# Generation of Strength Statistics for Concrete Beam with Alternative of Permanent Ferrocement form

Laxmikant A Doddamani
Department of Civil Engineering,
P.D.A. college of Engineering,
Gulbarga

Vaijanath Hallali
Department of Civil Engineering,
P. D. A. college of Engineering,
Gulbarga

***Abstract-*** **In this experimental work fourteen beams has been prepared under which two are controlled beams having dimension 120x260x1600mm and eight beams of total dimension 120x260x1600mm consisting of reinforced concrete core cast in 25mm U shaped permanent ferrocement forms and four beams of total dimension 120x260x1600mm consisting of light weight brick core built in 25mm U shaped permanent ferrocement form. Control beams were reinforced with two steel bars of 12mm diameter at top and two steel bars of 10mm diameter at bottom and stirrups of 8mm diameter placed at 200mm intervals. The beam incorporating permanent ferrocement form was reinforced with two steel bars of 12mm diameter placed at tension side of the beam without any stirrups. Two types of steel mesh were used welded and hexagonal wire mesh. Single and double layers of each mesh type were employed for concrete core specimens while single layer only was employed for light weight brick specimen. All the beams were tested under flexural loading using single point load method.**

***Keywords – Welded wire mesh, Hexagonal wire mesh, super plasticizer.***

IJERT

## 1. INTRODUCION

Ferrocement is one of the relatively new cementitious composite considered as a construction material. It is a type of thin walled reinforced concrete commonly consisting of cement mortar reinforced with closely spaced layers of continuous and relatively small wire mesh. The closely-spaced and uniformly-distributed reinforcement in ferrocement transforms the otherwise brittle material into a superior ductile composite. Thus, ferrocement technology is becoming more attractive to housing construction, particularly for roofs, floors, slabs and walls because of its relatively low cost, durability and weather resistance. Its versatility further increases its utility for producing prefabricated components required in housing. The fabrication technique of ferrocement is easy to learn and ferrocement structures, if properly built, are practically maintenance free. It has advantageous properties such as strength, toughness, water tightness, lightness, durability, fire resistance, and environmental stability which cannot be matched by any other thin construction material. The ferrocement is the promising composite material for prefabrication and industrialization of the building industry. Temporary wooden or steel formworks are used nowadays for most of concrete constructions.since the cost of such formworks is a critical issues in the construction industry, attention should be given to find alternative materials and technologies to replace current materials. [1] **Ezzat H Fahmy et.al** This paper describes the effect of the test parameters on the strength, stiffness, cracking behavior, and energy absorption properties of the tested beams was investigated. The results showed that high first crack, serviceability and ultimate loads, crack resistance control, and good energy absorption properties could be achieved by using the proposed permanent ferrocement forms compared with the conventional reinforced concrete beams. [2] **Z.R.Wadalawala et.al** This paper presents the potentials of Ferrocement in transforming brittle mode to ductile mode. The beams were loaded up to service load, de-loaded and strengthened prior to test up to failure. [3] **Mahmoud Abo El-Wafa and Kimio Fukuzawa.** This paper describes the structural behavior of lightweight ferrocement (LWF) sandwich composite beams is investigated byconducting flexural tests objective of the tudy is to investigate the comprehensive comparisons of eight beams represented in six lightweight ferrocement (LWF) beams and two reinforced concrete (RC) beams. [4] **Md Ihtesham Hussain et al.** This present study deals with the behavior of Ferro cement deep beams under central point load. A total of 27 rectangular deep beams have been casted of dimension 125 x 250mm and the lengths of beams have been varied along with the variation of wire mesh and mortar strength.

## 2. MATERIALS

*Cement:*

Ordinary Portland cement (53 grade) of ultratech brand manufactured from a single batch will be used throughout the course of project.

Table:1 Properties of cement

| S.No | Properties | Result |
|---|---|---|
| 1 | Specific gravity | 3.10 |
| 2 | Normal consistency | 32% |
| 3 | Initial setting time | 45 min |
| 4 | Final setting time | 210 min |

*Fine aggregate:*

The aggregate consists of well graded fine aggregate (shahpur sand) that passes a 4.75 mm sieve and salt-free source is used. The sand is selected from locally available river-beds and which is free from organic or other



(This work is licensed under a Creative Commons Attribution 4.0 International License.)

deleterious matter. The moisture content of the aggregate should be considered in the calculation of required water.

