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The design and study of structural behaviour of figer jetty in royapuram fishing harbor at Ennore port

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INTRODUCTION

1.1 GENERAL

The concept of reinforced mortar by closely spaced fine wire mesh was used for boat building construction by Lambot in 1849.Subsequentl in 1940's; Nervi promoted the use of ferrocement in civil engineering structures. Since then ferrocement has been studied extensively by various research group and gained wide acceptance only in 1960's.There has been wide spreaduse of ferrocement applications in agriculture and housing throughout the world including North and south America, east European and Asia-pacific countries. Ferrocement is a cementitous thin-wall composite structural material comprising of cement mortar matrix uniformly distributed throughout its cross section. The uniform distribution and dispersion of reinforcement in ferrocement composite provide better cracking characteristic high tensile strength, ductility and impact resistance. Ferrocement has high tensile strength to weight ratio and superior cracking behaviour in comparison with conventional reinforced concrete. Hence it is an attractive material for thin wall structure.

1.2 MATERIAL

The properties and types of constituent materials used in ferrocement construction are shown in table1.1. Although meshes of glass and vegetable fibres have been used the most common form involves steel and it is this type that is described in this paper. The cement mortar matrix should be designed for appropriate strength and maximum denseness and impermeability, with sufficient workability to minimize voids. The use of sharp fine grade sand as aggregate together with ordinary Portland cement is generally adequate, despite the low covers employed. This is due to comparatively high cement content in mortar matrix.

Table 1.1: Properties and type of constituents

MATERIALS	RANGE
WIRE MESH:	
Diameter of wire (Φ)	$0.5 \leq \Phi \leq 1.5$mm
Type of mesh	chicken wire or square woven or welded galvanized mesh or expanded metal
Size of mesh opening(S)	$6 \leq S \leq 25$mm
Volume fraction (V_R) of reinforcement	$2\% \leq V_R \leq 8\%$ in both directions.
Specific surface (S_R) of reinforcement	$0. \leq S_R \leq 0.4\%$mm²/mm³ in bothdirections
Elastic modulus (E_R)	140 - 200 N/mm²
Yield strength (σ_{Ry})	250 - 460 N/mm²
Ultimate tensile strength (σ_{Ru})	400 - 600 N/mm²
SKELETAL METAL:	
Type	Welded mesh, steel bars, strands.
Diameter (d)	$3mm \leq d \leq 10mm$
Grid size (G)	$50mm \leq G \leq 200mm$
Yield strength	250 - 460 N/mm²
Ultimate tensile strength	400 - 600 N/mm²
MORTAR COMPOSITION:	
Cement	any type of Portland cement(depending upon application)
Sand to cement ratio(S/C)	$1 \leq S/C \leq 3$ by weight
Water cement ratio(W/C)	$0.35 \leq W/C \leq 0.65$ by weight
Gradation of sand 10%passing150 micro meter BS test sieve	5mm to dust with no more than

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1.3 Polymer-Modified Concrete and Mortars

Modification of cement mortar and concrete by small amounts of water-soluble polymers such as cellulose derivatives and polyvinyl alcohol is used popularly for improving workability. In this case, the water-soluble polymers are mixed with the mortar and concrete as powders or aqueous solutions, and act as plasticizers because of their surface activity.In Japan, polymer-modified mortar is most widely used as a construction material for finishing and repair work, but polymer-modified concrete is seldom employed because of a poor cost-performance balance. However, the polymer-modified concrete is widely used for bridge deck overlays and patching work in U.S. In Particular, it is estimated that each year over 1.2 million m2 of bridge decks are overlaid with the polymer-modified concrete. In recent years, about 60,300 m3 of the polymer-modified concrete has been placed each year on both new and existing deteriorated concrete structures in U.S. lists the main projects that have used SBR-modified concretes as overlays on bridge decks in U.S. for the past 20 years. Because the rapid deterioration of reinforced concrete structures has become a serious problem in Japan, a strong interest is focused on polymer-modified mortar and paste as repair materials, and there is a growing demand for them. Thus the polymer-modified mortars and concretes are currently becoming low cost, promising materials for preventing chloride induced corrosion and repairing damaged reinforced concrete structures. In the practical applications the potential importance of property mismatch between repair materials and the reinforced concrete substrates has been highlighted.

