Effect of Mortar Strength On The Behaviour of Ferrocement Panel Under Low Velocity Impact

Yash N. Patel, Darshan G. Gaidhankar, Mrudula S. Kulkarni

Abstract: The concept of industrialization of the construction technology has emerged as well accepted and preferred option in the field of building construction now days in order to reduce in – situ construction up to maximum extent. Ferrocement is the one of the relatively new cementitious composite considered as a construction material. The main aim of this study is to investigate the behavior of Ferrocement panel under low velocity impact. Size of panel is 250 x 250 mm and thickness is varying from 20mm to 40mm. Corrugated fibers were added in panels. Volume of corrugated fibers was considered as 1.5% of total volume of panel. Weld mesh and woven mesh were used in ferrocement panels. Numbers of layers of mesh were 2 and 3. Height of drop is 1m. M30 and M40 Grade of mortar were used. Equivalent stress, Normal stress and Deformation were the main parameters for this research work. From the results it can be concluded that weld mesh with corrugated fibers is good at the impact resistance.

Keywords: Ferrocement, Weld mesh, Woven Mesh, Corrugated fibers, Low velocity impact

I. INTRODUCTION

Usually the concrete buildings are intended for static load. Sometimes, however, these structures may be subjected to dynamic blasts, impulsive loads, external projectiles, militant or terrorist behavior, and accidental multi-chemical explosions, machine vibrations and earthquakes. The structure can shake, vibrate, serious concrete cracking during explosions and fragment effect and crater shapes on the front of the concrete and for large load, and huge penetration can occur and can result in rear facet wall scabbing or perforation with the risk of injury to individuals within the frame. Cement panels can be found under effect loading to be most helpful. Ferrocement was described as tightly strengthened mortar shaped into a thin shell that acts as a composite material whose features rely on the mixture of steel and thick, high-resistance mortar. Ferrocement components are usually very ductile when placed next to the standard reinforced concrete component, because the reinforcement is spread evenly across the whole component Ferrocement is a thin composite made of a cement-based full-mortar mix, reinforced with small diameter wire-mesh layers that are thoroughly spaced. Many researchers have also found that the ductility and shear capacity in the matrix has considerably enhanced by incorporating discontinuous brief synthetic fibers into the cement matrix, which in turn also shows an increase in tensile strength.

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***** Correspondence Author

Yash N. Patel, is currently pursuing Master's degree program in structural engineering in MIT World Peace University, Pune-India, Email: ynpatel99u@gmail.com

Prof. Darshan G. Gaidhankar, is currently associate professor in school of civil engineering, MIT World Peace University, Pune-India, Email: darshan.gaidhankar@mitpune.edu.in

- **Prof.Dr.Mrudula S. Kulkarni,** is currently professor in school of civil engineering, MIT World Peace University, Pune-India.

II. LITERATURE REVIEW

Abdulkader Ismail A. Al-Hadithi, Khalil Ibrahim Aziz et. al. (2015) In this paper, Authors carried out the behaviour of Ferro-cement panels under high and low velocity impact. Total 36 panels has been tested under low velocity impact test and 12 panels has been tested under high velocity impact test. Dimensions of panels were 500 x 500 x 50mm. Low velocity impact test has been done by using 1300gm hammer dropped from various heights of 2.4 m, 1.2 m and 0.83 m. High velocity impact test has been done by using 7.62 mm diameter bullet fired from distance of 15 m with velocity of 720 m/s. The main parameters evaluated in this works were content of SBR and height of falling mass. From this work researchers can be concluded that adding SBR in Ferro-cement panels shows good results in preventions of the appearance of cracks.

T.Subramani, R.Siva (2016) the researchers investigated the behaviour of Ferro-cement with addition of plastic fibre. The volume of plastic fibre varied between 5% to 15%. Total 8 panels with size of 600 mm x 600 mm x 25mm and 600 mm x 600 mm x 25 mm has been tested. Low velocity impact test has been done by using 1400 gm. steel ball dropping from height 2.4 m, 1.2m and 0.32 m. Four point flexural test has been done by using UTM machine. From the research it can be concluded that addition of plastic fibre increases the strength and energy absorption capacity of panels.