Table:2 Properties of fine aggregate

| Property | Result |
|---|---|
| Specific gravity | 2.61 |
| Bulk density(loose condition) | 1.48gm/cc |
| Bulk density(compacted condition) | 1.68gm/cc |

*Coarse Aggregate*

The crushed coarse aggregate of 20 mm & downsize rounded obtained from the local crushing plant is used in the present study.

**Table:3 Properties of fine aggregate**

| | |
|---|---|
| Specific gravity of C.A | 2.90 |
| Water absorption | 3.4% |

*Water*

Potable water will be used in the investigation for mixing and curing.

*Reinforcing Steel*

High tensile steel of 10mm & 12mm diameter is to be used for the reinforcing bars in the control beams and the core of the other groups and mild steel of 8mm diameter is to be used for the stirrups of the control beams.

*Super-plasticizer:* High range water-reducing admixture (HRWA) from Fosroc Chemicals India Limited, Bangalore of type Conplast SP-430 has been used.

*Reinforcing Wire Mesh:*

Wire mesh is one of the important constituents of ferrocement. This generally consists of thin wires depend upon the type, quantity and strength properties of the mesh reinforcement. High tensile steel welded wire mesh of 2.7mm in diameter and 40x30mm in spacing was used for reinforcing the ferrocement U-Shaped forms.

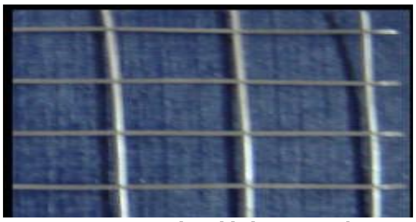

Fig 1. Steel Welded Wire Mesh

*Hexagonal wire mesh: Wire mesh*

Wire mesh is one of the important constituent of Ferrocement. This generally consists of thin wires. The mechanical properties of ferrocement depend upon the type, quantity and strength properties of mesh reinforcement. The different types of wire mesh Hexagonal wire mesh of 1.2mm diameter, square woven or welded mesh, expanded metal mesh lath etc. Except for expanded metal mesh, generally all the meshes use are galvanized.

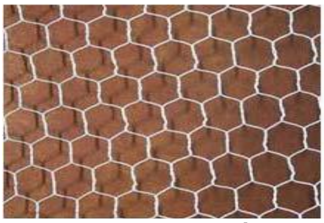

Fig 2. Hexagonal wire mesh

*Mix proportioning* The mix design was done as per Is:10262(2009). The grade of concrete adopted for this study is M30 grade and water cement ratio as 0.43 for concrete and mortar. The mix proportion for concrete is 1:1.949:3.53:0.43 and for mortar proportion 1:1.949:0.43.

## 3 EXPERIMENTAL PROGRAMME

The experimental program of this project is designed to investigate the feasibility and effectiveness of using U-shaped ferrocement laminates as permanent forms for reinforced concrete beams. The beams were divided into seven groups according to the layers of steel mesh and core material. Group number 1 is the control group which contained two beams in which the beams were cast using ordinary formwork and were reinforced with two steel bars of 12mm diameter at the tension side and two steel bars of 10mm diameter at the compression side as well as shear reinforcement (stirrups) of 8mm diameter @200mmc/c. For the group 2 single layer welded wire mesh and for group 3 double layer welded wire mesh is used, beams were cast in 25mm thick pre-cast U-shaped ferrocement forms. The concrete core of these groups was reinforced with two steel bars of 12mm diameter at the tension side. No reinforcing bars at the compression side or stirrups were used in these groups. For Groups 4 single layer welded wire mesh is provided and the concrete core was replaced by brick. Two steel bars of 12mm diameter were embedded in a thin layer of mortar at the tension side of the beam before building the brick core. The group 5 single layer hexagonal wire mesh and for group 6 double layer hexagonal wire mesh is used, beams were cast in 25mm thick pre-cast U-shaped ferrocement forms. The concrete core of these groups was reinforced with two steel bars of 12mm diameter at the tension side. No reinforcing bars at the compression side or stirrups were used in these groups. For Groups 7 single layer welded wire mesh is provided and the concrete core was replaced by brick. Two steel bars of 12mm diameter were embedded in a thin layer of mortar at the tension side of the beam before building the brick core.

IJERT


(This work is licensed under a Creative Commons Attribution 4.0 International License.)

