

Experimental Investigation on Ferrocement Composite Slab Using Flyash and Egg Shell

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Abstract: This project deals about energy effective building using innovative materials and cost effective. Due to global warming nowadays the temperature of earth keep on increases this may causes uncomfortable to the human environment. People spend lot of money and electricity to make them comfort. Based on this we try to reduce the room temperature by waste material. We used a waste material as our innovative materials such as flyash, egg shell powder and waste wax. By constructing wall masonry and providing a wax and egg shell powder base as final coating to the masonry. Finally the temperature of that construction was checked.

Keywords: Global Warming, Fly Ash, Egg Shell Powder, Waste Wax

Introduction:

With an increased demand for the building infrastructure at economical cost, it has lead to use the available materials in an efficient way. The basic idea is utilization of the material strength possessed in it. Today's structures are situated in more aggressive environment. These leads to the development of Ferro cement structures. Ferrocement is a type of thin-wall reinforcement concrete commonly constructed of hydraulic cement mortar, reinforced with closely spaced layers of continuous and relatively small diameter mesh. But in general, Ferrocement can be defined as "A Composite material consisting of a matrix and a reinforcement in a finely distributed manner which act together to form a new material with characteristics superior to either of its constituents. Ferrocement possesses a degree of toughness, ductility, strength and crack resistance that it is considerably greater than that found in other forms of concrete construction. These properties are achieved in structures with a thickness that is generally less than 25mm, a dimension that is nearly unthinkable in other forms of concrete construction, and a clear improvement over Conventional reinforced concrete. Surprisingly, good performance can be achieved in Ferrocement with almost primitive field conditions and it does not necessarily require highly skilled practitioners. The need of the construction industry to look for a reliable and cheaper strengthening component for reinforced concrete structure has led to the usage of ferrocement which proves to be a promising solution. The most widely used construction materials in today's world would be concrete and steel combined to make reinforced concrete as can be seen in most building construction.

Composite slab:

It consists of profiled steel decking with an in-situ reinforced concrete topping. The decking(profiled steel sheeting) not only acts as permanent formwork to the concrete, but also provides sufficient shear bond with the concrete so that, when the concrete has gained strength, the two materials act together compositely. If the slab is unpropped during construction, the decking alone resists the self weight of the wet concrete and construction loads. Subsequent loads are applied to the composite section. If the slab is propped, all of the loads have to be resisted by the composite section. They are usually designed as simply supported members in the normal conditions.

Objectives:

The main objectives of this experimental work is

1. To study the behaviour of conventional RC slab under loading conditions.
2. To investigate the behaviour of ferrocement composite slab under flexural loading.

Need for present study:

The need for study includes

1. Ferrocement panels used to act compositely with in-situ slabs offer practical, economic and durability benefits over conventional one.
2. It will also increase in stiffness, excellent crack control, higher ultimate strength and enhanced serviceability performance.
3. All the ferrocement composite sections exhibit excellent ductility and energy absorbing properties.

Review of literatures:

1. Experimental and Analytical Model of Ferrocement Slabs - BoshraAboul-Anen and Ahmed El-Shafey (2009)

This paper described that the composite action between the ferrocement slabs and steel sheeting. This is an important issue that could impact the performance and strength of space trusses. The current paper presents the experimental models of ferrocement slabs with and without steel sheeting and their numerical models using the finite element method. Finite element models were

developed to simulate the behaviour of the slab through nonlinear response and up to failure, using the ANSYS Package. Additionally, the comparison between the theoretical and experimental models is presented and discussed.

In this research, the authors focused on the composite action of the ferrocement slabs and steel sheets. In the following pages, experimental models of ferrocement slab with and without steel sheeting and their numerical models using the finite element method will be presented. Finite element models are developed to simulate the behaviour of the slab through nonlinear response and up to failure, using the ANSYS package. The results of both experimental and analytical investigations to examine the composite action between the ferrocement slabs and steel sheeting are reported and discussed. This was done as an initial step towards using the ferrocement slabs to improve the behaviour of compression member in spaced trusses.

