

Experimental Analysis of Ferrocement Panels in Flexure

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ABSTRACT: The present study portrays the after effects of testing level ferrocement boards fortified with various number of wire work layers. The principle target of this work is to think about the impact of utilizing diverse no of wire work layers on the flexural quality of level ferrocement boards and to look at the impact of fluctuating the no of wire work layers and utilization of steel strands on a definitive quality and flexibility of ferrocement chunk boards. The no of layers utilized are one, two and three. Section boards of size (900*200) with thickness 25 mm, 50 mm, 75 mm are strengthened with welded square work with changing no of layers of work. Boards were threw with mortar of blend extent (1:2) and water concrete proportion (0.40). Boards were tried under two point stacking framework in UTM machine subsequent to curing time of 28 days. Test result demonstrates that boards with all the more no of layers shows more noteworthy flexural quality and less redirection as that contrasted and boards having less no of layers of work.

KEYWORDS: Ferro-cement, Wire-Mesh, Flexure, Modulus of Elasticity, Ductility, Layers, Panels

I. INTRODUCTION

Countless frameworks around the globe are in a condition of genuine crumbling today because of carbonation, chloride assault, and so on. Additionally numerous common structures are no longer viewed as sheltered because of increment load details in the outline codes or because of over-burdening or due to under plan of existing structures or because of absence of value control. Keeping in mind the end goal to keep up productive serviceability, more established structures must be repaired or fortified with the goal that they meet similar prerequisites requested of the structures manufactured today and in future. Ferrocement throughout the years have picked up regard as far as its unrivaled execution and adaptability. Ferrocement is a type of strengthened solid utilizing firmly dispersed various layers of work or potentially little distance across bars totally invaded with, or embodied in, mortar. In 1940 Pier Luigi Nervi, an Italian designer, draftsman and contractual worker, utilized ferrocement first for the development of air ship sheds, pontoons and structures and an assortment of different structures. It is an extremely sturdy, shoddy and flexible material.

Definition-

“Ferrocement is a kind of thin divider strengthened cement regularly built of water powered concrete mortar fortified with firmly dispersed layers of constant and generally little size wire work”. The work might be made of metallic and appropriate materials. In the expressions of Nervi who initially utilized the term ferrocement its prominent qualities is “More noteworthy flexibility and imperviousness to breaking given to the concrete mortar by the outrageous subdivision and dispersion of the fortification”. Fig 1 shows the typical cross section of Ferrocement Structure.

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A. CONSTITUENTS OF FERROCEMENT

The constituents of ferrocement incorporate the pressure driven bond mortar which ought to be composed by standard blend outline techniques for mortar and solid which incorporates Portland concrete, water, sand, wire work and admixtures.

Concrete: The bond ought to be new of uniform consistency and free of protuberances and remote matter and of the sort or review contingent upon the application.

Water: Potable water is fit for use as blending water and in addition for curing ferrocement.

Fine Aggregates: Normal weight fine total spotless, hard, and solid free of natural pollutions and harmful substances and moderately free of residue and earth.

Wire work: Steel networks for ferrocement incorporates square woven or square welded work and chicken wire work of hexagonal shape and extended metal work. Some work fibers are stirred. Properties of the subsequent ferrocement item can be relied upon to be influenced by work measure, malleability, produce and treatment.

B. PROPERTIES OF FERROCEMENT COMPOSITES

- Wire diameter across 0.5 to 5 millimeter
- Size of mesh opening 6 to 35 millimeters
- Maximum utilization of 3 layers of work for Different thickness
- Maximum 8% volume portion in both bearings
- Steel cover 1.5 to 5 millimeters
- Modulus of Elasticity up to 20 MPa