Anitha M *et.al,* the authors carried out an experimental work to review the behaviour of hybrid ferrocement block subjected to impact. The square ferrocement panels casted was of cross-section (500*500) mm. The thickness of the squared ferrocement panels is 25 mm and 35 mm. The ferrocement panels were tested for impact by using drop impact test. All the bottom four sides of the panel was fixed and repeated drop load test was carried out. The authors concluded that due to presence of number of layers of wire mesh, the panel requires more no. of blows for first crack as well as failure also the ductility of the ferrocement panel is increased with increase in no. of layers of wire mesh.

K.Mounika, A.Suchith Reddy, G.Latha (2015) the main objective of this study was to find out the flexural behaviour and impact resistance of ferrocement panel with different layer of welded mesh with varying percentage of steel fibres. Numbers of layers of mesh were 1 & 2. Percentage of steel fibres were varying between 0.5% to 2%. Ferrocement panels with dimensions of 500 x 500 x 25 mm were tested under low velocity impact. Low velocity impact test was done by using 3.84 kg steel ball and it was released from height of 1 m repeatedly. Ferrocement panels with size of 700 x 300 x 25 mm were tested under flexural test using UTM machine. Two point loading was given to panels under UTM machine. From this study it was concluded that increases in steel fibres content and layer of mesh increases impact resistance and flexural strength of panels.

P.B. Sakthivel, A. Ravichandran,N. Alagumurthi (2014) The main aim of researchers was to find out the effect of adding polyolefin fibres in steel mesh reinforced cementitious composites. Number of wire mesh layer was varying between 3 to 5 and polyolefin fibres content was varying between 0.5%to 2.5% of volume of specimen. Dimensions of specimen was 250 x 250 x 25 mm. Low velocity impact test was done by using 3kg steel ball. Steel ball was dropped at height of 600 mm repeatedly. From this study it can be concluded that adding of fibres in composites shows good energy absorption capacity of panel.

III. OBJECTIVES

- Effect of panel thickness on the deformation, equivalent stress and normal stress.
- Effect of different type of wire mesh on the deformation, equivalent stress and normal stress.
- Effect of different type of grade of mortar on the deformation, equivalent stress and normal stress
- Effect of height of drop on the deformation, equivalent stress and normal stress.

IV. ANALYTICAL WORK

ANSYS 16.0 used for analytical study. An explicit dynamics analysis is used to determine the dynamic response of a structure due to stress wave propagation, impact or rapidly changing time-dependent loads.

4.1 Modelling for Impact load test

1. Mortar with wire mesh

In this study analytical work is done totally in ANSYS Explicit Dynamics. In which Ferro cement panel was modelled. The size of Ferro cement panel is 250 x 250mm. The thickness of the panel is taken as 20mm, 30mm and 40mm. The diameter of the wire is taken as 1.2mm.

2. Drop Weight

The weight of the drop is 3.5kg. Total Height of the weight hammer is 365mm, out of which 340mm is cylindrical in shape and rest of it is conical in shape. The conical part is located at the bottom side of the drop. Diameter at the bottom side of the conical is 10mm and diameter at the top side of the conical is 40mm. Diameter of the cylindrical shape is 40mm throughout and total length of it is 340mm.

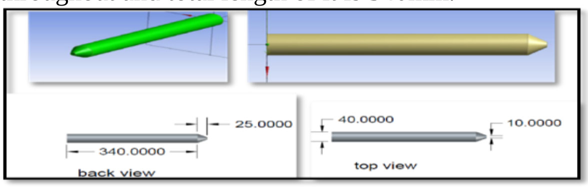

Fig 1 Dimension of Drop Weight

3. Properties of Mesh

Two types of meshes are used in the Ferro cement panel in this study, Welded square mesh and Woven Square mesh. Yield strength of both the meshes is 450MPa. Young's modulus of welded square mesh is 200GPa and due to more elasticity in woven square mesh its elastic modulus or young's modulus is less than that of welded square mesh, it is 138GPa.

