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Impact Strength of Ferrocement Panel under Low Velocity Impact Loading

Darshan G. Gaidhankar, Mohammad Omid Naqshbandi, Mrudula S. Kulkarni

Abstract*: *The capability to absorb energy, often called as toughness, is of importance in actual service conditions of mesh reinforced composites, when they may be subjected to static, dynamic and fatigue loads. Toughness evaluated under impact loads is the impact strength. The toughness of materials are determined by two methods, (i) by measuring deformation under impact load, (ii) by determining energy adsorption capacity of materials under impact load. Several methods were used to investigate to determining toughness of materials. In this research work, drop weight impact test were used. The present experimental work describes testing of flat ferrocement panels with different number of layer steel mesh as well as enhancement of panels with steel fiber. The main purpose of this study is to investigate the effect of using different number of wire mesh layer on the flexural strength and impact strength and also effect of varying thickness of panels on the energy absorption of ferrocement panels. The experimental work includes preparation of ferrocement panels reinforced with welded square mesh, woven square mesh with and without hooked steel fibers The ferrocement panels of different sizes were prepared and tested for flexural strength under the two point loading as well as drop weight for impact testing. It is expected that as the mesh layers will be increased the energy absorption capacity of the panel should be increased and the also its effect should be seen for addition of hooked steel fibers.

Keywords*: *Wire Mesh, Effect, Flexural Strength, Layer, Panel, Ferrocement, Impact Energy

I. INTRODUCTION

In civil engineering, a high number of civil infrastructures is subjected to serious deterioration as result of chloride attack, carbonation, pollution etc. and many of the civil structures are not considered safe as because of overloading, to maintain the serviceability of older buildings as well to be strengthened and rehabilitation of historical monuments to maintain our cultural heritage. The properties of concrete have shown low tensile strength and low strain capacity, limited ductility, its brittle and the resistance to crack propagation is comparatively low. As per the behavior of RCC structure is ductile, which leaves the structure exposed to ductile failure. Due to ductile failure of concrete, large cracking along with crack widths and deflections that will affect the structures appearance. Therefore, serviceability criteria will be more important to strength. As a result of the problems stated above it is vital to find a new material with improved behavior compared to concrete. In ferrocement, closely spaced multiple layers of mesh or small diameter steel fiber completely infiltrated with, or incapsulated in mortar. In order to improve the behavior of ferrocement, multiple ingredients such as silica fumes, admixtures, fly ash and fibers are also added to it, in general the thickness of ferrocement ranges from 20-100mm. the fibers reinforced concrete is a composite material, essentially consisting of concrete reinforced by random placement of short discontinuous steel fiber.

Material Constituents of Ferrocement:

Properties of material for ferrocement including the hydraulic cement mortar, according to the mix design for mortar concrete which include water, sand, wire mesh, Portland cement and admixtures. Water: water is an major ingredient of concrete which should be potable and fit for use as mixing water as well as for curing ferrocement. The quantity and quality of water are required to be looked into very carefully. Sand: fine aggregate give body to the concrete one of the most important factors for producing workable concrete is a good gradation of aggregates. The aggregate should be normal weight, clean, hard, strong free of organic impurities and relatively free of silt and clay. Wire mesh: steel mesh, square welded mesh or chicken wire mesh is made by welding of wire perpendicular with each other which have hexagonal shape as well as some of the mesh filament are galvanized.

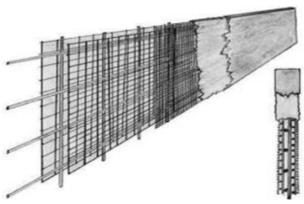

Figure 1. Typical cross section of ferrocement structure

II. LITERATURE SURVEY

Subromani R. siva. This study main focus on the behavior of ferro cement reinforcement with waste plastic fiber panels under impact loading. For impact test the result showed that the addition of waste plastic fiber and PCV coated wire mesh layers increased ultimate failure of panels against cracking a total of 8 ferro cement panels with dimension of 600mmx600mmx25mm and 600mmx400mmx15mm were constructed and tested 8 panels tested under low velocity impact.

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As reported by the ACI committee 544 is the rig which is used in this research the low velocity impact test was conducted using 1400gm steel ball dropping freely from height 2.4m and 1.2m thirty two 56- day age 600x60025mm slab and 600x400x15mm slab specimens were tested under low velocity impact. In testing of flexure panels. A special flexural loading frame was exclusively fabricated for testing in order to test the slab on a four point loading at 1/3rd span over on effective span of 600mm a total of 8 specimens were tested in this investigation on four point loading test Alternatively three category specimens by using of different 1,2 and 3 layers of mesh were tested in this research the proper and the result showed that by increasing of number layers mesh and steel fiber the ultimate strength increase and the crack started from center of top face and propagated on length and width of specimens.