1.4 Principles of latex modification

Latex modification of cement mortar and concrete is governed by both cement hydration and polymer film formation processes in their binder phase. The cement hydration process generally precedes the polymer formation process. In due course, a co-matrix phase is formed by both cement hydration and polymer film formation processes. It is important to understand the mechanism of the co-matrix phase formation.

Table 1.2MATERIAL PROPERITIES OF POLYMER LATEX (SBR)

PROPERITIES	SBR
Colour	White liquid
Odour	Slight
PH	8.5 -11
Water Solubility	Soluble
Relative density (g/cm^{3})	1.025
Solids content (%)	46.5 -49.5
Particle size	0.15µm

1.5 Mechanism of Polymer-Cement Co-matrix Formation

It is believed that a co-matrix phase which consists for cement gel and polymer films is generally formed as a binder according to a three steps simplified model shown in figure. It has recently investigated the microstructures and composite mechanism of the latex-modified pastes and mortars, and found the interfacial layer of cement hydrates with large amount of polymer particles on the aggregates and cement particles. As a result, both the particle dispersion of the polymer and the formation of polymer films are necessary for explaining the composite mechanism of latex-modified systems

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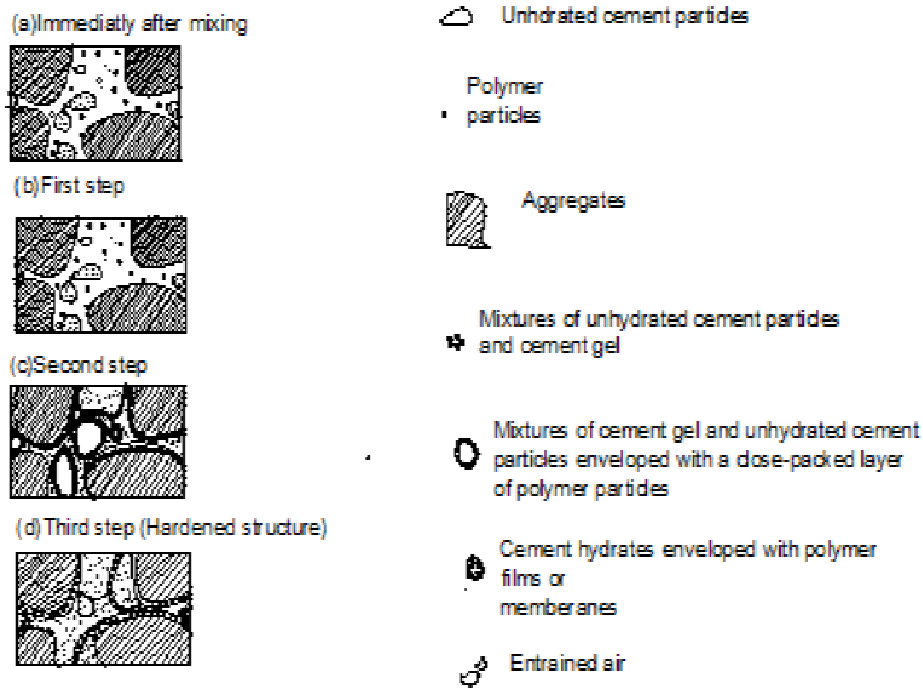

