Study on ferrocement slab with different meshes for flexure and punching shear

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ABSTRACT
Ferrocement is a form of reinforced concrete using nearly spaced multiple layer of galvanized iron wire mesh applying on frame of skeletal bar and completely infiltrated in rich cement mortar. It is durable and cheap material. The main objective of this experiment is to behavioural study on ferrocement slab under flexure loading and punching shear strength between chicken and square welded mesh. Also various parameters are effect of volume fraction, effect of panel thickness and load-deflection relationship considered in this study. Test result shows that specimen reinforced with square welded mesh gives high flexural strength and specimen reinforced with chicken mesh exhibit highest punching shear strength. Specimen with high volume fraction has highest stiffness but less ductility and increase in slab thickness leads to decrease in deflection and more stiffness.
Keyworld.:-Ferrocements,meshes etc

1. INTRODUCTION

Ferrocement slab is a composite reinforced section consists of wire mesh covered on skeletal frame and covered with cement mortar. It is very cheap and versatile material posses high performance characteristics especially in behavior of cracking, strength, durability and impact resistance. There is ample of scope for mass production and standardization together in construction. Ferrocement shell ranges from 20 to 50 mm with uniformly distributed in longitudinal and transverse direction closely spaced through thickness of section. This material was developed by P. L. Nervy an Italian architecture and engineer in 1940. Ferrocement finally achieved wide acceptances in the early 1960 for aircraft hanger, boat, building structure and other variety. [12] To evaluate a system of construction which eliminate work at site in formwork there by reducing and removing on trade and its impact on site schedules. Obvious solution is to precast frame element of ferrocement slabs, columns and beams in casting yard on or off the site [6]. Construction of precast building frame element and their assembly is required quality and timely execution of the job. The recently research indicated confinement provided for the shear capacity at the floor junction of the beam and column. At the junction when concentrated load are initiated causing very high shear and axial stresses. International codes are leads to different approaches of calculating the punching shear failure. Also punching shear has been an object of an intense experimental effort since 1950. Punching failure of slab based on experimental result was addressed by various authors. Where as experimental study of flexural behaviour of ferrocement and cementitious composite two way slab reported by many investigator [1]. Hence behavioural studies on ferrocement slab with different meshes for flexure and punching shear is the main objective of this experiment. The ferrocement slabs were tested under simply supported conditions. Also investigate parameters are effect of volume fraction, thickness of panels and load deflection relation for both test condition. The ferrocement slabs are reinforced with square welded mesh and hexagonal woven meshes.

Nomenclature
SFS – Ferrocement slab reinforced with square welded mesh.
CMFS – Ferrocement slab reinforced with hexagonal woven mesh.
V_f – Volume fraction in ferrocement slab.
F_{Ana} – Analytical result of ferrocement slab for flexural strength.
F_{Epp} – Experimental result of ferrocement slab for flexural strength.

2. Experimental Program

2.1. Material and mix proportion

The constituent material used in this investigation was procured from local sources. Ordinary Portland cement of 53 grade was used. Uniformly graded crushed sand (zone- II) was used having Sp. Gravity 2.85 and fines modulus 2.65. Potable bore water are used for mixing and curing. BASF PC base admixture is used as super plasticizer. Chicken wire mesh and square welded mesh are locally available in the market was used as a reinforcement. The galvanized hexagonal chicken mesh with opening 18 x 15 mm having 1 mm dia. and square welded mesh with opening 25 x 25 mm with 2 mm dia. Mesh are used. The cement-sand ratio 1:2 with adding 1% of super plasticizer in water cement ratio 0.45. Using these proportion total 6 cubes is casted of size 70.7 x 70.7 x 70.7 mm. and three prism beam of 100 x 100 x 500 mm were casted.

2.2. Casting of specimen

The timber mould was oiled before casting and mortar was prepared by exact amount of cement and sand by weighing. Before casting reinforcing bar are cut into required number of pieces. While casting a specimen a spacer of height 30 mm and 25 mm are used. The grooves are provided to spacer for maintaining appropriate distance between the meshes. Also bottom and top of spacer is help to maintaining proper cover to slab. At first cement and sand mixed dry. After dry mixing add water and admixture in dry mix. Cement mortar are placed in mould with reinforcement. Specimens were demoulded after 24 hours and allow in curing tank for 28 days.