2. Experimental study on light weight ferrocement beam under monotonic and repeated flexural loading- Naveen and Suresh (2012)

It is reported that the light weight ferrocement is a composite material consisting of cement-sand mortar (matrix) along with light weight fine aggregate (In this work foamed blast furnace slag is employed as light weight fine aggregate) as a replacement of sand in some quantity reinforced with layers of small diameter wire meshes. The present work is concentrated on two major aspects, Effect of blast furnace slag on first crack and ultimate strength and Behaviour of light weight ferrocement element under monotonic & repeated flexural loading.

The first part of the present study has been focused on the effect of blast furnace slag (BFS) on ultimate strength with replacement of slag by 0%, 10%, 20% and 30% and second part of the work focusing the behaviour of Light weight ferrocement beam under monotonic load and repeated load with increased load. The results obtained from this work is expected to be useful in determining the strength and ductility of light weight ferrocement beam subjected to similar types of forces and thus will help toward designing ferrocement elements to withstand monotonic and repeated flexural loading.

Light weight ferrocement consists of closely spaced, multiple layers of mesh or fine rods completely embedded in cement mortar. Usually steel bars are used in addition, to form a steel skeleton, which helps in retaining the required shape of the ferrocement components until the cement mortar hardens. It differs from conventional reinforced concrete primarily by the manner in which the reinforcement is arranged within the brittle matrix. Since its behaviour is quite different from that of conventional reinforced concrete in performance, strength and potential applications, it is classed as a separate material.

Light weight ferrocement has high resistance against cracking; also many of its engineering properties such as toughness, fatigue against resistance, and impermeability etc. are improved when compared to reinforced concrete. In India, light weight ferrocement is used often because the constructions made from it are better resistant against earthquakes. Earthquake-resistance is dependent on good construction technique and additional reinforcement of the cement.

3. Membrane Action of Composite Fibre Concrete Slab in Fire- J. Bednara, F. Walda et al(2012)

The fire resistance of a properly designed floor structure increases by its membrane behavior. The membrane fire resistance is evaluated by advanced as well as simple design procedures, approved by tests, and for partially protected floors reaching 60 mins and more. Composite constructions are more and more reinforced by steel fibers without added steel bars. Due to distributed mesh, steel fiber concrete can achieve good deformation capacity compared to traditional reinforced concrete even at elevated temperatures and questions have been raised about its fire resistance.

The composite floor slabs with fiber concrete at ambient and at elevated temperature were tested at the Czech Technical University in Prague in the last two years. At elevated temperature, the floor was only partially fire protected. Intermediate beams and fibre-concrete slab in steel sheeting were without protection. Concrete slabs were reinforced by steel fiber only without added steel bars. The main aim of the tests was to demonstrate the suitable properties of the steel fiber concrete slab in fire.

For the fire resistance of the floor slabs it is important that the material has sufficient ductility and adequate tensile and shear strength. These material properties of the fiber-concrete allow the slab to create a different load bearing mechanism, which increases the fire resistance of the floor slabs. The fiber-concrete was tested at ambient ductility and tensile strength of the fiber-concrete.

4. Response of Ferrocement Confinement On Behaviour Of Concrete Short Column- V.M.Shinde and J. P. Bhusari(2012)

In this study it is reported that the repair of unstrengthened and damaged reinforced concrete member by external bonding such as ferrocement laminate is increasing which demands need of investigations on behaviour of ferrocement confinements. Significant amount of work has been carried out on confinement of column with ferrocement laminates considering change in parameter such as types of meshes with different sizes, concrete grade, height of column, etc.