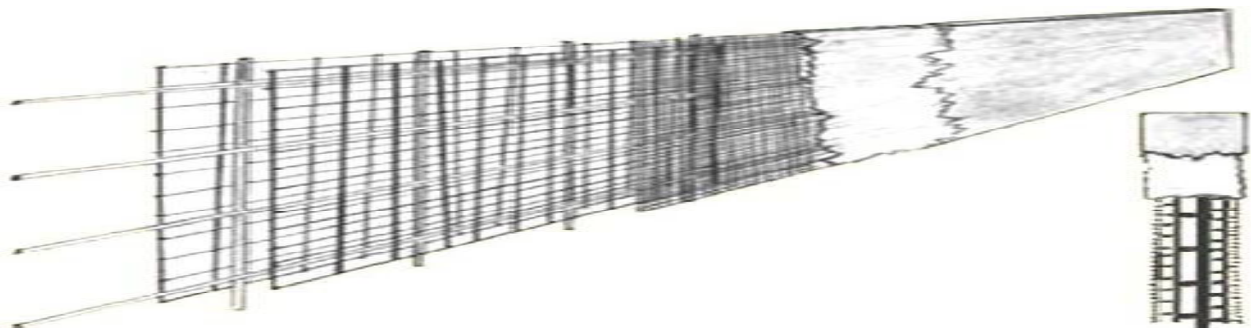


Fig-1: A typical cross-section of ferrocement structure

II. LITERATURE REVIEW

Al-Kubaisy and MohdZaminJumaat¹ have presented of the flexural behaviour of reinforced concrete slabs with ferrocement tension zone cover. The results of tests on 12 simply supported slabs were presented. The effect of the following parameters have percentage of wire mesh reinforcement in the ferrocement cover layer, thickness of the

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ferrocement layer and the type of connection between the ferrocement layer and the reinforced concrete slab on the ultimate flexural load, first crack load, crack width and spacing, and the load deflection relationship were examined. This paper proved that reinforced concrete slabs with ferrocement tension zone cover was superior in crack control, stiffness and first crack moment to similar slabs with normal concrete cover. Construction costs with ferrocement cover will be higher

Hassan Mohamed Ibrahim² performed experimental tests on 27 square cementitious slabs of 490x490 mm simply supported on four edges and subjected to patch load are presented. The slabs had a clear span of 400x400 mm and provided with a 445x445 mm closed frame of 8 mm diameter steel bar to hold the reinforcement in place and to act as a line support. The test results showed that as the volume fraction increased the punching strength of the slabs was also increased. Adding a wire mesh to ordinary reinforcement increases significantly the punching resistance at column stub.

Waleed A. Thanoon, M.S. Jaafar , M. Razali , A. Kadir and J. Noorzaei³ have studied the structural behaviour of cracked reinforced concrete one-way slab, which was repaired using different techniques. It could also be concluded that all repairs techniques like grouting, epoxy injection and ferrocement layers etc. were used effective to at least restore the structural performance of cracked reinforced concrete slabs.

A. Masood, M.Arif, S.Akhtar and M.Haquie⁴ conducted study on the performance of ferrocement panels under normal, moderate, and hostile environments. The ferrocement slab panels cast with varying number of woven and hexagonal mesh layers were tested under flexure. Compressive and tensile strength of control specimens and load-carrying capacity of the panels under flexure with and without fly ash were investigated. Addition of fly ash in different environments affects the flexural strength of panel for both woven and hexagonal wire fabric. the strength of panels under saline casting and saline curing condition is more as compared to panels under normal casting and saline curing condition because of better pore structure due to the presence of fly ash and the saline water during casting.

Mohamad N. MahmoodSura A. Majeed⁵ carried out an experimental work on flat and folded ferrocement panels for studying their flexural behaviour. The panels tested for flexure are of size 380mm X 600mm with 20mm thickness for both flat as well as folded slab panels. The wire mesh used was mild steel galvanized welded wire mesh of 0.65 mm diameter and 12.5 mm square grid size. From his experimental work the author concludes that the cracking load was not significantly affected by the number of the wire mesh particularly for the folded panels. The also concludes that the flexural strength of the folded panel increased by 37 and 90 percent for panels having 2 and 3 wire mesh layers compared with that of single layer; while for the flat panel the percentage increase in the flexural strength using 2 and 3 layers is 65% and 68% compared with that of plain mortar panel.

III. OBJECTIVE OF EXPERIMENTAL STUDY

The fundamental goal of this test work is to concentrate on the conduct of ferrocement boards under flexural stacking in which welded square work has been utilized as a fortification.

The different parameters considered in this study are as per the following - :

- a) Impact of number of work layers on the flexural quality of chunk boards.
- b) Effect of steel filaments on the flexural quality of section boards.
- c) Effect of volume part on the flexural quality of boards.

3.1 Experimental Work

The trial program incorporates planning and testing of level ferrocement piece boards under two-point stacking. The essential factors were the quantity of layers of lattices in boards and the utilization of steel strands.