Table 1. Specimen details of slab for flexure

Slab dimension mm			Type of mesh	Volume fraction % l	No of layer	No of slab
l	b	h				
1000	500	30	Hexagonal woven	2.6	8	2
1000	500	25		2.3	6	2
1000	500	30	Square welded	2.5	3	2
1000	500	25		2	2	2

Table 2. Specimen details of slab for punching shear

Slab dimension mm			Type of mesh	Volume fraction %	No of layer	No of slab
l	b	h				
500	400	30	Hexagonal	2.6	8	2
500	400	25	woven	2.3	6	2
500	400	30	Square	2.5	3	2
500	400	25	welded	2	2	2

2.3. Testing of specimen

2.3.1. Flexural strength of Slab

The test setup of the four point load under UTM machine will be shown in fig. 1 The 8 specimen having length 1000 mm, width 500 mm with varying thickness of 30 and 25 mm were tested in simply supported condition. The load was applied as two symmetrically arranged concentrated line load. The load is applied small increment and simultaneously. The midspan deflection was monitoring using a dial gauge up to failure. White wash applied to the panel to get clear indication of cracks due to bending under service load.

Fig.1 - Loading arrangement for flexural test.

2.3.2. Punching shear strength of Slab

The tested slabs were placed on rigid steel frame as shown fig. 2. Slab having length 500 mm, width 400 mm with varying thickness 30 and 25 mm. The dial gauge was placed at the bottom face to record deflection at different phase of loading. A single concentrated load was applied at the centre of each slab via a concrete cube having dimension 70 x70 x 70 mm. White wash are applied on both side of ferrocement slab for monitoring of crack development during test.

Fig.2 – Loading arrangement for punching shear test.

3. RESULT AND DISCUSSION

3.1. Load carrying capacity

Three cube specimens were tested under compression testing machine for each mix and for each curing age the mean value was recorded. Average ultimate compressive strength ferrocement mortar at 7th and 28th day is 51 N/mm^2 and 70.28 N/mm^2 and also three prism beams were tested for flexure. The average flexural tensile strength of mortar at 28th day is 4.41 N/mm^2. The flexural strength under three point loads and punching shear test was conducted on slabs. The flexural behaviour of ferrocement slab transferred stress to surrounding of concrete matrix through the bond between reinforcing bar and concrete matrix. During test corresponding flexural strength and punching shear strength are presented in table no.3

Table- 3 Test results of flexural strength of slabs

Slab	h mm	V_f in (%)	Analytical Flexural strength N/mm^2	Experimental Flexural strength N/mm^2	$F_{Ana.}$ / F_{Epp}
CMFS	30	2.6	35.45	33.60	1.055
	30	2.6	35.45	33.50	1.058
	25	2.3	23.66	21.88	1.081
	25	2.3	23.66	20.73	1.141
SFS	30	2.5	35.10	34.8	1.008
	30	2.5	35.10	34	1.032
	25	2.0	23.73	27.64	0.86
	25	2.0	23.73	26.49	0.896

Table- 3 Test results of punching strength of slabs

Slab	h mm	V_f in (%)	Analytical Flexural strength N/mm^2	Experimental Flexural strength N/mm^2	$F_{Ana.}$ / F_{Epp}
CMFS	30	2.6	17.32	24.6	0.704
	30	2.6	17.32	24	0.712
	25	2.3	16.98	20.6	0.842
	25	2.3	16.98	22.68	0.75
SFS	30	2.5	14.87	17.6	0.845
	30	2.5	14.87	16.8	0.885
	25	2.0	13.87	10.2	1.359
	25	2.0	13.87	8.4	1.651

3.2. Load-Deflection Relationship

3.2.1. Flexural behaviour

Slab specimen reinforced with square welded shows high strength and flexural behaviour as compared to ferrocement slab reinforced with hexagonal woven mesh. Failure of ferrocement slab panel under flexural behaviour was observed to occur when the extreme layer of steel mesh failed under tensile stress. Ferrocement slab reinforced with square welded mesh exhibits large deflection compared to the small thickness in flexural behaviour. Failure pattern and cracking behaviour of ferrocement slab depend upon the volume of fraction and type of reinforcement.