In this study, use of ferrocement as an external confinement to concrete specimen is investigated with reference to layers of confinement and orientation of meshes. The effectiveness of confinement is achieved by comparing the behaviour of confined specimen with that of unconfined specimen. The experimental program consists of testing 30 specimens under uniaxial compression. Ferrocement is a type of thin reinforced concrete laminates commonly constructed of hydraulic cement mortar reinforced with closely spaced layers of continuous and relatively small size wire mesh. The conventional construction materials such as steel and concrete have exhibited signs of deterioration over the years in their long-term performance which can be attributed to either the inherent nature of the materials or the weak resistance offered by these materials to adverse environmental conditions and natural disasters such as fires and earth quakes. There are a lot of confinement materials that are used for strengthening the concrete structures. Ferrocement, glass fiber, aramid fiber, carbon fiber, etc. are some of the few materials that are used in the confinement of concrete columns.

The use of ferrocement as an external confinement to concrete column is investigated in this study. Ferrocement is a special form of reinforced concrete, which exhibits a behaviour differing much from conventional reinforced concrete in strength performance and potential application.

5. Structural Behaviour of Ferrocement channels Beams- Yousry B.I. Shaheen and Noha M. Soliman (2013)

This research is to study the structural behaviour of ferrocement concrete composite channels reinforced with various types of reinforcing materials. The dimensions of the developed ferrocement and control test specimens were kept constant as 100 mm width, 200 mm height and 2000 mm length. The thickness of the two webs and base was kept constant as 25 mm. The test specimens were loaded under four point loadings until failure. The effects of the main parameters were extensively studied. High resistance ferrocement channels beams were developed with high crack resistance, high deformation characteristics, high strength, high ductility and energy absorption properties could be used with great economic advantages in the same way as steel channels in some of its uses and very useful for developed and developing countries alike. 1945 Nervi built the first ferrocement structure then a vaulted roof over shopping centre was built in Leningrad in Soviet Union In 1974. In 1975, two ferrocement aqueducts were designed & built for rural irrigation in China.

Characteristics and properties of materials



Fig.4.1 FA



Fig.4.2 CA

Specific gravity of Cement:

S.No	DESCRIPTION	Weight(g)
1	Weight of empty bottle(W_1)	440
2	Weight of bottle + water(W_2)	990
3	Weight of bottle + kerosene(W_3)	940
4	Weight of bottle + kerosene + cement(W_4)	920
5	Weight of cement(W_5)	28

$$\text{Specific gravity of kerosene (G)} = \frac{W_3 - W_1}{W_2 - W_1}$$

$$\text{Specific gravity} = \frac{W_5 \times (W_3 - W_1)}{(W_5 + W_3 - W_4)(W_2 - W_1)}$$

Initial setting time

A net cement paste with 0.85 times of water required is prepared to give a standard consistency, the time at which the water is added is noted. The vicat mould is filled with the cement paste in 3-5 minutes. The surface of paste is smoothened, making at level with the top of the mould, the needle is gently lowered to the surface of the paste and is quickly released and allowing it to sink into the paste by its own weight.

Final setting time

The procedure is similar to initial setting time, in this procedure needle with annual collar is inserted in vicat apparatus, time for penetration is noted for every 3 minutes. The procedure is repeated until the attachment fails to make an impression on the test block.

Fineness modulus test

100g of cement taken in standard IS sieve no.90 μ . The air which gets lumps is broken down and the material was sieved continuously for 15 minutes using the sieve shaker. The residue left on the sieve is weighed and the percentage of residue left on the sieve can be calculated as (weight retained/weight taken) x 100

S.NO	OBSERVATION	WEIGHT(g)
1	Weight of sample taken	100
2	Weight of material retained after sieving	2.7
3	% of residue left on the sieve on 90 μ	2.7

Properties of cement

The ordinary Portland cement which conforms to IS 12269 –1987 was used for making concrete. The physical properties of cement which was used for the experimental investigation are given in Table 4.3

S.No	Characteristics	Test results of cement used	Requirements as per IS 12269-1987
1	Fineness modulus	2.8	10%
2	Normal consistency	28%	-
3	Initial setting time	32 minutes	30 minutes
4	Final setting time	125 minutes	600 minutes
5	Compressive strength	46 N/mm ²	43 N/mm ²
6	Expansion in Le-chatelier's method	1 mm	10 mm
7	Specific gravity	3.15	-