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MATERIALS-Cement Ordinary Portland Cement (Grade 43), Sand - :Passing through 2.36 mm I. S. Strainer, Water – Ordinary Drinking Water, Mesh Used – Welded Square Steel Mesh of 1.02 mm Diameter. Steel strands of ridged sort with angle proportion.

Cement sand ratio (1:1.75).Water cement ratio (0.38). A total of 9 cubes of size (70*70) of above proportion were casted with and without steel .Compressive strength obtained is tabulated below

Table-1: Comp Strength Of Cubes At 28 Days

WITHOUT STEEL FIBERS				
NO	SIZE	LOAD AT FAILURES (KG)	COMP. STRENGTH(N/MM ²)	AVG. COMP. STRENGTH
1	70*70	20,000	40.04	
2	70*70	20,000	40.04	40.84
3	70*70	21,200	42.44	
WITH STEEL FIBERS				
4	70*70	18,800	37.63	
5	70*70	24,300	48.64	43.43
6	70*70	22,000	44.04	

Table-2: Details Of Panels To Be Casted

WITH STEEL WIREMESH			
NO	SIZE OF PANELS (MM)	LAYERS	NO OF PANELS
1	900*200*25	1	3
2	900*200*50	2	3
3	900*200*75	3	3

Table 1 shows the compressive strength of 70*70 mm cube with steel fibers and without steel fibers. It also shows the load failure in KG and higher compressive strength with steel fibers than without steel fibers; Table 2 shows the detail of panels to be casted and tested in Universal Testing Machine. Panels show the size with different thickness and layers of Steel wire mesh.

Planning of Mortar was set up by computing the correct measure of concrete sand and water. At first the concrete and sand were blended dry. Water added and afterward added to dry blend. Steel strands with measurement volume of composite were added.50% of steel filaments were included dry mortar and staying half in the wake of blending of water.

Casting-The wooden mould prepared were properly oiledbefore casting .At bottom a layer of mortar was applied of thickness 3 mm followed by layer of welded square mesh and again followed by layer of mortar. The procedure continues for placing layers of mesh in panel.The mesh pieces were cut down according to the size of panel leaving a cover of 3 mm on both side of mesh (894*194).

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Fig-2: Wooden Mould

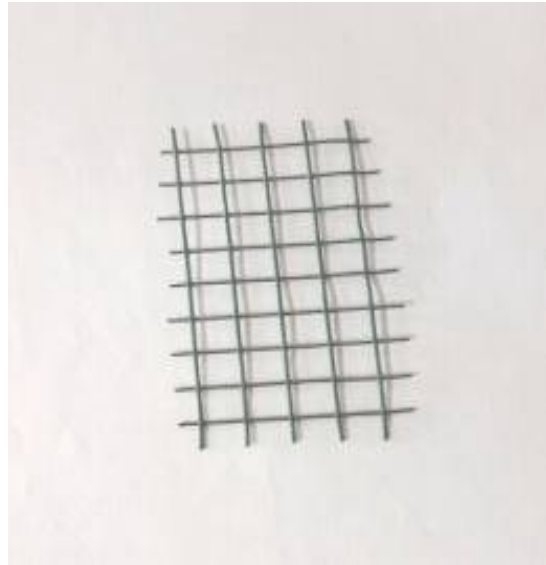


Fig-3: Welded Square Steel Mesh

Fig 2 display of wooden mould which is used for casting the ferrocement panels and it is oil painted inside and bottom. Fig 3 shows the welded square steel wire mesh which is used in casting of ferrocement panels.

Curing-After casting of panels they were removed from mould after a period of 24 hours. After removal the panels were cured in normal water tank for a period of 28 days.

Testing-The panels were removed from the curing tank after a period of 28 days. White wash was applied to the panels to get clear indication of the cracks due to bending under service load. Panels were tested for flexure test under Universal testing machine. The panels were placed on support leaving a space of 100 mm from both ends. Dial gauge was placed below the panel to record the deflection in mm at each stage of loading. After testing to calculate the Modulus of Elasticity of the panels were loaded under two point loading and load and deflections were noted down. Fig 4 shows that the position of 25 mm panel for test on the universal testing machine. The distance is marked on panel.