3. Fibres

Corrugated steel fibres of length 67mm and diameter 1.0mm were used for modelling. Tensile strength of fibres was 500MPa.

4. Body Interaction

A body interaction is defined while modelling, which is used to define that the wire mesh which is placed inside the Ferro cement panel is reinforcement of it. Reinforcement body interaction should be supported in the case when only line bodies are scoped to a body interaction of type reinforcement. The line bodies will then be tied to any solid body that they intersect. This body interaction type is used to apply discrete reinforcement to solid bodies. All line bodies scoped to the object will be flagged as potential discrete reinforcing bodies in the solver. On initialization of the solver, all elements of the line bodies scoped to the object which are contained within any solid body in the model will be converted to discrete reinforcement. Elements which lie outside all volume bodies will remain as standard line body elements. A body interaction is defined while modeling, which is used to define that the wire mesh which is placed inside the Ferro cement panel is reinforcement of it.

5. Meshing

Meshing is the process in which your geometry is spatially discretized into elements and nodes.

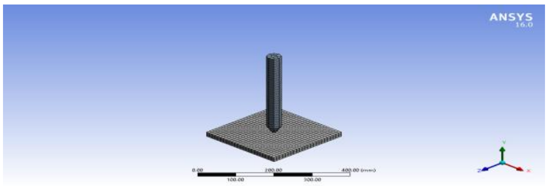

Fig 2 Meshing of Model

6. Fixed Support

All the four bottom edges of the Ferro-cement panel is assigned with fixed support such as to restrained it from displacing after the impact of bullet or when the drop weight is dropped. Following is the figure of the fixed support condition.

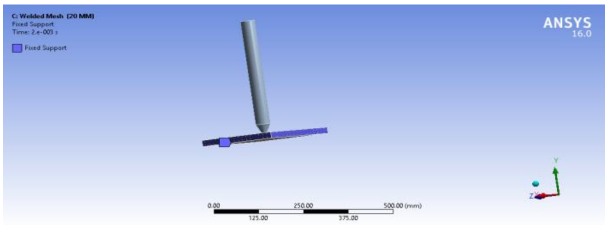

Fig 3 Fixed support of model

V. RESULT AND DISCUSSION

The Analytical work has been carried out for ferrocement panels with and without corrugated fibers. The panel size of 250x250mm with thickness of 20mm, 30mm and 40mm. For cement mortar M30 and M40 grade was used.

WLD- Weld Mesh, WLDCF- Weld Mesh with Corrugated Fiber, WVN- Woven Mesh, WVNCF- Woven Mesh with Corrugated Fiber.

Table I: 250x250x20mm panel using M30 Grade

Sr No	Type of Panel	Deformation (mm)	Equivalent Stress (MPa)	Normal Stress (MPa)
(2 Layer)				
1	WLD	12.091	35.343	14.732
2	WLDCF	11.575	32.325	11.707
3	WVN	15.807	45.935	19.16
4	WVNCF	14.925	41.699	15.089
(3 Layer)				
5	WLD	10.94	33.125	13.238
6	WLDCF	10.425	30.013	10.156
7	WVN	14.222	42.512	16.43
8	WVNCF	13.437	38.723	12.695

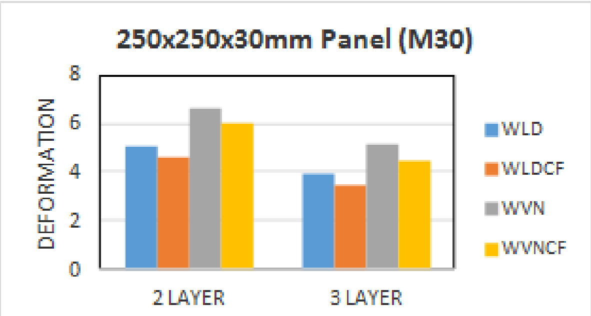

Fig 5. Deformation of 30mm thick panel for M30 grade

Table II: 250x250x40mm panel using M30 grade

Sr No	Type of Panel	Deformation (mm)	Equivalent Stress (MPa)	Normal Stress (MPa)
(2 Layer)				
1	WLD	3.811	20.530	12.589
2	WLDCF	3.324	17.456	9.613
3	WVN	5.954	24.089	15.736
4	WVNCF	4.287	22.543	12.016
(3 Layer)				
5	WLD	2.651	16.320	10.509
6	WLDCF	2.111	13.467	7.876
7	WVN	3.450	20.888	13.046
8	WVNCF	2.746	17.372	9.856

