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Flexural Behavior of Ferro Cement Slabs and its Applications

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***Abstract*: Ferro cement is a composite material produced by using reinforced meshes and cement mortar. It is a versatile material with great engineering benefits. It has great mechanical properties with better durability. It is cheap and easy to handle. These properties of ferrocement makes it more popular in construction industry.**

***Keywords*: Construction, Ferro cement slabs, Flexural behaviour, Durability.**

1. Introduction

The purpose of this project is to design ferro cement slab with varying design parameters using engineering expertise. The main objective of this work is to determine the flexural strength, deflection, energy, ductility, and energy ductility.

Symbols and notations

- Ac = cross sectional area of ferrocement slab
- b = width of ferrocement slab cross section
- db = Diameter of equivalent diameter of reinforcement used
- fc = specified compressive strength of mortar
- fy = yield strength of mesh reinforcement
- h = thickness of ferro cement section
- Mn= nominal moment strength
- Vf = volume fraction of reinforcement
- ή = Global efficiency factor of embedded reinforcement in resisting tension or tensile bending loads

Slab designation and marking Scheme

2. Background of the Project

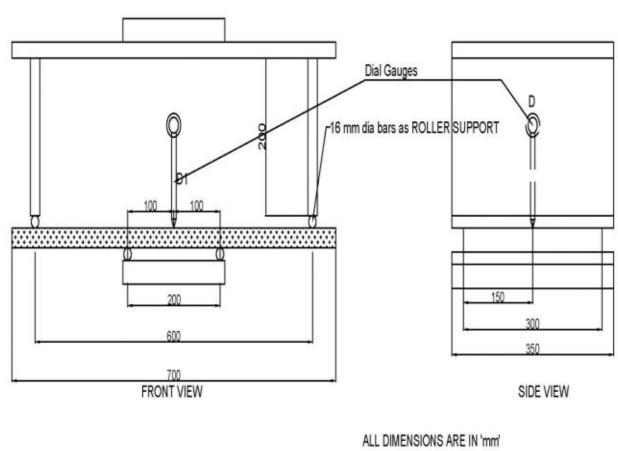
1) Applications

Ferro-cement has been widely used in the construction of various structural elements in the construction industry. This project, evaluates the flexural properties of Ferro cement under a two-point static loading system by varying the layers of welded mesh placed inside the slab and evaluating the results. This provided the engineers to use Ferro cement more effectively and to check the acceptability of Ferro cement for a given application and also help engineers build more aesthetically appealing buildings.

2) Ferro Cement Slab Casting & Test Setup

According to the set plan, standard procedure for completing the tasks were adopted. During the experiment, ferrocement slabs of size 700 mm x 300 mm x 25 mm were cast with varying the layers of welded mesh and chicken mesh. The slabs are cast with materials as tabulated below. The slabs are cured in curing tank for 28 days and compressive strengths were ascertained. The slabs are then placed along with the test setup on the Universal Testing Machine. Then test load is applied by two-point loads on the slab at 100 mm on either side of the centre line. The arrangements are made such that the two simply supported edges were at a 50 mm distance from the edges of the slabs, so that the span between the supports was 600 mm. The deflection at the centre of the slab was measured using a deflectometer supported on a magnetic stand. The load is applied using Universal Testing Machine (UTM) and at suitable intervals of load, deflection and numbers of cracks were measured. The load corresponding to the first crack and the ultimate load along with the respective number of cracks were noted. The cracks formed on the slabs were traced with a black felt tip pen for easy identification of the cracking pattern. The graph is generated to estimate the load Vs deflection curve.

3) Test Set up schematic representation



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4) Properties and types of materials used

Table 1

Materials	Range
Wire mesh:	
Diameter of wire (Φ)	$0.5 \leq \Phi \leq 1.5$mm
Type of mesh	chicken wire or square woven or welded galvanized mesh or expanded metal
Size of mesh opening(S)	$6 \leq S \leq 25$mm
Volume fraction (V_R) of reinforcement	$2\% \leq V_R \leq 8\%$ in both directions.
Specific surface (S_R) of reinforcement	$0.1\% \leq S_R \leq 0.4\%$ mm^2/mm^3 in both directions.
Elastic modulus (E_R)	140-200 N/mm^2
Yield strength (σ_{Ry})	250-460 N/mm^2
Ultimate tensile strength (σ_{Ru})	400-600 N/mm^2
Skeletal metal:	
Type	Welded mesh, steel bars, strands.
Diameter (d)	$3mm \leq d \leq 10mm$
Grid size (G)	$50mm \leq G \leq 200mm$
Yield strength	250-460 N/mm^2
Ultimate tensile strength	400-600 N/mm^2
Mortar composition:	
Cement	Ordinary Portland cement
Sand to cement ratio(S/C)	$1 \leq S/C \leq 3$ by weight
Water cement ratio(W/C)	$0.35 \leq W/C \leq 0.65$ by weight
Gradation of sand	5mm to dust with no more than 10% passing150ɥm BS test sieve

Three mix proportions of Cement: Fine Aggregates were determined to cast the Ferro cement slab with respect to the mortar strength. The water to cement content ratio was decided based upon the workability of the trial mix. The following tables show the various mix proportions and the compressive strength of various mixes for 3, 7, and 28 days of curing.

Table 2

Batch	Materials		
	Cement	**Sand**	**W/C Ratio**
A	1	1	0.41
B	1	2	0.47
C	1	3	0.575

3. Test Results

Sample Results are tabulated for batch A with varying layers of reinforced mesh.