Fig-4: Panel under Testing Set Up

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Calculation of Modulus of Elasticity:

The Modulus of Elasticity (E) is given by the following equation:

$$E = \frac{23 \cdot W \cdot L^3}{648 \cdot \delta \cdot I}$$

Where,

- W = load.
- L = Length of the Beam
- δ = Deflection
- I = Moment of inertia.
- E = Modulus of Elasticity

IV. TEST RESULTS

Tables demonstrates the aftereffect of load and diversion comes about which appeared on the general testing machine. The avoidance is in "mm" and load noted in "KN". The diverse Ultimate load results are noted for same thickness of boards. Avg. extreme load is additionally specify in the table. Charts are demonstrating the heap versus avoidance and variety measured shape the diagram. Chart demonstrated the diverse variety for the distinctive thickness of boards and same thickness of board arrangement have distinctive bend.

Table-3: Load vs Deflection readings for 75 mm Panel (Layers-3)

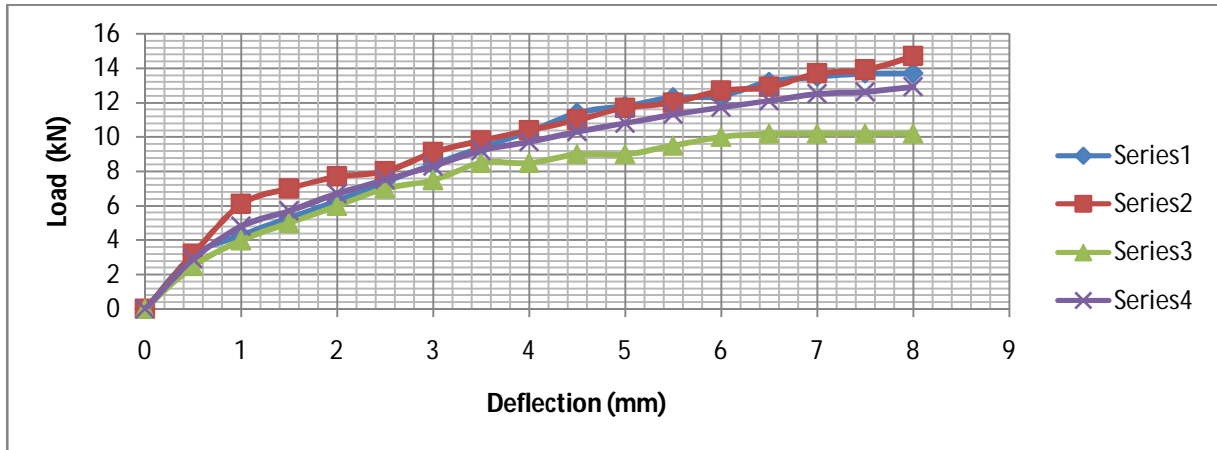
Deflection	Ultimate Load(KN) series 1	Ultimate Load(KN) series2	Ultimate Load(KN) series 3	Avg. Ultimate Load(KN)
0	0	0	0	0
0.5	3.1	3.2	2.5	2.9
1	4.3	6.1	4	4.8
1.5	5.3	7	5	5.7
2	6.3	7.7	6	6.7
2.5	7.4	8	7	7.5
3	8.4	9.1	7.5	8.3
3.5	9.4	9.8	8.5	9.2
4	10.3	10.4	8.5	9.7
4.5	11	11	9	10.3
5	11.8	11.7	9	10.8
5.5	12.3	12	9.5	11.3
6	12.4	12.7	10	11.7
6.5	13.2	12.9	10.2	12.1
7	13.5	13.7	10.25	12.5
7.5	13.7	13.9	10.25	12.6
8	13.7	14.7	10.25	12.9

Table 3 have shown the deflection and ultimate load results. Deflection is same but load measured in 75 mm thickness of panels series are different. Avg. Ultimate load is also calculated for modulus of Elasticity.