Test on fine Aggregates:

Specific gravity:

S.No	OBSERVATION	Weight(g)
1	Weight of pycnometer (W_1)	440
2	Weight of pycnometer + sand (W_2)	750
3	Weight of pycnometer + sand + water (W_3)	1145
4	Weight of pycnometer + water (W_4)	950

$$\text{Specific gravity of fine aggregate} = \frac{(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)}$$

Sieve Analysis for Fine Aggregate:

Test on coarse aggregate:	Passing through IS sieve (mm)	Retained on IS sieve(mm)	Cumulative % retained	Passing %
	4.75	2.36	2.00	98.00
	2.36	1.18	21.20	78.88
	1.18	0.6	46.20	53.60
	0.6	0.3	63.14	33.68
	0.3	0.15	88.14	11.86

aggregate:

Specific gravity:

S.No	OBSERVATION	Weight(g)
1	Weight of pycnometer (W_1)	440
2	Weight of pycnometer + sand (W_2)	680
3	Weight of pycnometer + sand + water (W_3)	1100

4	Weight of pycnometer + water (W_4)	950
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Specific gravity of fine aggregate = $\frac{(W_2 - W_1)}{(W_2 - W_1) - (W_3 - W_4)}$

$$(W_2 - W_1) - (W_3 - W_4)$$

Sieve Analysis for Coarse Aggregate:

Mix proportioning of materials:

Mix ratio	Water	Cement	Fine aggregate	Coarse aggregate
Ferrocement slab	0.45	1	3	Nil
Conventional slab	0.45	1	1.42	3.10

Passing through IS sieve (mm)	Retained on IS sieve(mm)	Cumulative % retained	Passing %
20	12.5	100	100
12.5	10	7.5	92.50
10	4.75	30.01	69.99
4.75	Pan	90.45	9.55

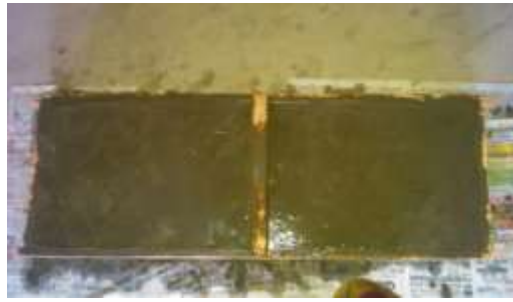
Casting of specimens:



Casting of ferrocement panel with wire mesh



Panels connected by shear connectors



Ferrocement slab

Demoulding and curing

The casted specimen should be left in the moulds for 24 hours. After that identification was marked on the exposed face of the specimens, the specimens were demoulded, and immediately placed under water for curing process. The specimens were allowed to cure under water for a period of 28 days.

Loading configuration

The slab was tested on a 50 ton loading frame. The experimental setup of the slab specimen supported on simply support at both the ends. Effective length of the slab was fixed as 800mm. Load was applied by means of a manually operated jack and it can be transmitted through the slab. In addition, Real-time measurement of the structural response was achieved using a dial gauge at various points. The curvature per unit length of the slab is obtained from the deflection value. The deflection measured by the dial gauge and load measured from the data logger were stored for further calculations. For monotonic loading the load was applied in load increments of 5KN until the ultimate load was reached. At each increment of loading, the reading in dial gauge was noted.