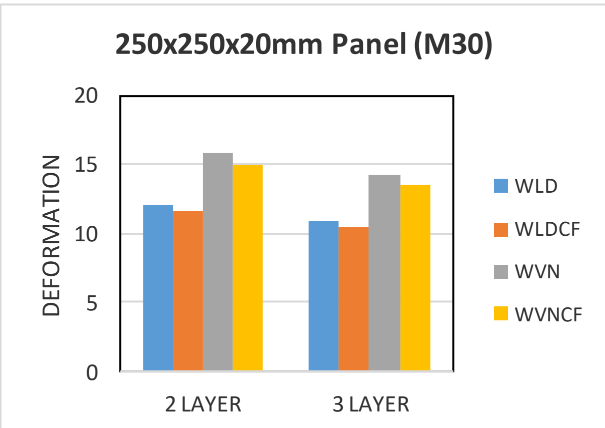

Fig. 4. Deformation of 20mm thick panel for M30 grade

Table III: 250x250x30mm panel using M30 grade

Sr No	Type of Panel	Deformation (mm)	Equivalent Stress (MPa)	Normal Stress (MPa)
(2 Layer)				
1	WLD	12.091	35.343	14.732
2	WLDCF	11.575	32.325	11.707
3	WVN	15.807	45.935	19.160
4	WVNCF	14.925	41.699	15.089

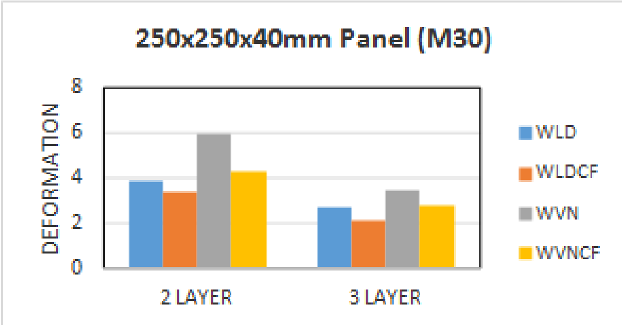

Fig. 6. Deformation of 40mm thick panel for M30 grade

Table IV: 250x250x20mm panel using M40 Grade

Sr No	Type of Panel	Deformation (mm)	Equivalent Stress (MPa)	Normal Stress (MPa)
(2 Layer)				
1	WLD	12.005	32.678	12.987
2	WLDCF	11.478	30.354	10.245
3	WVN	15.599	42.064	16.217
4	WVNCF	14.965	39.175	12.789
(3 Layer)				
5	WLD	10.849	28.507	11.514
6	WLDCF	10.323	25.434	9.612
7	WVN	13.881	36.702	14.25
8	WVNCF	13.231	32.823	12.081