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Graph-1: Load vs Deflection for 75 mm thick Panel of Steel Wire mesh

Table-4: Load vs Deflection readings for 50 mm Panel (Layers-2)

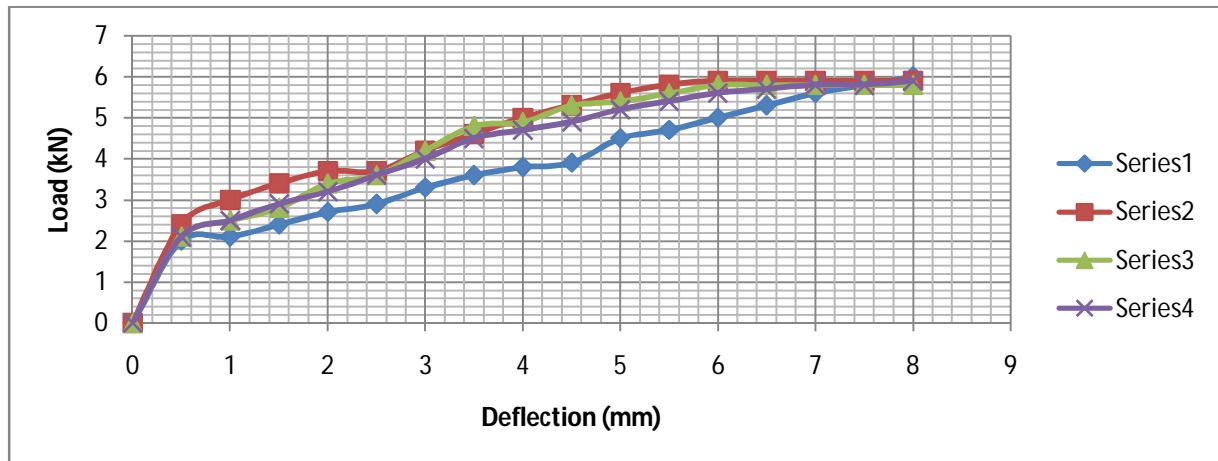
Deflection	Ultimate Load(KN) series 1	Ultimate Load(KN) series 2	Ultimate Load(KN) series 3	Avg. Ultimate Load(KN)
0	0	0	0	0
0.5	2	2.4	2.1	2.1
1	2.1	3	2.5	2.5
1.5	2.4	3.4	2.8	2.9
2	2.7	4.2	3.4	3.2
2.5	2.9	4.6	3.6	3.6
3	3.3	5	4.2	4.0
3.5	3.6	5.3	4.8	4.5
4	3.8	5.6	4.9	4.7
4.5	3.9	5.8	5.3	4.9
5	4.5	5.9	5.4	5.2
5.5	4.7	5.9	5.6	5.4
6	5	5.9	5.8	5.6
6.5	5.3	5.9	5.8	5.7
7	5.6	5.9	5.8	5.8
7.5	5.8	5.9	5.8	5.8
8	6	5.9	5.8	5.9

Table 4 have demonstrated the diversion and extreme load comes about. Redirection is same yet stack measured in 50 mm thickness of boards arrangement are distinctive. Avg. Extreme load is likewise ascertained for modulus of Elasticity.

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Graph-2: Load vs Deflection for 50 mm thick Panel of Steel Wire mesh

Table-5: Load vs Deflection readings for 25 mm Panel (Layers-1)