Fig 1.1 Simplified model of formation of polymer –cement co -matrix

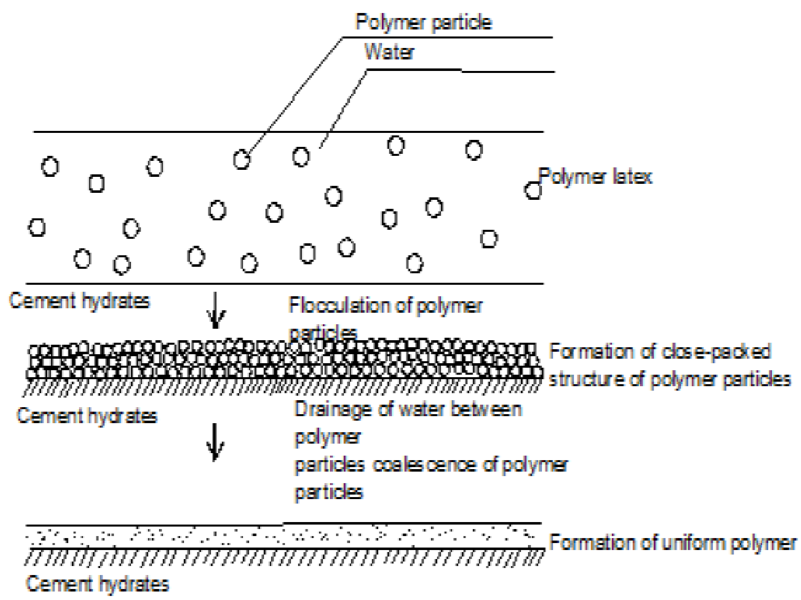

Fig 1.2 Simplified model of process of polymer film Formation on cement hydrates.

1.6 Properties of Latex-Modified Systems

Properties of fresh mortar and concrete:

Workability

Generally, latex-modified mortar and concrete provide a good workability over conventional cement mortar and concrete. This is mainly interpreted in terms of improved consistency due to the ball bearing action of polymer particles and entrained air and the dispersing effect of surfaces in the latexes. It is proved by zeta-potential determination and cryo-scanning electron microscopy that the improved consistency or fluidity is due to the ball bearing action of the polymer particles, cement particles

Air Entrainment

In most latex-modified mortar and concrete, a large quantity of air is entrained compare to that in ordinary cement mortar and concrete because of an action of the surfaces contain as emulsifiers and stabilizers in polymer latexes. An excessive amount of entrained air causes a reduction in strength and must be controlled by using proper antifoaming agents. Recent commercial latexes for cement modifiers usually contain proper antifoaming agents and the air entrainment is considerably decreased. Consequently, the air content of most latex-modified mortars is in the range of a 5 to 20%, and that of most latex-modified concrete is less than 2%, much the same as ordinary cement concrete. Such decreased air content of the latex-modified concrete over the latex-modified mortars is probably explain by the fact that air is hard to entrain in the concrete because of the larger size of aggregate used.

Water Retention

Latex-modified mortar and concrete have a markedly improved water retention over ordinary cement mortar and concrete. The water retention is dependent on the polymer-cement ratio. The reasons for this can probably be explain in terms of the hydrophilic colloidal properties of latexes themselves and the water evaporation due to the filling and sealing effects of impermeable polymer films formed. Accordingly a sufficient amount of water required for cement hydration is held in the mortar and concrete and, for most latex-modified systems, dry cure is preferable to wet or water cure.

Bleeding and segregation

In contrast to ordinary cement mortar and concrete, which are apt to cause bleeding and segregation the resistance of latex-modified mortar and concrete to bleeding and segregation excellent in spite of their larger flowability characteristics. This is due to the hydrophilic colloidal properties of latexes themselves and the air-entraining and water-reducing effects of the surfaces contain in the latexes. Accordingly in the latex-modified system, some disadvantages such as reduction in strengths and waterproofness caused by bleeding and segregation do not exist.

5. SettingBehaviour

In general, the setting of latex-modified mortar and concrete is delayed to some extent in comparison with ordinary cement mortar and concrete and this trend is dependent on the polymer type and polymer-cement ratio.

1.7PROPERTIES OF HARDENED MORTAR AND CONCRETE

Strength
Effect of the nature of the material
Effects of control factures for mix proportions
Effects of sand-cement ratio
Effects of curing conditions
Stress-strain relationship, modules of elasticity and ductility
Shrinkage, creep and thermal expansion
Waterproofness and water resistance
Adhesion or bond strength
Impact resistance
Abrasion resistance
Chemical resistance
Temperature effect, Thermal resistance and Incombustibility
Bore size distribution, resistance to chloride ion penetration, carbonation and oxygen diffusion
Frost resistance and weatherability.

1.8Applications

Various polymer-modified mortar and concrete, latex-modified mortar and concrete have superior properties, such as high tensile and flexural strengths, excellent adhesion, high waterproofness, high abrasion resistance, and good chemical resistance, compared to ordinary cement mortar and concrete.

Accordingly, they are widely used in many specialized applications in which the ordinary cement mortar and concrete have been employed to a lesser extent till now.

In these applications, the latex-modified mortar is widely used rather than the latex-modified concrete from the viewpoint of a balance between their performance and cost.