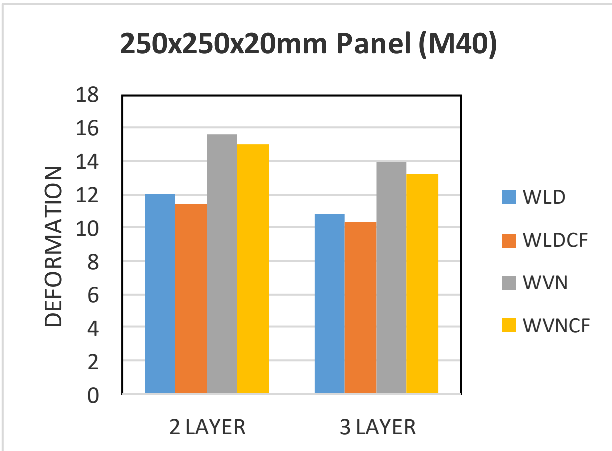

Fig. 7. Deformation of 20mm thick panel for M40 grade

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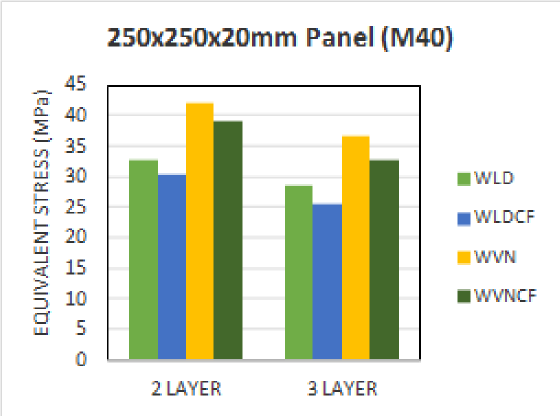

Fig.8.Equivalent Stress of 20mm thick panel for M40 grade

Table V: 250x250x30mm panel using M40 Grade

Sr No	Type of Panel	Deformation (mm)	Equivalent Stress (MPa)	Normal Stress (MPa)
(2 Layer)				
1	WLD	4.02	25.346	11.942
2	WLDCF	3.421	23.323	9.745
3	WVN	5.219	33.205	14.672
4	WVNCF	4.713	30.089	12.189
(3 Layer)				
5	WLD	2.855	23.226	9.45
6	WLDCF	2.331	21.169	7.328
7	WVN	3.654	29.7	12.46
8	WVNCF	3.112	27.345	9.385

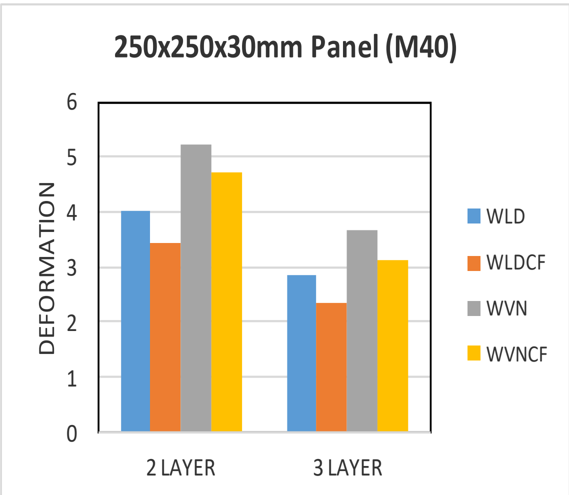

Fig. 9. Deformation of 30mm thick panel for M40 grade

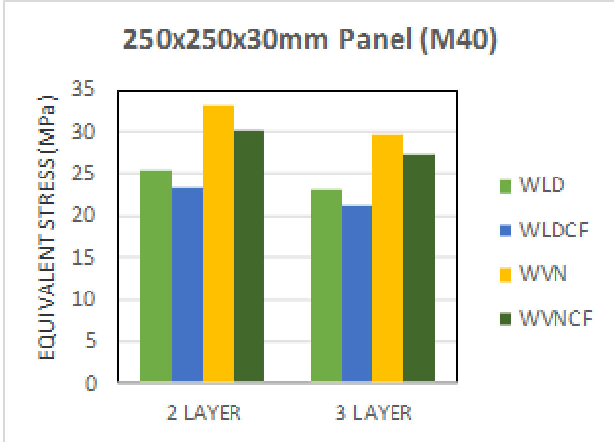

Fig. 10.Equivalent Stress of 30mm thick panel for M40 grade

Table VI: 250x250x40mm panel using M40 Grade

Sr No	Type of Panel	Deformation (mm)	Equivalent Stress (MPa)	Normal Stress (MPa)
(2 Layer)				
1	WLD	12.005	32.678	12.987
2	WLDCF	11.478	30.354	10.245
3	WVN	15.599	42.064	16.217
4	WVNCF	14.965	39.175	12.789
(3 Layer)				
5	WLD	10.849	28.507	11.514
6	WLDCF	10.323	25.434	9.612
7	WVN	13.881	36.702	14.250
8	WVNCF	13.231	32.823	12.081