Comingstarful marthong[1] and deba kumar sarma[2.] .The main objective of the experimental work was to study the effect of combing reinforcement steel meshes with discontinuous fibers as reinforcement in this mortar matrix. The experiment done to investigation the flexural behavior of fiber reinforcement ferrocement panels increment 60 plates of size 400x100x12.5mm were tested in bending included number of mesh layers and this continues fiber incorporate steel or PET two types of fibers steel and PET specimens were subjected under the different loading. result showed the some number of mesh layers are strongest assembly in both elastic and inelastic ranges shows a good in both flexural strength and energy absorption to failure too spalling of the mortar curve at ultimate load can be very effective with the addition of dis continuous fibers.

Gunasekaran muraliu[1] Mugahed Amran[2] Roman Fediuk[3]. The main purpose of this research proper to recognize flexural and low velocity impact response of simply support ferro cement panels reinforced with expanded wire mush and 122 different ferrocement panels was tested against three point flexural load and falling mass impact test. In this experimental work different percentage of 1, 2 and 3% layers used to comprises with mortar reinforcement. with0.4 water cement ratio was impound for mortar preparation and all panels wire cured in water for 28 days. the investigation was accomplished on the flexural and impact response of ferro cement panels and for the highest compressive strength at 28days was 70.8% and 50.5 for the incorporating 2 and 1% dos age of fiber respectively compared to non fiber motors by increasing number of EWM and steel fiber significant flexural strength and ductility index of the ferrocement panels.

AM Shande[1] and AM Pande[2] Gulfam Pathan[3]- The critical investigation accomplished to study the compressive strength of flexural strength slit task strength for m-40 grade of concrete having mix preparation 1:1 and 1:43 with water cement ratio 0.35 and containing fiber of 0% 1% 2% and 3% volume fraction of hook steel fiber of 50, 60 and 67 aspect ratio were used the cube specimens for compressive strength test 150x150mm were cost for m40 grade of concrete the subs specimens dimension 100x100x500mm were cost for flexural strength of beam and split tensile strength test cylinder specimens of dimension 150m and 300mm compressive strength, split strength and flexural strength are on higher side for 3% fiber as compared to that product from 0% 1% and 2% fibers and also its perceive that compressive strength increase from 11 to 24% with addition of steel fiber and also its perceive that can compressive strength increase from 11 to 24% flexural strength increase from 12 to 49% and split tensile strength increase from 13 to 41% with addition of steel fiber.

P.B. Sakthivel[1], A. Ravichandran[2].This experimental study emphasized and attempt to explore the possibility of adding polyolefin fibers in steel mesh reinforcement cementations composite and conduct low velocity impact test for investigation test specimens of slab size 250 x 250 x25mm were constructed with steel mesh 3 to 5 layers and polyolefin fiber and compared with constructed specimens by having of 3 to 5 layers of steel mesh, statically test were engaged to find out the paired difference in impact energy absorption as well as there were significant different in the energy absorption capacity of cementitious slabs. if steel mesh layers were keeping varied fiber percentage constant the ultimate energy absorption has increased at test to three times when the layers were increase from 3 to 5 layers as well as when 5m all amount of polyolefin fiber were tested in small quantities.

III. OBJECTIVE OF EXPERIMENTAL WORK

The main purpose of this experimental investigation to study the behavior of ferrocement panels under flexure and impact loading as well as effect of using different layers of steel welded, woven mesh and varying of steel fiber 50mm length 1.00mm diameter. The several parameters under the consideration of this investigation.

1. Effect of varying steel fiber on flexural strength as well as impact loading.
2. Volume fraction effect on flexural strength of panels.
3. Effect of multiple layers of steel mesh on the energy absorption of slab panels.

IV. EXPERIMENTAL WORK

In the experimental study flat ferrocement panels constructed and tested under two point loading. First a fall various number of layer steel mesh were tested and then steel fiber used. For Energy absorption capacity drop weight used to collect number of blow for initial and final failure.