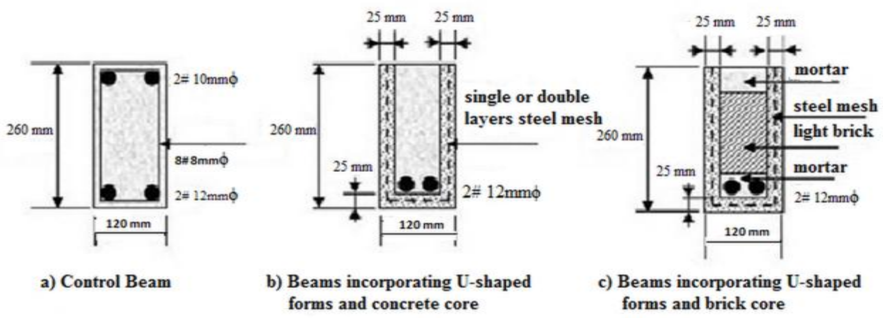


Fig 3. Cross section of test specimens

Table:4 Details of test specimen

| Designation of beam | Type Of mesh | Tension | Compression | stirrups | Type of core material | Total weight of steel reinforcement (kg) |
|---|---|---|---|---|---|---|
| $C_1$, $C_2$ | - | 2# 12mmΦ | 2# 10mmΦ | 8# 8mmΦ | - | 9.00 |
| Wsc1,Wsc2 | Wwm(single Layer) | 2# 12mmΦ | - | - | concrete | 4.90 |
| Wdc1,Wdc2 | Wwm(double layer) | 2# 12mmΦ | - | - | concrete | 7.40 |
| Wsb1,Wsb2 | Wwm(single Layer) | 2# 12mmΦ | - | - | brick | 4.90 |
| Hsc1,Hsc2 | Hwm(single Layer) | 2# 12mmΦ | - | - | concrete | 4.20 |
| Hdc1,Hdc2 | Hwm(double layer) | 2# 12mmΦ | - | | concrete | 6.00 |
| Hsb1,Hsb2 | Hwm(single Layer) | 2# 12mmΦ | | | brick | 4.20 |

IJERT

## 4. PREPARATION OF TEST SPECIMENS

The casting process could be summarized as follows:

1. The wooden mould was assembled and the reinforcing steel mesh was formed in a U-shaped form and placed in each vent of the mould. The constituents of the mortar were mixed and cast in each vent to the required thickness of 25mm as shown in Figure 4.1.
2. Wooden pans were placed on top of the cast ferrocement layer and the sides of the ferrocement forms were cast around the wooden pans in each vent of the steel mould as shown in Figure 4.2.
3. The ferrocement forms were left for 24 hours in the mould before de-assembling the mould. At the end of this step, two U- shaped ferrocement forms are produced as shown in Figure 4.2.

Fig 4.1 Laying of steel mesh in the mould

Fig 4.2 Casting and form of U-shaped Ferrocement beam

## 5. TESTING OF SPECIMENS

The specimen was laid on a loading frame, where the test was conducted under single point load system.The specimen was centered on the testing machine. A dial gauge with accuracy of 0.01 mm was placed under the specimen at the center to measure the deflection versus load. Load was applied at 2kN increments on the specimen exactly at the center. Concurrently, the beam deflection was determined by recording the dial gauge reading at each load increment. Cracks were traced throughout the sides of the specimen. The first crack-load of each specimen was recorded. The load was increased till the complete failure of the specimen is reached.

Crack Pattern of Various Beams

Fig 5.1 Control Beam 1

Fig 5.2 Control Beam 2


(This work is licensed under a Creative Commons Attribution 4.0 International License.)

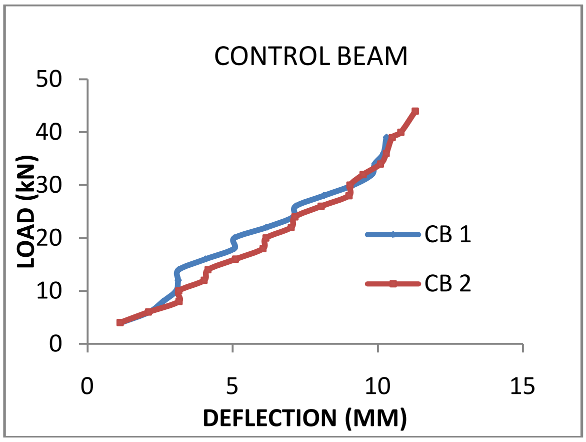


Fig 5.3 load v/s deflection curve for Control Beams

Fig 6.1 Beam - Wsc1 (Single layered welded wire mesh with concrete core)