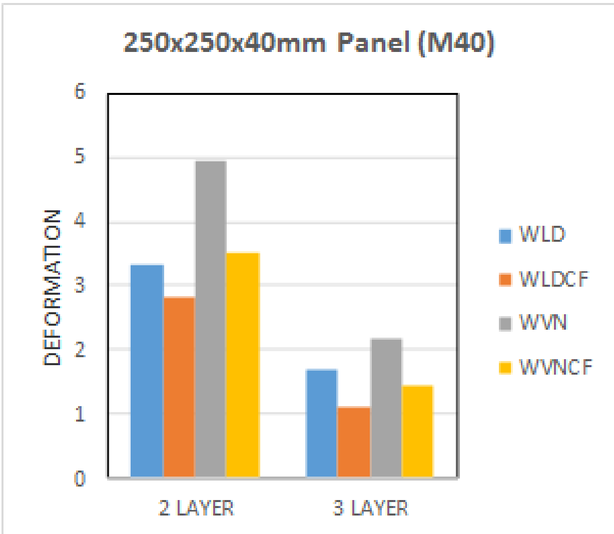

Fig. 11 Deformation of 40mm thick panel for M40 grade

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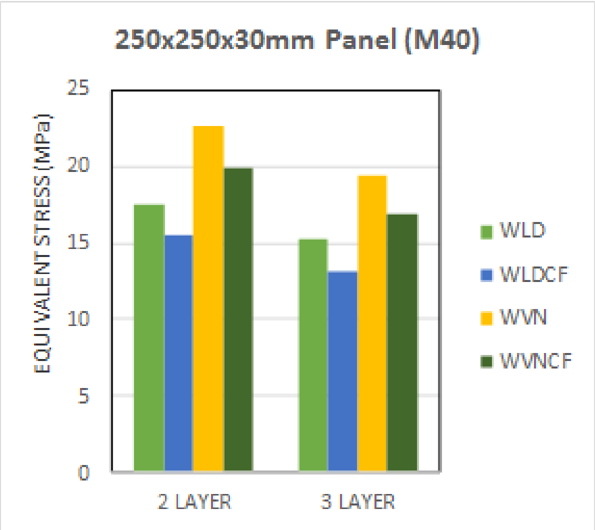

Fig. 12 Equivalent Stress of 30mm thick panel for M40 grade

VI. CONCLUSION

- For M30 Grade of mortar, deformation of 30mm thick panel is higher by 34%, as compared with 40mm thick panel using 2 layers of weld mesh.
- For M40 Grade of mortar, equivalent stress of 30mm thick panel is lower by 28% than 20mm thick panel using 2 layer of weld mesh.
- The equivalent stress of 30mm thick panel is 54% more than 40mm thick panels using 2 layers of woven mesh for M30 grade of mortar.
- The reduction is observed in the equivalent stress is 10-17% in M30 grade as compared with M40 grade of mortar for 40mm thick panel with 2 layer weld mesh.
- According to analytical results, for M30 as compared with M40 grade, it shows that Average Normal stress decreased by 14% and 16% for weld and woven mesh respectively.
- When 30mm thick panel is compared with 40mm thick panel, it shows that Average deformation decreased by 49% and 48% for weld and woven mesh using 3 layer respectively.
- For both M30 and M40 grade of mortar, deformation and equivalent stress for weld mesh is around 29% less than woven mesh.
- For both M30 and M40 grade of mortar, normal stress for weld mesh is around 24% less than woven mesh.