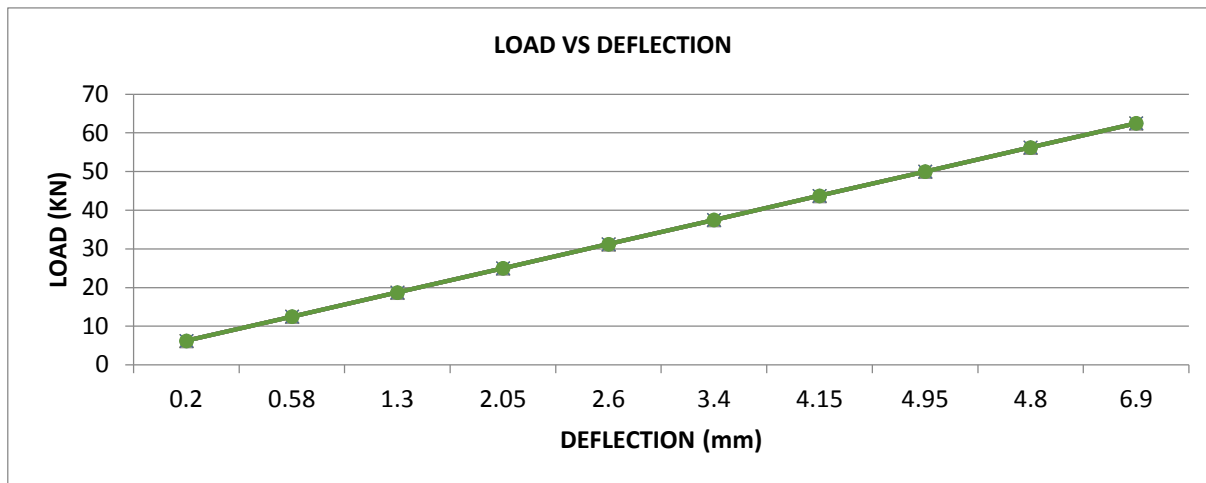
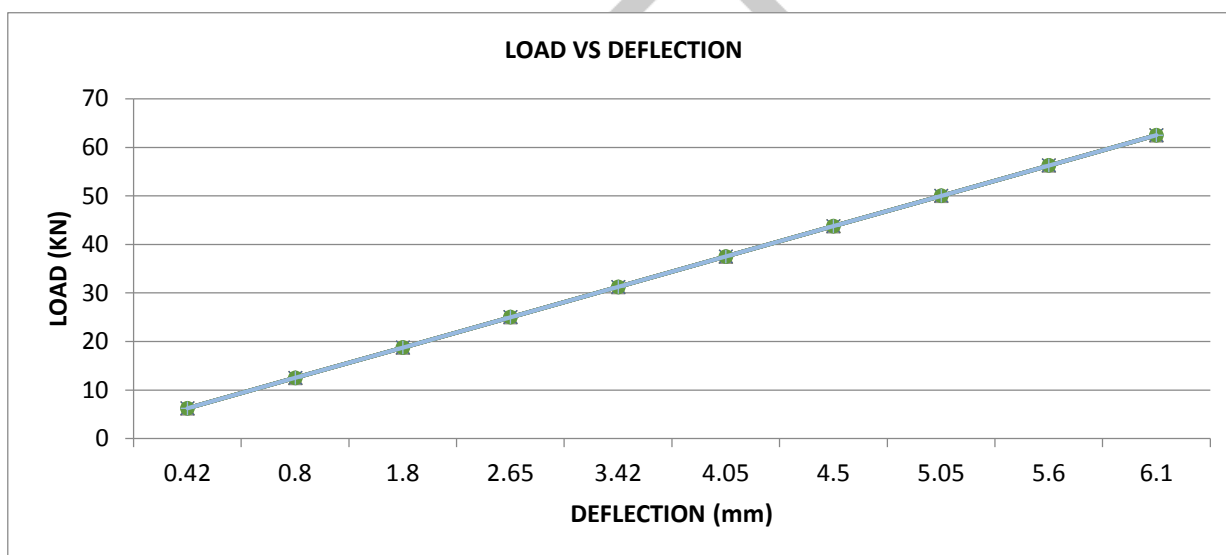
Testing of specimen