A.Materials

Portland cement grad (43), sand: passing through 2.36 mm I.S sieve, water, galvanized welded square mesh and galvanized woven mesh diameter of 1.4 mm (15x15mm opening), steel fiber by having of 50mm length 1.00mm diameter

B. Mix Proportion

Cement: sand ratio (1:1.5) water cement ratio (0.40 and 0.38) Total of 15 panels of size (70.7x70.7x70.7) with and without steel fiber constructed and tested.

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Table 1. Comp. Strength of cubes using Hooked steel fibers

Sr. No.	No. of days	Load at Failure (KN)	Comp Strength (N/mm^2)	Aver Comp Strength (N/mm^2)
1	28	176	35.918	36.394
2	28	179	36.53	
3	28	180	36.734	

Table 2.Comp. Strength of Cement Mortar Cubes

Sr. No.	No. of days	Load at Failure (KN)	Comp. Strength (N/mm^2)	Avg Comp. Strength (N/mm^2)
1.	07	123	25.100	25.441
2.	07	125	25.510	
3.	07	126	25.714	
4.	28	172	35.102	35.850
5.	28	178	36.326	
6.	28	177	36.122	

Keyword: Compressive (Comp), Average (Avg)

C. Casting and Testing Procedure

The framework properly oiled before costing. Proper content for costing is cement, sand, water and admixture as per the mix design. At first the dry cement and sand were mixed then we putted water and mixed well. Alternatively, we applied one layer of mortar and steel welded mesh or woven mesh by keeping of specified distance between layer of mesh and clear cover. And also 1.5 % in the total weight of specimen steel fiber used in costing for combination of steel fiber and steel welded mesh. . Steel fiber were placed randomly in all the specimen. After 24 hours of costing panels were remove from framework. The all specimen were about to curing for 28 days panel were placed under the testing machine which had 500 mm space from both ending.

D. Details of flexural strength

The flexural strength test under two point loading was constructed on all the panels. During the testing loads and the corresponding deflection are noted down.

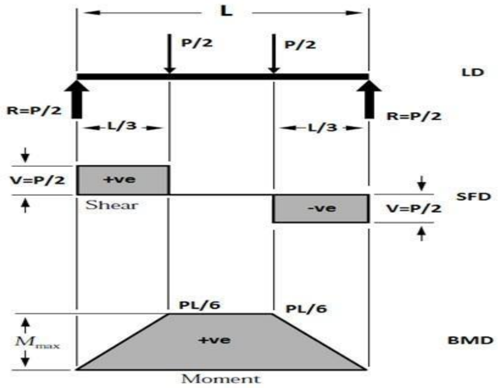

Figure 2. SFD and BMD Under Two Point Loading

Flexural strength was calculated by using the following formula

$$\frac{M}{I} = \frac{\sigma}{Y} \quad \sigma = \frac{M}{I}\, x\, y$$

Where, M = Maximum Bending Moment = PL/6, I = Moment of Inertia = $BD^3/12$, L = Span

B = Width of the section, D = Depth of the sect

Following table are analytical analysis for flexural strength test.

Table 3. Flexural strength of Ferrocement

Panel Size: 500x200x20mm (Experimental)

Sr. No.	Description	Flexural strength a Failure (MPa)		
		Layers 02	Layers 03	Layers 04
1.	WLD Mesh	17.5	18.5	22.5
2.	WLD Mesh with HF	19	20	25
3.	WVN Mesh	15.5	15.5	16.5
4.	WVN Mesh with HF	16	16.9	17.5

Table 4. Flexural strength of Ferrocement Panel Size: 700x200x30mm (Experimental)

Sr. No.	Description	Flexural strength a Failure (MPa)		
		02 Layers	03 Layers	04 Layers
1.	WLD Mesh	15	16	17.3
2.	WLD Mesh with HF	15.6	16.66	19.6
3.	WVN Mesh	13	13.6	16.66
4.	WVN Mesh with HF	14	14.5	15.6

Table 5. Flexural strength of Ferrocement Panels Panels Size: 800x200x40mm(Experimental)

Sr. No.	Description	Flexural strength at Failure (MPa)		
		Layers 02	Layers 03	Layers 04
1.	WLD Mesh	11.7	11.9	13.3
2.	WLD Mesh with HF	12.03	12.4	14.7
3.	WVN Mesh	9	10	10.3
4.	WVN Mesh with HF	10.06	10.4	11.2

V. TEST RESULT

Energy Absorption of Ferrocement Panels:

Calculation for finding energy absorption capacity of ferrocement panel at initial, final crack.