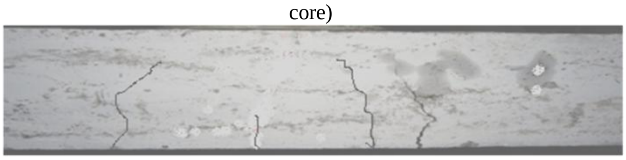

Fig 6.2 Beam – Wsc2 (Single layered welded wire mesh with concrete core)

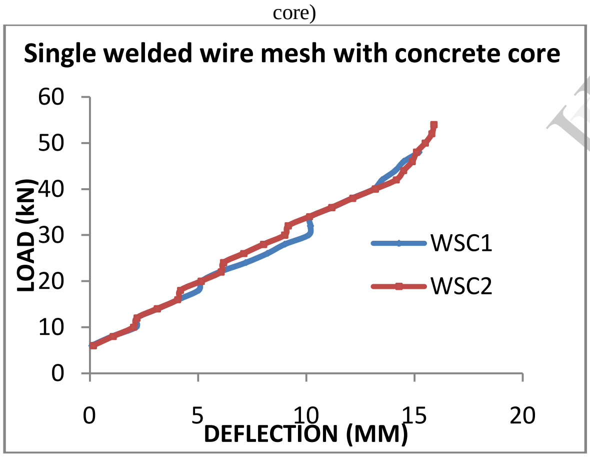


Fig 6.3 load v/s deflection curve for single layered welded wire mesh Beams

Fig 7.1 Beam - Wdc1 (Double layered welded wire mesh with concrete core)

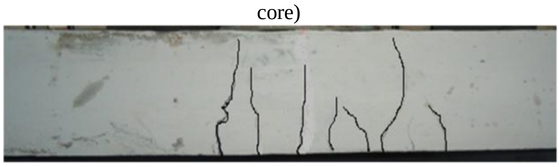

Fig 7.2 Beam – Wdc2 (Double layered welded wire mesh with concrete core)

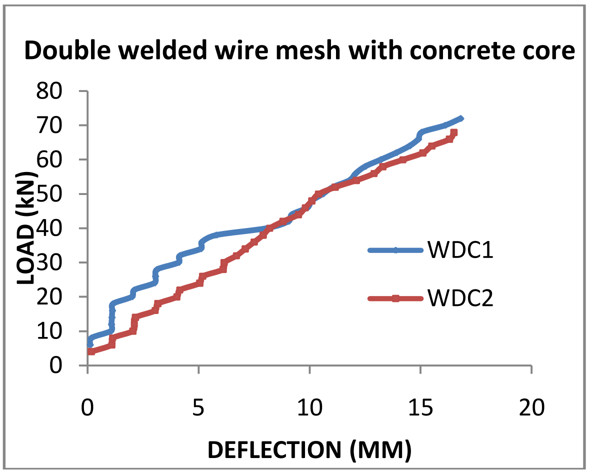


Fig 7.3 load v/s deflection curve for double layered welded wire mesh Beams

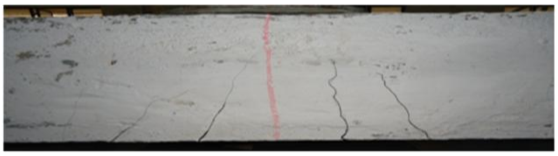

Fig 8.1 Beam - Wsb1 (Single layered welded wire mesh with brick core)

**Fig 8.2 Beam – Wsb2 (Single layered welded wire mesh with brick core)**

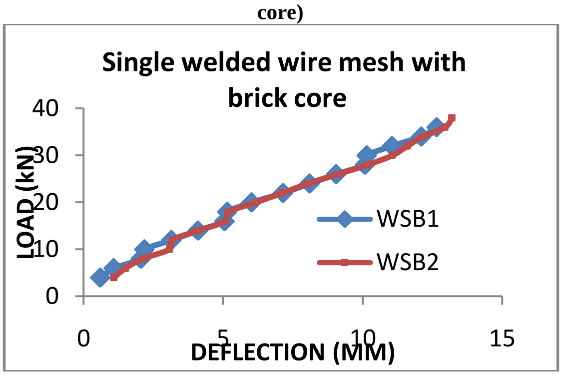


Fig 8.3 load v/s deflection curve for single layered welded wire mesh Beams

Fig 9.1 BEAM - Hsc1 (Single layered Hexagonal wire mesh with concrete core)