LITERATURE REVIEW

2.1 Properities Of Latex Ferrocement In Flexure

Fahrizal Zulkarnain1, Mohd. Zailan Suleiman

This paper discusses the durability study of polymer-modified ferrocement in comparison with conventional ferrocement particularly when exposed to severe environmental conditions. The development of strength, deformability and fracture properties were slightly different from conventional ferrocement. Test result indicates a significant improvement in reducing and bridging micro cracks, especially in the prepeak load region. Fracture toughness and deformability increased significantly. However, the post peak behavior was quite similar to conventional ferrocement.

2.2 Study on Flexural Behavior of Ferrocement Slabs Reinforced with PVC-coated Weld Mesh

P.B. Sakthivel and A. Jagannathan

The authors of this experimental research work have made an attempt to experimentally investigate the ultimate flexural load of ferrocement slabs of size 700mm. X 200mm. X 15mm. (thickness) reinforced with PVC coated steel weld mesh, and compare the results with slabs using GI-coated steel weld mesh, by varying the number of layers from 1-3. Ordinary Portland Cement, locally available river sand and potable water have been used in preparation of cement mortar, and the sand-cement ratio of 2:1 and water-cement ratio of 0.43 have been used in accordance with ACI codes. The flexural strength of ferrocement slabs was determined on four-point loading using a specially fabricated flexure loading frame. The flexural load, maximum deflection, crack-pattern and crack-width of ferrocement slabs reinforced have been analyzed using varying PVC and GI coated weld mesh layers (1-3). Increasing the number of mesh layers from 1-3 caused a substantial increase in flexural load as well as improvement in ductility behavior of ferrocement slabs. It was also found that the flexural load of slabs with PVC-coated weld mesh is 90% that of specimens reinforced with GI-coated weld mesh, and therefore, PVC-
coated weld mesh can be effectively used in ferrocement slabs, as non-corrosive reinforcement.

2.3 Performances of SBR Latex Modified Ferrocement for Repairing Reinforced Concrete Beams

D.Rajkumar, B.Vidivelli

The use of ferrocement is a promising technology for increasing the flexural strength of
Deficient reinforced concrete members. The study reported herein investigates the mechanical properties of mortar through difference in polymer content and also by ferrocement with three different volume fractions of mesh reinforcement incorporated by Styrene Butadiene Rubber Latex. Consequently in order to exercise proper quality control from materials point of view, the ferrocement specimens being
Intended from Ferrocement Model Code and in addition to that the results were checked through the limitations of relevant code. Eight full-size beams, (two control beams and
six strengthened beams) tested with different loading conditions and the variables were examined through the flexural test of the rehabilitated beams by the methods of attachment of mesh among various volume fractions with the influence of polymer modification on the properties of cement mortar. Performance of the tested
Beams and modes of failure are presented and discussed in this paper. The test results confirm that polymer modified ferrocement laminates can be used to significantly increase the flexural capacity of RC beams, with efficiency that varies depending on the tested variables.

APPLICATIONS

Innovative Applications of Ferrocement Element
A few applications are mentioned in brief below

3.1. Sunscreens

The reinforced concrete blocks used in today's world for the purpose of serving as sunscreens are generally too bulky and heavy for long spans more than 3 metre and also cumbersome connection details for precast construction. A number of alternate designs using lightweight materials such as glass fibre reinforced concrete, aluminium and ferrocement were carefully assessed and compared with conventional reinforced concrete. The advantages of using a ferrocement sunscreen is that it has ease of handling and erection, architectural requirements, durability and overall cost led to the choice of ferrocement. Generally inverted L-shaped sunscreen modules of length 2.7m are proposed with bolted connections.

3.2. Secondary Roofing Slabs

These are used on the roof tops of buildings to insulate against intense heat. Their components include precast cellular concrete slabs containing a centrally placed layer of a galvanized welded wire mesh. The dimensions of the welded mesh and the number of layers used, the mixed ratio of the mortar are the critical points on which the design is dependent. If in case the thickness is reduced the dead weight of the ferrocement slabs remains the same as that of cellular concrete slabs

3.3. Water Tanks

The scarcity of water for drinking and washing is met mainly from rain water. The storage of rain water is done through water tanks using unskilled labours. Steel tanks are comparatively much costlier and rust during times of bad weathers and hence reduce their life span. Ferrocement constructions being of low level technology but labour intensive, is ideally suitable for water tanks in ruralareas.