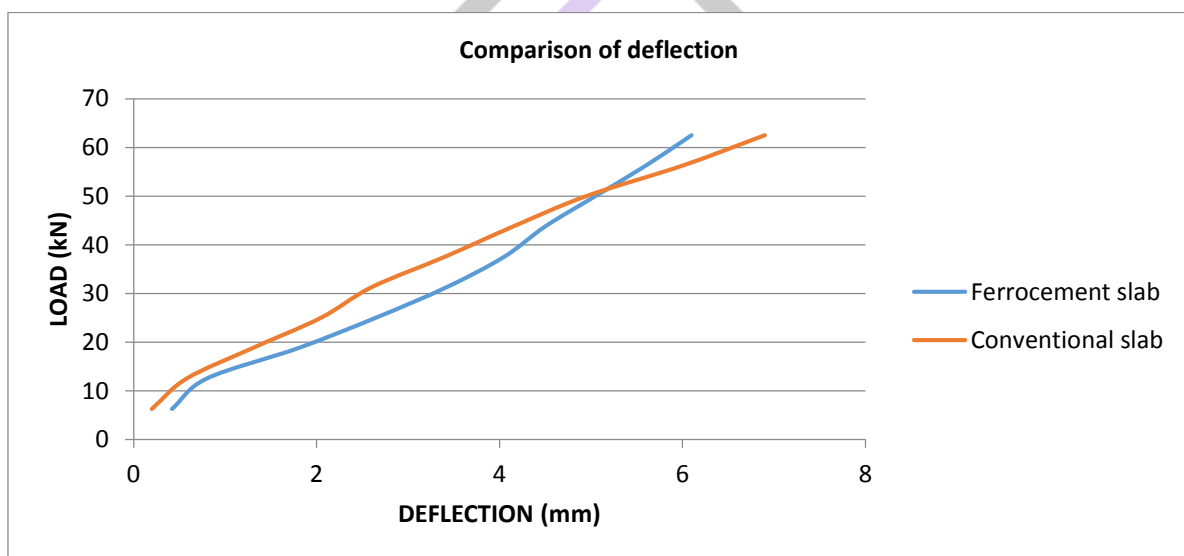
On the bottom face of the slab, the support position (800mm c/c) marked at a distance of 100mm from the edges were provided with two rollers placed in the loading frame. Multi dial indicator (range 0.01-20mm) was used for deflection measurement. They were supported on magnetic base resting the tip of the dial gauge at positions marked as 1,2,3,4,5& 6. Initial readings were taken at zero load positioning. Then the specimen is subjected to gradual loading by operating the lever of hydraulic jack and at suitable intervals, for different loads, the deflectometer readings noted. The formation of the first crack was carefully noted using a lens and the load at first crack was noted. The deflectometers were removed when the deflection was at the maximum capacity of the dial gauge or when the specimens were about to collapse. The loading was continued till collapse of the specimens and collapse load noted. The readings were tabulated. On each day of testing the slabs the cubes cast along with the same series of the slab from the same mortar were tested for its compressive strength.

Results and discussion

Load carrying capacity of specimens:

TYPES OF LOADING	LOAD CARRYING CAPACITY IN (N)	FLEXURAL STRENGTH (N/mm ²)
Two point Loading	4100	9.42
Centre point Loading	3000	6.89

Load vs Deflection curve for RCC slab**Load vs Deflection curve for composite slab****Specimen testing setup:**

After testing of slab:**Comparison of RCC Slab and ferrocement Composite Slab****Conclusion:**

This paper proves that reinforced concrete slabs with ferrocement tension zone cover is superior in crack control, stiffness and first crack moment to similar slabs with normal concrete cover. Construction costs with ferrocement cover will, of course, be higher. However, this could be greatly offset by sparing millions of pounds spent on repairing damaged structures caused by cracked or spalled normal concrete covers. Moreover, it allows existing conventional concrete materials and practices to be used. Further research work will be required to investigate the use of ferrocement cover for other applications, especially the use of deep covers, usually advocated in corrosive conditions, without giving rise to wide surface cracks. Within the range of the variables covered by the present study, the following conclusions may be drawn:

- The preliminary investigation reported in this study indicates that ferrocement cover can be successfully used for reinforced concrete slabs.
- Crack width of the tested reinforced concrete slabs was considerably narrowed by the use of ferrocement. Specimens with ferrocement cover showed higher stiffness and higher cracking moment than those with normal concrete cover. Deflection near service load was significantly reduced in the specimens with ferrocement cover.
- A improvement in the bending capacity of the specimens with ferrocement cover.
- Full composite action can be achieved by shear connector used to inter connect between the shear loading panel of ferrocement slab, then it increases the shear behaviour.