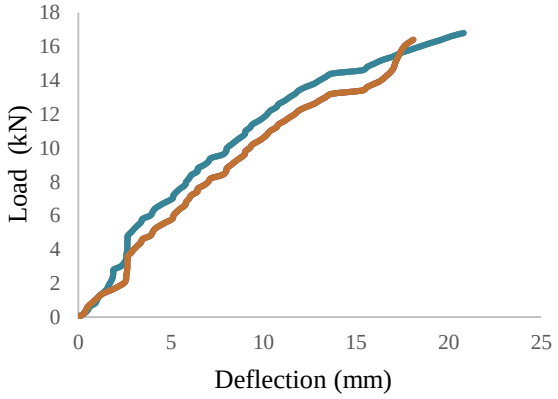

Fig. 3 Load vs. Deflection curve of flexural behaviour of CMFS slab. (h=30 mm)

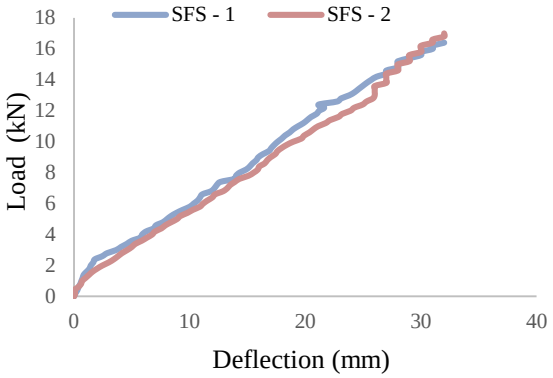

Fig. 4 Load vs. Deflection curve of flexural behaviour of CMFS slab. (h=30 mm)

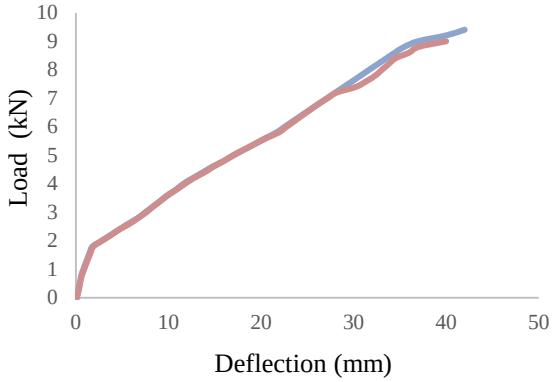

Fig. 5 Load vs. Deflection curve of flexural behaviour of all ferrocement slabs. (h=25 mm)

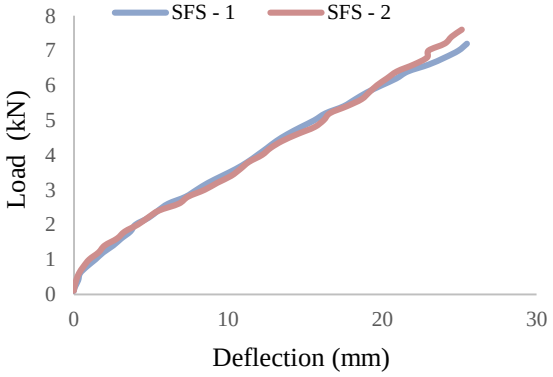

Fig. 6 Load vs. Deflection curve of flexural behaviour of CMFS slab. (h=25 mm)

3.2.2. Punching shear

Bond between reinforcement and mortar of slab arrest the slab from punching failure. The maximum central deflection and the ultimate punching shear load of ferrocement slab reinforced with chicken mesh exhibits better than square welded ferrocement slab. Ultimate punching shear strength depends upon the opening size of mesh and volume fraction.