3.4. Strengthening of RC Beams using Ferrocement Laminates:

The need to repair and strengthen concrete structural elements are commonly reported due to over loading, structural alterations, poor workmanship and non-compliances of standards. The performances of the strengthened beams were compared to the control beams with respect to cracking, deflection and ultimate strength. The results show that the strengthened beams exhibited higher ultimate strengths, greater stiffness and reduced crack widths and spacing. The use of ferrocement in repair is relatively new .the material is ideally suitable due to its ability to arrest crack and high tensile strength -to-weight ratio.

SCOPE AND METHODOLOGY

4.1 SCOPE

Flexural and impact behaviour of polymer modified ferrocement slab , mainly describes about flexural and impact behaviour of the slab at various loading conditions with standard materials.
We have chosen PPC, River sand, square welded mesh, latex as a standard materials for our study and experimental work.To determine the flexural and impact behaviour of the polymer modified ferrocement slab the flexural test and impact test has been done.
The method of testing adopted for flexural behaviour of ferrocement slab is 4 point load method using universal testing machine.

From the flexural test we can obtain the toughness and flexural strength of the polymer modified ferrocement slab.Impact test conducted on slabs shows the resistance offered of polymer modified ferrocement slabs.
Further flexural and impact test of ferrocement slab will provide details on ductility and energy properties of the polymer modified ferrocement slab.
The same test has been carried out with conventional ferrocement slabs and thus the value obtained has been compared with those obtained data's of polymer modified ferrocement slab .
Finally after comparing the flexural strength and impact resistance between the conventional ferrocement slab and polymer modified ferrocement slab we are able to say that polymer modified ferrocement slab has more flexural and impact resistance than conventional ferrocement slab.

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4.2 MATERIALS SPECIFICATION

4.2.1 Cement:

Portland Pozzolanic Cement (PPC, Fly ash based) of grade 53 was used throughout the project. The cement conforms to the IS 1489:1991 (part 1) code. The cement was manufactured in the month of February,2013. The initial setting time of cement as specified by the manufacturer was 30 minutes.

4.2.2Fine aggregate:

Ordinary river sand passing through sieve of size 2.36 mm was used for this project. The sand was ensured that it was dry. The fineness modulus of sand is 2.68.

4.2.3Mortar:

Compressive strength is the capacity of a material or structure to withstand axially directed forces pushing forces. When the limit of compressive strength is reached, materials are crushed.

Compressive strength is usually measured on an Universal Testing Machine. Measurements of compressive strength are affected by the specific test method and conditions of measurement. Compression test is the most common test conducted on concrete and mortar, partly because it is an easy test to perform and also because most of the desirable properties of concrete are related to its compressive strength. The following procedure has been adopted for the compression test of mortar. Cube specimens of size 70 mm x 70 mm x 70 mm are cast and cured for 3 days, 7 days and 28 days. For each day of testing, 3 cubes are casted. The cured samples are placed in the Universal Testing Machine, loaded up to failure and corresponding compression load is noted. For each compressive load, the compressive strength is calculated as follows

$$\text{Compressive Strength} = \frac{\text{Compressive load in KN}}{\text{Loaded area of the specimen}}$$

The mix proportions were used to find the variation in properties of the Ferro cement slab with respect to mortar strength. The water to cement content ratio was decided based upon the workability of the trial mix. The Table show the mix proportions of the mortar mix

Table 4.1 Mix proportions and Water – Cement ratio

Sl.No	Batch	Materials		
		Cement	Sand	W/C Ratio
1	CementMortar	1	2	0.43
2	P.M.Cementmortar	1	2	0.43

4.2.3.1CEMENT MORTAR CUBE

The details of specimens and ultimate load of individual specimens of cement mortar cube are tabulated in Table 3.2. The average compressive strength and the strength development curve are given in Table 3.3 and graph 3.1. The averagecompressive strength of 3, 7 and 28 days are 8.91,11.46 and 18.57 N/mm^2 respectively