Table 3

Batch A- Slab Designation

Slab Designation: A2-1 (Static Loading)					
S. No	Load(KN)	**Deflection Middle (mm)**	**Actual Deflection**	**No of Cracks**	**Spacing of Cracks (cm)**
1	0	0.54	0	1	0.8 1st Crack
2	3	10.96	10.42	5	4
3	6	13.56	13.02	15	4
4	8.2	Ultimate Load			

*A2 – 1-Slab of Batch A with 2 layers of welded mesh and serial no 1

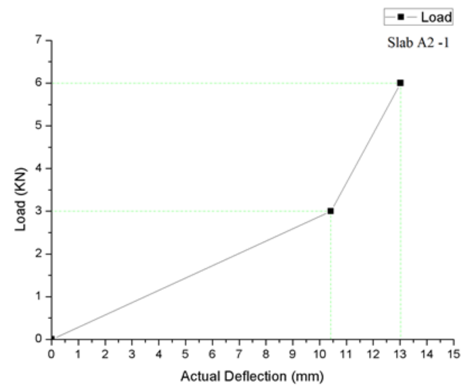


Table 4

Slab Designation: A3-1 (Static Loading)					
S. no	**Load (KN)**	**Deflection Middle (mm)**	**Actual Deflection (mm)**	**No of Cracks**	**Spacing of Cracks**
1	0	0.41	0		
2	2.4(1st crack load at 2KN)	2.65	2.24	5	4
3	4	6.68	6.27	11	
4	6.4	9.48	9.07	12	
5	6.8	11.51	11.1	14	2
6	9.2	15.79	15.38		
7	9.92	Ultimate Load			

A3 – 1- Slab of Batch A with 3 layers of welded mesh and serial no 1

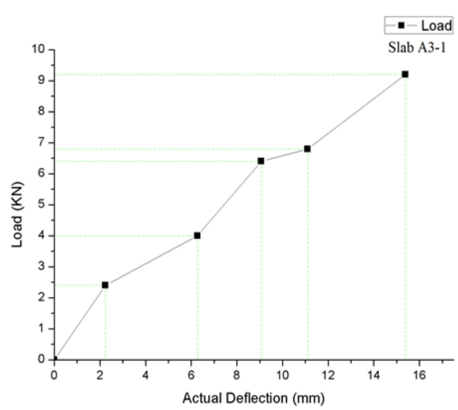
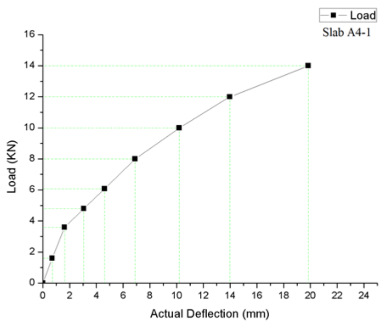
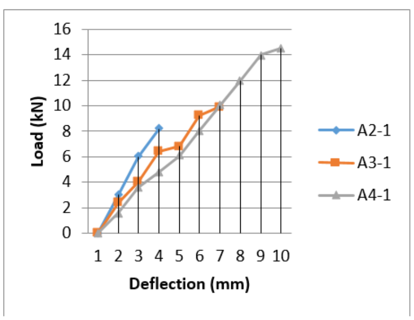


Table 5 Slab Designation

Slab Designation: A4-1 (Static Loading)					
S. No	**Load (KN)**	**Deflection (mm)**	**Actual Deflection (mm)**	**No of Cracks**	**Spacing of Cracks (cm)**
1	0	0.9	0		
2	1.6	1.6	0.7		
3	3.6 (1st crack load)	2.52	1.62	7	3
4	4.8	3.96	3.06	10	3
5	6.08	5.52	4.62	13	3
6	8	7.8	6.9		
7	10	11.1	10.2	15	3
8	12	14.88	13.98		
9	14	20.75	19.85		
	14.48	Ultimate Load			

A4 – 1-Slab of Batch A with 4 layers of welded mesh and serial no 1





A2 – 1-Slab of Batch A with 2 layers of welded mesh and serial no 1
A3 – 1- Slab of Batch A with 3 layers of welded mesh and serial no 1
A4 – 1-Slab of Batch A with 4 layers of welded mesh and serial no 1

The energy, ductility and the energy ductility for each of the slabs are determined according to the following formula

$$\text{Ductility} = \frac{ULTIMATE\ LOAD}{FIRST\ CRACK\ LOAD}$$

Energy ductility =

$$\frac{AREA\ UNDER\ THE\ LOAD - DEFLECTION\ CURVE\ UPTO\ YIELD\ LOAD}{TOTAL\ AREA\ UNDER\ LOAD - DEFLECTION\ CURVE}$$

Batch A

1) Slab A2-1

Energy 36.16 kN mm

Ductility = $\frac{8.2}{0.8}$ = 10.25

Energy ductility = $\frac{15.63}{36.16}$ =0.43

2) Slab A3-1

Energy 75.25 kN mm

Ductility = $\frac{9.92\ kN}{2\ kN}$ = 4.96

Energy Ductility = $\frac{1.867}{75.25}$ = 0.0248

3) Slab A4-1

Energy = 209.23 kN mm

Ductility = $\frac{14.48\ kN}{3.6\ kN}$ = 4.02

Energy Ductility = $\frac{2.952}{209.23}$ = 0.0141

4. Conclusion

To recapitulate, all these reports generated shall be used for better understanding of loading behaviors and Flexural properties of ferro cement slabs.

References

[1] ACI Report 549.1R 18 Design Guide for Ferrocement
[2] Internal Guide : Prof. Dr.M.Neelamegam – Senior