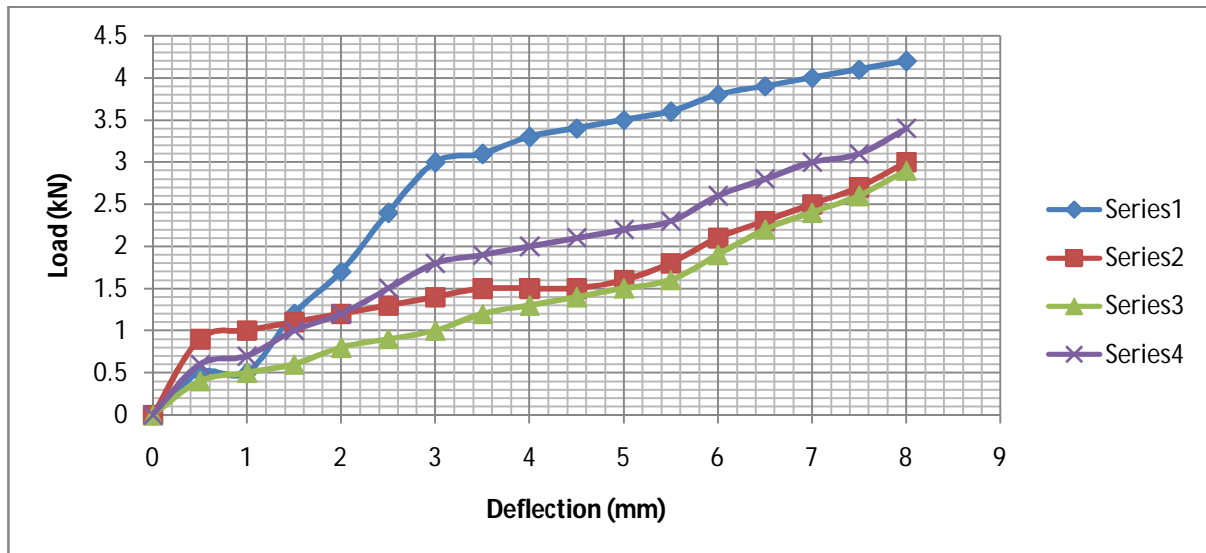
Deflection	Ultimate Load(KN) series 1	Ultimate Load(KN) series2	Ultimate Load(KN) series 3	Avg. Ultimate Load(KN)
0	0	0	0	0
0.5	0.5	0.9	0.4	0.6
1	0.5	1	0.5	0.7
1.5	1.2	1.1	0.6	1.0
2	1.7	1.2	0.8	1.2
2.5	2.4	1.3	0.9	1.5
3	3	1.4	1.0	1.8
3.5	3.1	1.5	1.2	1.9
4	3.3	1.5	1.3	2.0
4.5	3.4	1.5	1.4	2.1
5	3.5	1.6	1.5	2.2
5.5	3.6	1.8	1.6	2.3
6	3.8	2.1	1.9	2.6
6.5	3.9	2.3	2.2	2.8
7	4	2.5	2.4	3.0
7.5	4.1	2.7	2.6	3.1
8	4.2	3	2.9	3.4

Table 5 have shown the redirection and outrageous load happens. Redirection is same yet stack measured in 25 mm thickness of sheets course of action are particular. Avg. Extraordinary load is moreover figured for modulus of Elasticity.

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Graph-3: Load vs Deflection for 25 mm thick Panel of Steel Wire mesh

Table-6: Load Compilation Table Of Different Thick Panel Using Steel Wiremesh

Panel Thickness(mm)	Ultimate Load (KN)	Deflection at Ultimate Load (mm)	Modulus of Elasticity (E) (KN/mm ²)	Average of Modulus of Elasticity (KN/mm ²)
75	12.3	5.5	1.23	1.3685
	9.8	3.5	1.54	
	8.5	3.5	1.3356	
50	4.5	5.0	1.656	2.087
	5.3	4.0	2.438	
	5.3	4.5	2.167	
25	1.7	2.0	12.512	7.2128
	1.6	5.0	4.7104	
	1.5	5.0	4.416	

Table 6 is demonstrated the consequences of Modulus of Elasticity for the flexure. Modulus of Elasticity ascertained from above given recipe. The modulus of flexibility distinctive for various thickness of boards. Modulus of flexibility more for less thick board.

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Fig-5: Panel Failure of 50 mm Thick



Fig-6: Panel Failure of 25 mm Thick

Fig 5 displays that panel failure of 50 mm thick panel with 2 layers of steel wiremesh on Universal testing machine. Fig 6 shows that panel failure of 25 mm thick panel with 1 layers of steel wiremesh on Universal testing machine.

V. CONCLUSION

1. Panels produced using ferrocement have indicated malleable conduct. Boards made with wiremesh have indicated splitting first and then it broke step by step. So the pliable conduct has been watched.
2. From the heap conveying limit examination of all the particular thickness of boards the steel wiremesh boards made of 75 mm thickness has demonstrated the most extreme load conveying limit with regards to same avoidance when contrasted with 50 mm and 25 mm wire mesh boards.
3. For 25mm thickness board have demonstrated more Average of Modulus of Elasticity (KN/mm²) than 50mm and 75mm thickness of Panel.
4. The flexural loads at first split and extreme burdens rely on upon number of fortifying cross section layers utilized as a part of Ferro cement board.
5. Increasing the quantity of layers of wire work from 1 to 3 layers fundamentally builds the flexibility and capacity to assimilate vitality of the boards.
6. Presence of steel wire mesh builds the flexural quality of boards furthermore flexibility of boards.

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