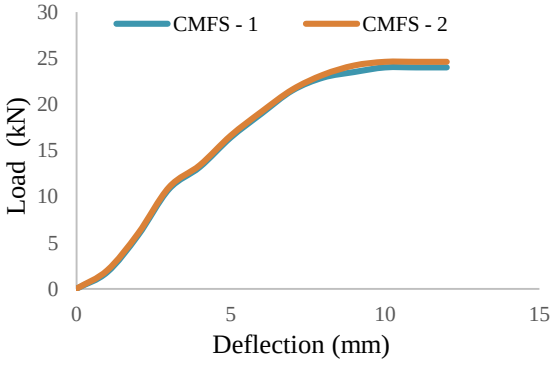

Fig. 7 Load vs. deflection curve of punching shear of all ferrocement slab. (h=30 mm)

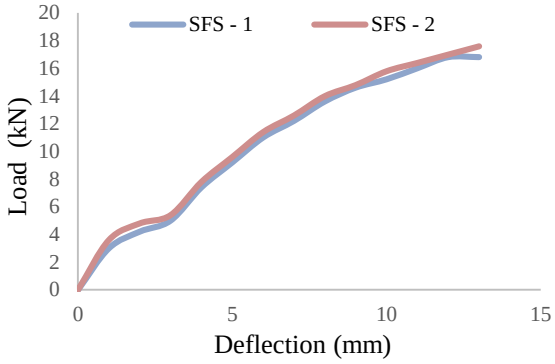

Fig. 8 Load vs. deflection curve of punching shear of all ferrocement slab. (h=30 mm)

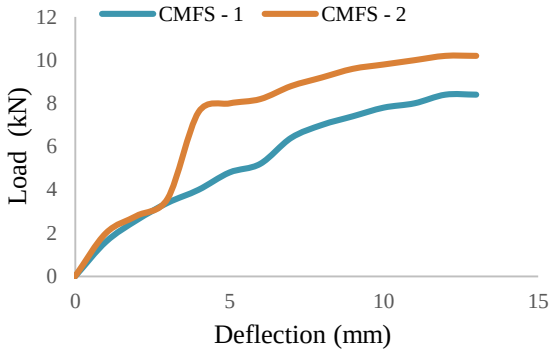

Fig. 9 Load vs. deflection curve of punching shear of all ferrocement slab. (h=25 mm)

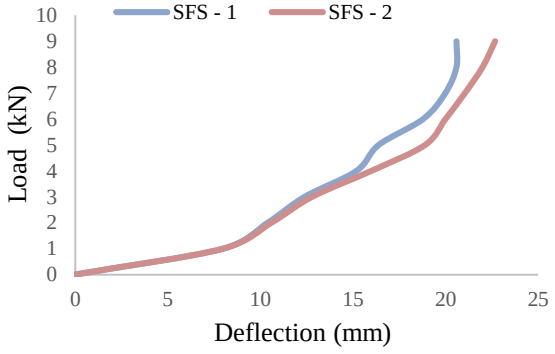

Fig. 10 Load vs. deflection curve of punching shear of all ferrocement slab.(h=25 mm)

3.2.3. Cracking and failure pattern

In flexural behaviour of ferrocement slab were crack are formed at middle portion along with width in one direction and a major continuous crack joining is formed at bottom and increase toward the top surface of slab. The crack and failure pattern at bottom surface of slab is shown in fig. 11. Ferrocement slab reinforced with chicken mesh panel under flexural load. Due to Dowel action of chicken mesh no spalling of mortar before and after failure of slab. is shown in fig. 12.