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REFERENCES

1. Abdulkader Ismail A. Al-Hadithi, Khalil Ibrahim Aziz, Mohammed TarradNawar Al-Dulaimi,"Behaviour of Ferro-cement slabs containing SBR under impact loads", International Journal of Sustainable and Green Energy 2015; pp 34-50.
2. T.Subramani, R.Siva. "Experimental Study On Flexural And Impact Behavior Of Ferro-cement Slabs", sInternational Journal of Application or Innovation in Engineering & Management (IJAIEM) , Volume 5, Issue 5, May 2016.
3. Anitha, M.tenmozhi, R. and Deepa Shri, S., "Behaviour of hybrid ferrocement slabs subjected to impact", International Journal of Emerging trends in Engineeringand Development,2(4), May 2012.
4. K.Mounika, A.Suchith Reddy, G.Latha, "Experimental Investigation On Performance of Fibrous Ferrocement", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 4, Issue 8, August 2015.
5. P.B. Sakthivel , A. Ravichandran and N. Alagumurthi, "An Experimental Study on Mesh and Fibre Reinforced Cementitious Composites", Concrete Research Letters, Vo. 5(1), March 2014.
6. SmithaGopinath∗, R Ayashwarya, V Ramesh Kumar,PrabhatRanjanPrem, A Rama Chandra Murthy,C K Madheswaran and R NageshIyer, " Low Velocity Impact Behaviour of Ultra High Strength Concrete Panels", Indian Acadamyn of Science, Vol. 39, Part 6, December 2014, pp 1497 – 1507.
7. ZakariaCheMuda, AgusrilSyamsir, Kamal Nasharuddin Mustapha, SorefanSulleman, SalmiaBeddu , SivadassThiruchelvam, Firas B. Ismail5, Fathoni Usman1, NurLiyanaMohd Kamal, Md AshrafulAlam, Ahmed H Birima, ZarinaItam, O S Zaroog, "The Effect of Mortar Grade and Thickness on The Impact Resistance of Ferrocement Slab", International Conference on Advances in Renewable Energy and Technologies, 2016.
8. Dr.Abdulkader Ismail Abdulwahab Al-Hadithi and Zayd Abdul-Jabbar Al-Obaidi, "Behavior of Ferrocement Slabs Containing Waste Plastic Fibers under Impact Loadings",Dams & Water Resources Engineering Department, College of Engineering, University of Anbar. Ramadi, Anbar, Iraq.Amar Prakash, Srinivasan, S.M. and Rama Mohan Rao,A., "High Velocity Impact Behaviour of Layered Steel Fibre Reinforced Cementitious Composite(SFRCC)Panels" CMC, vol.42, no.1, 2014, pp.75-102.

AUTHORS PROFILE

Yash N. Patel Mr.Yash Patel was born in 1995 in small village Maktupur of Gujaratr. He got his bachelor of engineering of degree in Civil Engineering from L.C.Institute of Technology, Bhandu in 2017. He is pursuing his Master of Technology in Structural Engineering at MIT-World Peace University, Pune-Maharashtra.
Email: Id ynpatel99u@gmail.com

Prof. Darshan G. Gaidhankar He is associate professor at School of Civil Engineering at MIT-WPU. He has completed his master of technology in structural engineering and righ now he is pursuing his Ph.D. He has total 16 years of teaching experience and 1.5 years of Industrial experience.
Email:Id. darshan.gaidhankar@mitwpu.edu.in

Prof.Dr.Mrudula S. Kulkarni She is Professor at the School of Civil Engineering at MITWPU and heading this school since its inception. Prior to this, she was Professor and Head of Department of Structural Engineering at MIT Pune. until June 2017. Earlier she did her doctoral research at College of Engineering Pune, Pune University, in the field of Bio Mechanics under the guidance of Dr. Satish Sathe and Dr. K.H.Sancheti.(2003-2007). She received her Bachelors from MIT Pune, Pune University in 1990. and Masters in Structural Engineering from Government College of Engineering Karad in 1994. She is involved in teaching since 1990 and teach various structural mechanics and design subjects at undergraduate and Postgraduate level. She was instrumental in setting up MIT CAD CAM CAE Design and Training center (2000-2008). She is the Ph.D. supervisor and Three students have been awarded doctoral degree till date. She has involved in funded research projects of an International level and done academic collaborations for her Institute and Department. Her specific research interests lie in Bio-Mechanics, Precast Structure, Innovative Designs, and Construction Technology. she has worked on various administrative bodies at Pune University in the capacity of Senate Member, member Board of studies, member Faculty of Engineering Email-id mrudula.kulkarni@mitwpu.edu.in