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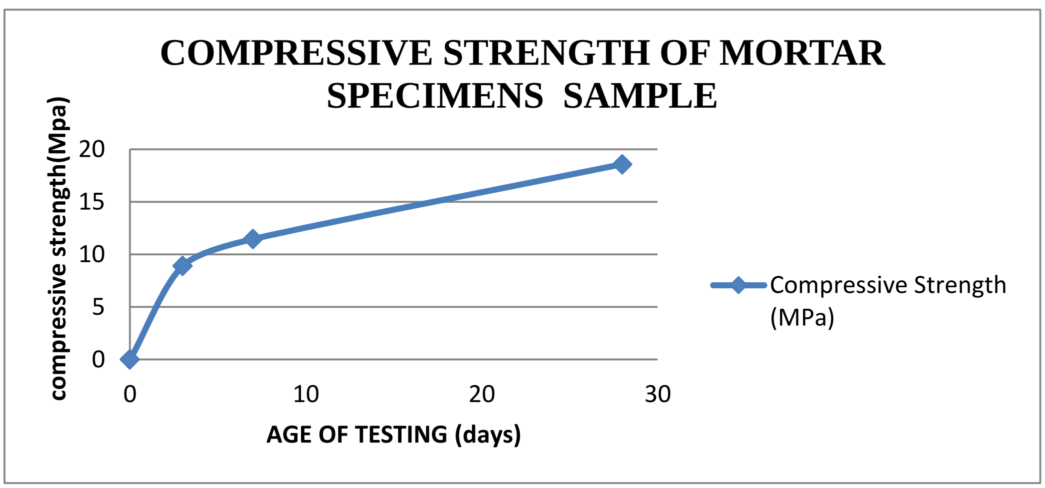
Table 4.2: Ultimate Load of mortar specimens of Batch

Mortar Cube - 3 Days - 07/02/2012				
Specimen	C-4	C-6	C-8	Average
Weight (grams)	760	743	772	758.33
Ultimate Load (kN)	44	41	48	44.33
Mortar Cube - 7 Days - 11/02/2013				
Weight (grams)	720	746	782	749.33
Ultimate Load (kN)	49	48	74	57
Mortar Cube - 28 Days - 04/03/2013				
Weight (grams)	789	763	762	771.33
Ultimate Load (kN)	132.8	52	92.12	92.30

Table 4.3 **Compressive Strength of cement mortar specimens**

Sl.No	**AGE OF TESTIN G (Days)**	**Compressive Strength** (MPa)
1	**0**	**0.00**
2	**3**	**8.91**
3	**7**	**11.46**
4	**28**	**18.57**



Graph 4.1: Compressive Strength Development Curve for Cement Mortar

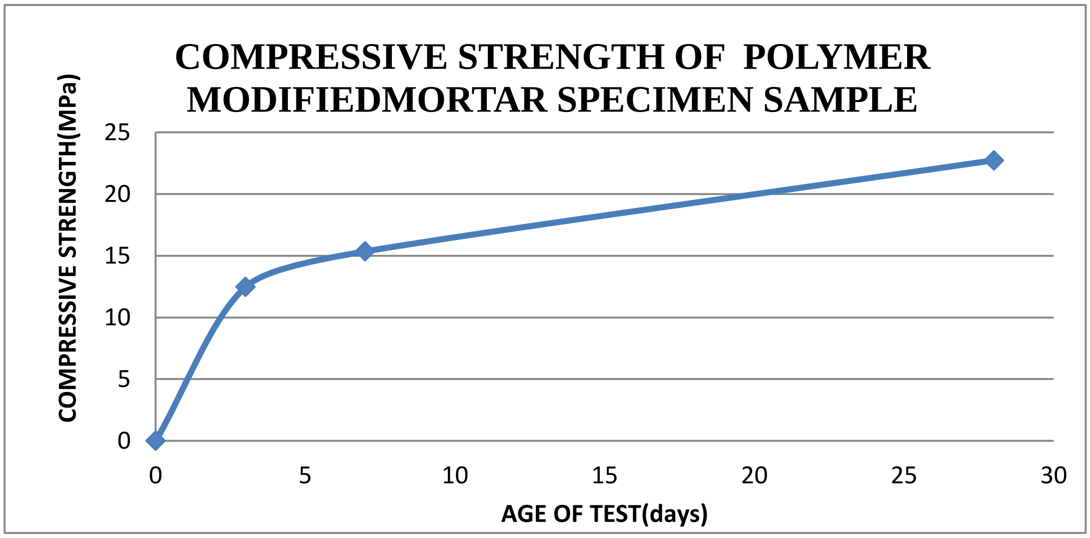
4.2.3.2 POLYMER MODIFIED CEMENT MORTAR SPECIMENS
The details of specimens and ultimate load of individual specimens of Batch B are tabulated in Table 3.4