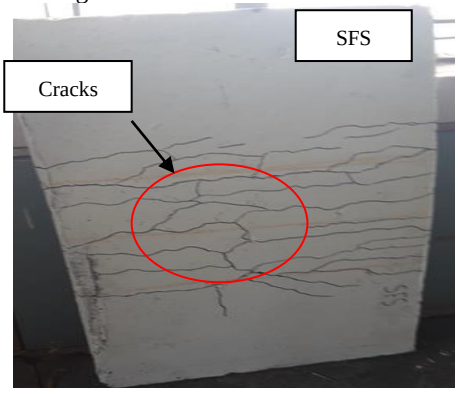

Fig. 11 Bottom surface of SFS slab after Flexural failure

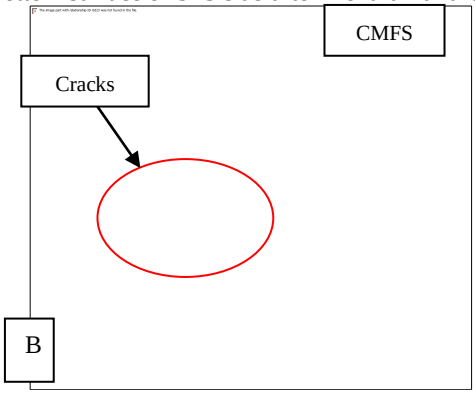

Fig. 12 Bottom surface of CMFS slab after Flexural failure

Ferrocement slab reinforced with square welded mesh under punching shear after first crack started flexural stiffness to drop under increasing load up to ultimate failure. Ferrocement slab reinforced with square welded mesh under punching shear after first crack started flexural stiffness to drop under increasing load up to ultimate failure shown in fig. 13. Ferrocement slab reinforced with square welded mesh undergoes flexural shear failure

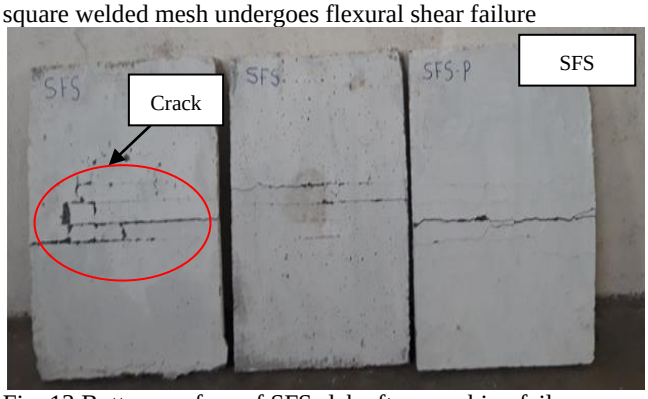

Fig. 13 Bottom surface of SFS slab after punching failure

Ferrocement slab reinforced with chicken mesh under punching shear, first the combined stress performs leads to radial cracks, starting at the edge of the load application zone. Increasing load causes tangential cracks around the column. Without shear reinforcement the punching shear failure of ferrocement slab performs in a brittle manner within the discontinuity region of the slab at column shown in fig.14

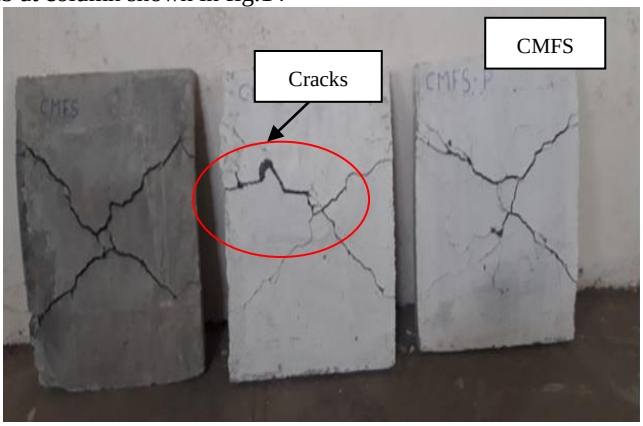

Fig. 14 Bottom surface of SFS slab after punching failure

4. CONCLUSION

1. The ferrocement slab having 30 mm depth reinforced with square welded mesh exhibits high 3.45 % and 1.47 % in flexural strength as compared to both slab reinforced with chicken mesh.
2. The ferrocment slab having 25 mm depth reinforced with square welded mesh exhibits high 20.83 % and 21.74 % in flexural strength as compared to both slab reinforced with chicken mesh.
3. The specimen reinforced with chicken mesh having depth 30 mm exhibits 28.46 % and 30 % high in punching shear strength as compared to slab reinforced with square welded.
4. The specimen reinforced with chicken mesh having depth 25 mm exhibits 50.49 % and 51.10 % high in punching shear strength as compared to slab reinforced with square welded.
5. Failure pattern and cracking behaviour of ferrocement slab depend upon the volume of fraction and type of reinforcement.
6. Load carrying capacity and flexural load increases with increase in diameter of mesh and maintaining proper space between two mesh layers. Then it complete section behaves better in tension.

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