$E_{imp} = N \cdot g \cdot h \cdot m$

$E_{imp} = energy\ impact$ $\qquad N = Number\ of\ blow$

$h = Hieght\ of\ drop$

$m = Mass\ of\ drop\ weight$

Following table are for Energy Absorption of ferrocement panels test.

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Table 6. Number of blows For Ferrocement Panels 250 x 250 (For h = 0.5m)

Sr. No.	Description	Number of Blow For Initial Failure		
		Layer 02	Layer 03	Layer 04
1.	20mm WLD	15	16	22
2.	30mm WLD	17	19	24
3.	40mm WLD	21	23	27
4.	20mm WLD with HF	16	18	22
5.	30mm WLD with HF	17	20	25
6.	40mm WLD with HF	22	23	29

Table 7. Number of blow for ferrocement Panels 250 x 250 (For h = 0.5m)

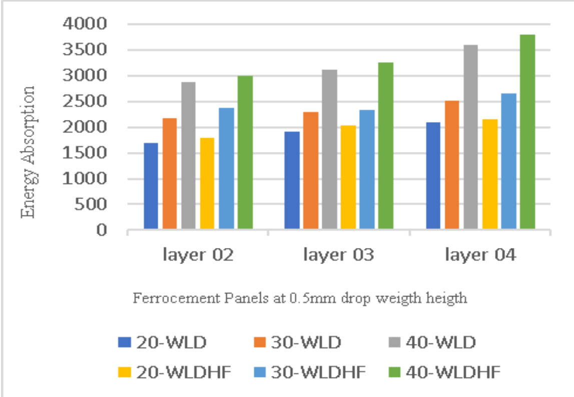
Sr. No.	Description	Number of Blow For final Failure		
		Layer 02	Layer 03	Layer 04
1	20mm WLD	98	112	122
2	30mm WLD	128	134	147
3	40mm WLD	168	182	210
4	20mm WLD with HF	104	118	126
5	30mm WLD with HF	138	136	155
6	40mm WLD with HF	175	190	221

Table 8.Initial energy absorption table For Ferrocement Panels Size 250 x 250 (For h = 0.5m)

Sr. No.	Description	Initial Energy Absorption of Ferrocement Panels		
		Layer 02	Layer 02	Layer 02
1.	20mm WLD	257.51	274.68	394.9
2.	30mm WLD	291.85	326.18	412.02
3.	40mm WLD	306.6	394.86	463.52
4.	20mm WL with HF	274.68	309.02	373.69
5.	30mm WLD with HF	291.85	343.4	429.19
6.	40mm WLD with HF	`377.69	394.9	497.86

Table 9. Final Energy Absorption of Ferrocement Panels 250 x 250 (For h = 0.5m)

Sr. No.	Description	Final Energy Absorption of Ferrocement Panels		
		Layer 02	Layer 03	Layer 04
1	20mm WLD	1682.42	1922.76	2094.4
2	30mm WLD	2179.44	2300.46	2523.62
3	40mm WLD	2884.14	3124.49	3605.18
4	20mm WL with HF	1785.42	2025.77	2163.11
5	30mm WLD with HF	2369.12	2334.78	2660.96
6	40mm WLD with HF	3004.31	3261.83	3794.01



Graph 1. For final Energy absorption of ferrocement panels

Table 10. Number of blows For Ferrocement Panels 250 x 250 (For h = 1m)

Sr. No.	Description	Number of Blow For Initial Failure		
		Layer 02	Layer 02	Layer 02
1.	20mm WLD	9	9	11
2.	30mm WLD	9	10	11
3.	40mm WLD	10	10	12
4.	20mm WL with HF	9	9	12
5.	30mm WLD with HF	10	10	13
6.	40mm WLD with HF	11	10	13

Table 11.Number of blow for ferrocement Panels 250 x 250 (For h = 1m)

Sr. No.	Description	Number of Blow For final Failure		
		Layer 02	Layer 03	Layer 04
1	20mm WLD	45	50	53
2	30mm WLD	52	57	64
3	40mm WLD	66	72	83
4	20mm WL with HF	56	63	72
5	30mm WLD with HF	60	65	86
6	40mm WLD with HF	72	85	95

Table 12. Initial energy absorption table For Ferrocement Panels 250 x 250 (For h = 1m)

Sr. No.	Description	Initial Energy Absorption of Ferrocement Panels		
		Layer 02	Layer 03	Layer 04
1	20mm WLD	309.02	309.02	373.69
2	30mm WLD	309.02	343.4	373.69
3	40mm WLD	343.04	343.4	412.02
4	20mm WL with HF	309.02	309.02	412