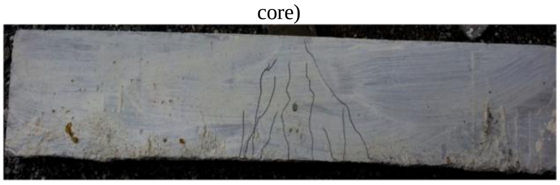

Fig 9.2 BEAM – Hsc2 (Single layered Hexagonal wire mesh with concrete core)

IJERT



(This work is licensed under a Creative Commons Attribution 4.0 International License.)

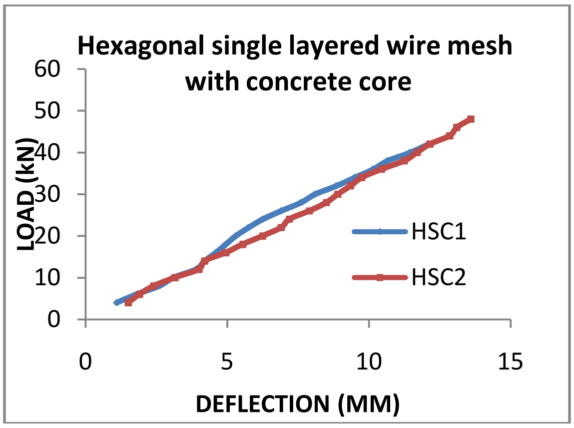


Fig 9.3 load v/s deflection curve for single layered Hexagonal wire mesh Beams

Fig 10.1 BEAM - Hdc1 (Double layered Hexagonal wire mesh with concrete core)

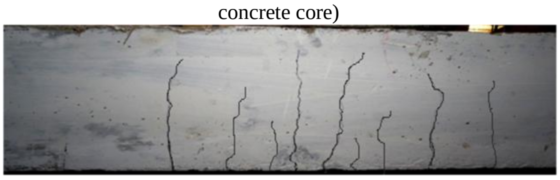

**Fig 10.2 BEAM – Hdc2 (Double layered Hexagonal wire mesh with concrete core)**

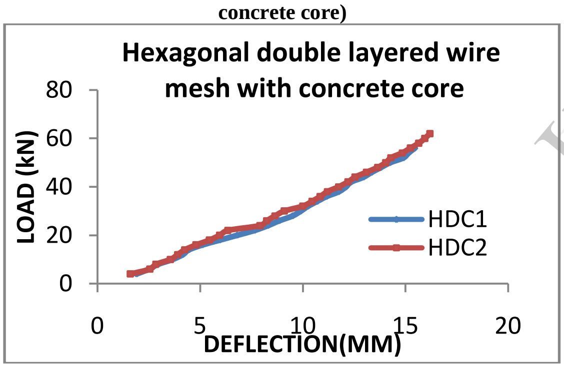


Fig 10.3 load v/s deflection curve for double layered welded wire mesh Beams

Fig 11.1 Beam - Hsb1 (Single layered Hexagonal wire mesh with brick core)

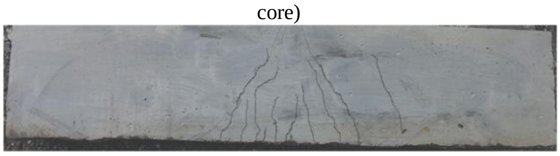

Fig 11.2 Beam – Hsb2 (Single layered Hexagonal wire mesh with brick core)

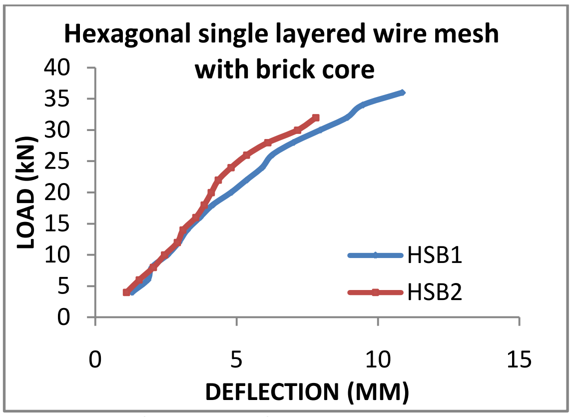


Fig 11.3 load v/s deflection curve for single layered Hexagonal wire mesh Beams

The load-deflection curves for the tested beams are shown in figure above.