References:

- [1] J. Bednara, F. Walda, J. Vodickaa (2012) 'Membrane Action of Composite Fibre Concrete Slab in Fire' Prague, Vol. 42, No.5, pp.498-503.
- [2] R Ian Gilbert(2013) 'Time-Dependent Stiffness of Cracked Reinforced and Composite Concrete Slabs', International Conference on Modern Building Materials', Vol. 57, No.2, pp.19-34.

- [3] Wail N Al-Rifaie, Azad Ahmed (2013), 'Experimental Investigation on Thin Ferrocement Dome Structures', IJEAT, Vol. 3, No.2, pp.2249-8958.
- [4] Dr. T.Ch.Madhavi, ShanmukhaKavya .V, Siddhartha Das(2013), 'Composite Action of Ferrocement Slabs under Static and Cyclic Loading', IJCIET, Vol. 4, No.3, pp.57-62.
- [5] Bong, J.H.L and Ahmed, E(2010), 'Study the Structural behaviour of ferrocement beam', UNIMAS.
- [6] Dr. Abdulkader Ismail Abdulwahab Al-Hadithi and Zayd Abdul-Jabbar Al-Obaidi(2009), 'Behavior of Ferrocement Slabs Containing Waste Plastic Fibers under Impact Loadings', University of Anbar, Iraq.
- [7] Chee Ban Cheah, Mahyuddin Ramli (2013), 'The structural behaviour of HCWA ferrocement-reinforced concrete composite slabs', University Sains, Malaysia.
- [8] Milon K. Howlader, M.H. Rashid (2013), 'Effect of Saline Water on the Flexural Performance of Ferrocement Wall Panel', International Journal of Advanced Structures and Geotechnical Engineering, Vol. 2, No.2, pp.2319-5347.
- [9] Anisha G Krishnan, Allzi Abraham (2013), 'Experimental Study on the Effectiveness of Ferrocement as a Permanent Form Work for Beams', International Journal of Science and Research.
- [10] K. Shunmugapriya & P. Balamurugan (2018), "Bacteria Healing In Concrete Cracking" International Journal of Pure and Applied Mathematics, Volume 119 No. 16 2018, 1891-1902
- [11] Y. B. I. Shaheen, B. Eltaly and M. Kameel (2011), 'Experimental and analytical investigation of ferrocement water pipe', Minufiya University, Egypt.
- [12] S. Binil Sundar, U. Dhiyaanesh (2016), 'Study on Ferrocement Panels for Use in Secondary Roofing', IJRASET, Vol. 4, No.4, pp.2321-9653.
- [13] A. S. Alnuaimi, A. Hago & K. S. Al-Jabri (2011), 'Flexural behaviour of ferrocement roof panels', Sultan Qaboos University, Sultanate of Oman.
- [14] T. Subramani, R. Siva (2016), 'Experimental Study On Flexural And Impact Behavior Of Ferrocement Slabs', IJAIEEM, Vol. 5, No.5, pp.2319-4847.
- [15] Boshra Aboul-Anen, Ahmed El-Shafey and Mostafa El-Shami (2009), 'Experimental and Analytical Model of Ferrocement Slabs', International Journal of Recent Trends in Engineering, Vol. 1, No. 6, pp.45-56.
- [16] Swayambhu Bhalsing, Sayyed Shoaib, Pankaj Autade, (2014), 'Tensile Strength of Ferrocement with respect to Specific Surface', IJRSET, Vol. 3, No. 4, pp.2347-6710.