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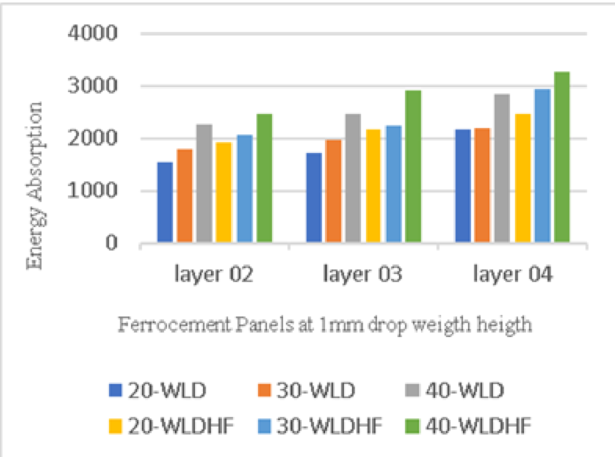
5	30mm WLD with HF	343.04	343.4	446.36
6	40mm WLD with HF	373.69	343.4	446.36

Table 13.Final energy absorption table For Ferrocement Panels 250 x 250 (For h = 1m)

Sr. No.	Description	Final Energy Absorption of Ferrocement Panels		
		Layer 02	Layer 03	Layer 04
1	20mm WLD	1545.1	1716.8	2163.12
2	30mm WLD	1785.42	1957.1	2197.44
3	40mm WLD	2265.11	2472.12	2849.8
4	20mm WL with HF	1922.76	2163.12	2472.12
5	30mm WLD with HF	2060.1	2231.76	2952.81
6	40mm WLD with HF	2472.12	2918.48	3261.86



Graph 2. For final Energy absorption of ferrocement panels

Table 14. Number of blows For Ferrocement Panels250 x 250 (For h = 0.5m)

Sr. No.	Description	Number of Blow For Initial Failure		
		Layer 02	Layer 03	Layer 04
1	20mm WVN	12	13	17
2	30mm WVN	12	13	17
3	40mm WVN	13	14	18
4	20mm WVN with HF	13	14	18
5	30mm WVN with HF	14	14	19
6	40mm WVN with HF	14	15	19

Table 15. Number of blow for ferrocement Panels 250 x 250 (For h = 0.5m)

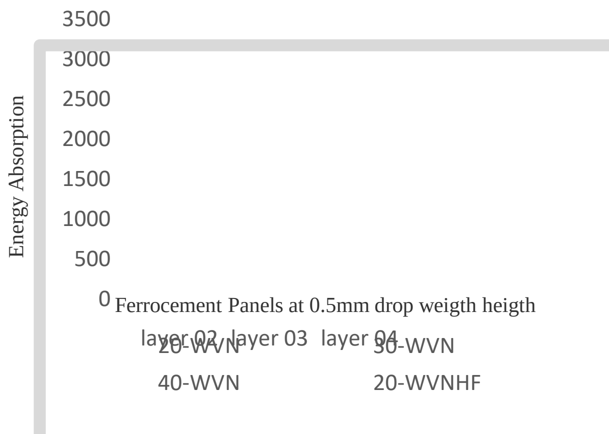
Sr. No.	Description	Number of Blow For final Failure		
		Layer 02	Layer 03	Layer 04
1	20mm WVN	88	96	106
2	30mm WVN	112	121	128
3	40mm WVN	146	160	175
4	20mm WVN with HF	92	99	110
5	30mm WVN with HF	118	127	135
6	40mm WVN with HF	162	172	189

Table 16.Initial Energy Absorption For Ferrocement Panels250 x 250 (For h = 0.5m)

Sr. No.	Description	Initial Energy Absorption of Ferrocement Panels		
		Layer 02	Layer 03	Layer 04
1	20mm WVN	206.01	223.18	291.85
2	30mm WVN	206.01	223.18	291.85
3	40mm WVN	223.18	240.35	309.02
4	20mm WVN with HF	223.18	240.35	309.02
5	30mm WVN with HF	240.35	240.35	326.18
6	40mm WVN with HF	240.35	257.51	326.18

Table 17. Final Energy Absorption ferrocement Panels 250 x 250 (For h = 0.5m)