Stage-I: The load-deflection relationship is linear (Steepest Slope) before the cracking of the mortar. Stage-II:The end of the linearity of the curve marked the beginning of cracking as indicated by the deviation from the load-deflection relationship corresponding to the load increment. This shows a little flatter slope. Stage-III: Finally in this stage, as the ultimate load is reached the cracks gets widened and the curve became almost parallel the deflection axis. At this stage the failure of specimen is clearly visible.

From The above fig it has been observed that the maximum load obtained for wdc1 (double layered welded wire mesh) of 72kN at a deflection of 16.8 mm as compared to CB2(control beam)has a load of 46 kN at a deflection of 11.30mm,wsc2 (single layered welded wire mesh with concrete core) of 54 kN at a deflection of 15.90 mm & wsb2 (single layered welded wire mesh with brick core)has a load of 38 kN at a deflection of 16.20mm.

From the above fig it has been observed that the double layered hexagonal wire mesh with concrete core has a maximum load of 62 kN at a deflection of 16.2mm,as compared to Hsc2(single layered hexagonal wire mesh with concrete core) has a load of 48 kN at a deflection of 13.20mm, Hsb1(single layered hexagonal wire mesh with brick core) has a load of 36 kN at a deflection of 10.85 mm.

IJERT

## 6. CONCLUSIONS

1. U-shape ferrocement beam demonstrate excellent crack control characteristics.
2. Great saving in the total weight of steel reinforcement ranging from 17.7% to 53.3% could be achieved by employing permanent ferrocement forms depending upon the type of steel mesh and number of steel layers.
3. The beams incorporating permanent ferrocement forms with welded wire mesh has an increment in percentage of average ultimate load is 19.30% and saving in total weight of steel reinforcement is 36.29% as compared to that of control beams.
4. The beams incorporating permanent ferrocement forms with hexagonal wire mesh has an increment in percentage of average ultimate load is 7.60% and saving in total


(This work is licensed under a Creative Commons Attribution 4.0 International License.)

weight of steel reinforcement is 46.66% as as compared to that of control beams.

5. The beams with light weight brick core achieved higher ultimate load of 48kN when welded wire mesh was employed and lower ultimate load 36kN when hexagonal wire mesh was used.

6. The great saving in economy could be achieved by using hexagonal single layered wire mesh has higher ultimate load 45kN and saving in weight of reinforcement is about 53.33% as compared to that of control beam have a ultimate load of 42.5kN,where shear reinforcement is used.

7. The thin u shape ferrocement forms could be used as permanent forms for beams in concrete construction as an alternative to the commonly used wooden or steel forms.

8. The u shape ferrocement forms can be used as an pre-cast element.

## 7.REFERENCES

[1] Ezzat H Fahmy, Mohamed N AbouZeid, Yousry B Shaheen, Ahmed A 30th Conference on our world in concrete & structures:2324August 2005,Singapore. Article Online Id:100030029.

[2] S.F.A Rafeeq , S.H Lodi and Z.R wadalawala "Behaviour of reinforced concrete beams strengthed in shear" Journal of ferrocement vol(35). No(1) January 2005.

[3] Mahmoud Abo El-Wafa, Kimio Fukuzawa "Flexural Behavior of Lightweight Ferrocement Sandwich Composite Beams" Journal of science and technology vol(15). No(1) 2010.

[4] Md Ihtesham Hussain,Vaijanath Halhalli, P.M.B Raj kiran Nanduri "Shear and Flexural Behavior Of Ferro Cement Deep Beams" international journal of research engg and technology technology eissn:2319-1163 ,(2013).

[5] S.P Shang,L.o Zeng,H.Peng "Flexural Strengthing of Reinforced concrete beam with Ferrocement " Singapore Concrete institute, Article online Id: 100028056. August (2003).

[6] Yousry B.I. Shaheen, Noha M. Soliman, Ashwaq M. Hafiz "Structural Behaviour of Ferrocement channels Beams" concrete research letter Vol. 4 (3) –Sept. 2013.

[7] M.A Mansur and P.Paramasivam ."Cracking Behaviour and Ultimate Strength of Ferrocement in Flexure" Journal of Ferrocement : Vol. 16, No.4,October(1986).

IJERT



(This work is licensed under a Creative Commons Attribution 4.0 International License.)