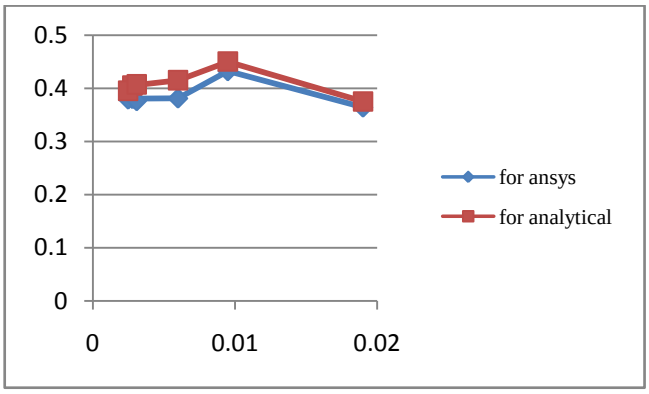
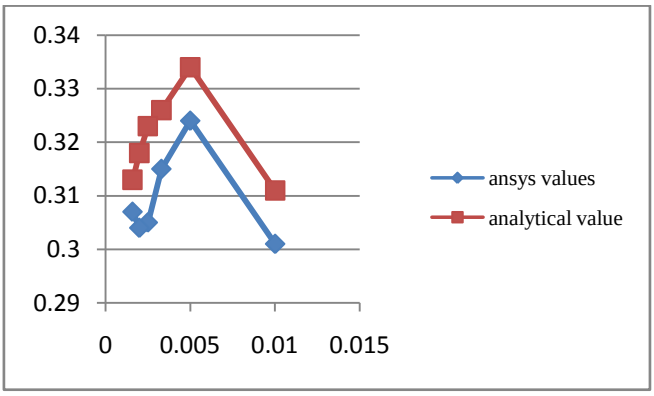


Graph no. 2 For diamond mesh plate



Graph no. 3 Hexagonal mesh plate

IV. CONCLUSION

After experimental as well as analytical work which includes ansys. It shows the shear strength of the plate depends upon the volume fraction of wire mesh. As the stress intensity of the plate obtained from theoretical equations present in available literature gives the close relation with values obtained from FEM (Ansys).hence same properties can be used in the Indian scenario.

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BIOGRAPHY

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