Sr. No.	Description	Final Energy Absorption of Ferrocement Panels		
		Layer 02	Layer 03	Layer 04
1	20mm WVN	1510.74	1648.08	1819.8
2	30mm WVN	1922.76	2077.27	3124.4
3	40mm WVN	2506.5	2746.8	3004.3
4	20mm WVN with HF	1579.41	1699.58	1888.4
5	30mm WVN with HF	2025.77	2180.27	2317.6
6	40mm WVN with HF	2781.14	2952.81	3244



Graph 3. For final Energy absorption of ferrocement panels

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Table 18.Number of blow for ferrocement Panels 250 x 250 (For h = 1m)

Sr. No.	Description	Number of Blow For Initial Failure		
		Layer 02	Layer 03	Layer 04
1	20mm WVN	07	09	10
2	30mm WVN	07	10	11
3	40mm WVN	08	10	11
4	20mm WVN with HF	08	10	12
5	30mm WVN with HF	09	11	13
6	40mm WVN with HF	09	11	13

Table 19.Number of blow for ferrocement Panels 250 x 250 (For h = 1m)

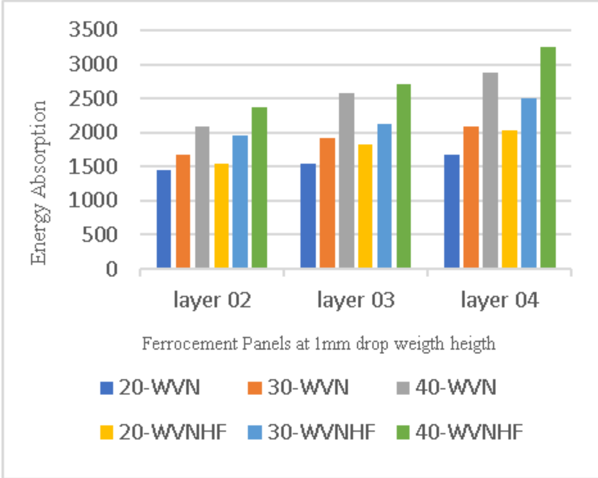
Sr. No.	Description	Number of Blow For final Failure		
		Layer 02	Layer 03	Layer 04
1	20mm WVN	42	45	49
2	30mm WVN	49	56	61
3	40mm WVN	61	75	84
4	20mm WVN with HF	45	53	59
5	30mm WVN with HF	57	62	73
6	40mm WVN with HF	69	79	95

Table 20. Initial Energy Absorption For Ferrocement Panels 250 x 250 (For h = 1m)

Sr. No.	Description	Initial Energy Absorption of Ferrocement Panels		
		Layer 02	Layer 03	Layer 04
1	20mm WVN	240.35	309.02	343.35
2	30mm WVN	240.35	343.35	377.69
3	40mm WVN	274.68	343.35	377.69
4	20mm WVN with HF	274.68	343.35	412.02
5	30mm WVN with HF	309.02	377.69	446.36
6	40mm WVN with HF	309.02	377.69	440.36

Table 21 Final Energy Absorption For Ferrocement Panels 250 x 250 (For h = 1m)

Sr. No.	Description	Final Energy Absorption of Ferrocement Panels		
		Layer 02	Layer 03	Layer 04
1	20mm WVN	1442.1	1545.08	1682.42
2	30mm WVN	1682.42	1922.76	2094.44
3	40mm WVN	2094.44	2575.13	2884.14
4	20mm WVN with HF	1545.08	1819.8	2025.77
5	30mm WVN with HF	1957.1	2128.8	2506.5
6	40mm WVN with HF	2369.12	2712.47	3261.83



Graph 4. For final Energy absorption of ferrocement panels

Nomenclatures used : FC – Ferrocement Panel
WLD – FC panel with welded mesh
WVN – FC panel with woven mesh
WLD with HF – FC panel welded mesh and Hooked Fibres
WVN with HF – FC panel woven mesh and hooked fibres

VI. CONCLUSION

An excellent investigation was conducted on energy absorption of ferrocement panels in different number of wire mesh with steel fiber and without steel fiber. as well different drop height has been in the cover of the investigation. All finding from experimental and analytical investigation the following main conclusion.

1) By increasing the height of drop of hammer energy absorption capacity of panel decreases.
2) Increasing the thickness of panel increases energy absorption capacity of panel.
3) The energy absorption capacity of ferrocement panel using welded mesh with hooked fibres shows excellent results than using woven mesh with hooked fibres .
4) Addition of fibers in mortar shows slight increases in compressive strength of mortar.
5) Increase in number of wire mesh layers increases the flexural strength of ferrocement panels.
6) Increase in thickness of ferrocement panel shows reduction in the flexural strength.

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