Table 4.4 : Ultimate load of polymer modified cement mortar specimens

Polymer modified cement Mortar Cube - 3 Days - 09/03/2013				
Specimen	L-4	L-6	L-8	Average
Weight (grams)	742	760	770	758.00
Ultimate Load (KN)	52	61	72	61.66
Polymer modified cement Mortar Cube - 7 Days - 13/03/2013				
Weight (grams)	720	746	758	741.33
Ultimate Load (kN)	67	88	74	76.33
Polymer modified cement Mortar Cube - 28 Days - 03/04/2013				
Weight (grams)	764	753	778	762.33
Ultimate Load (kN)	150	108	81	113.00

Table 4.5: Compressive Strength of polymer modified cement mortar specimens

Sl.No	Age of testing (Days)	Compressive Strength(MPa)
1	0	0
2	3	21.50
3	7	26.89
4	28	33.22



Graph 3.2: Compressive Strength Development Curve for Polymer Modified Cement Mortar

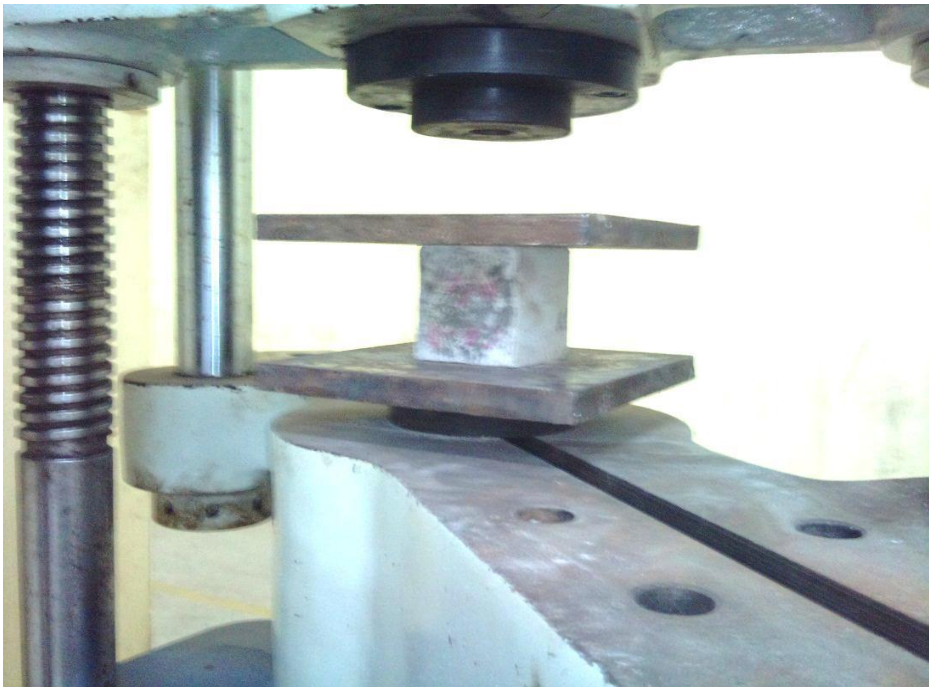


Fig 3.1: Cube Specimen placed for loading in UTM

Fig 3.2: Failure Pattern of Cube after Ultimate Load

4.2.4 Reinforcement

Welded mesh of square opening of 25mm and diameter 0.7 mm was used as the main reinforcement. The main reinforcement was enveloped with chicken mesh hexagonal in shape. The yield strength of the welded meshes was marked to be 450 N/mm^2. The welded mesh was cut into rectangular meshes of size 680 mm x 280 mm. In the longitudinal direction, 9 steel wires were present and in the transverse direction, 22 wires were present. The surface area of one layer of welded mesh embedded in the ferrocement slab is found to be 33.86mm^2

Fig 3.3 View of Square Welded Wire mesh Reinforcement

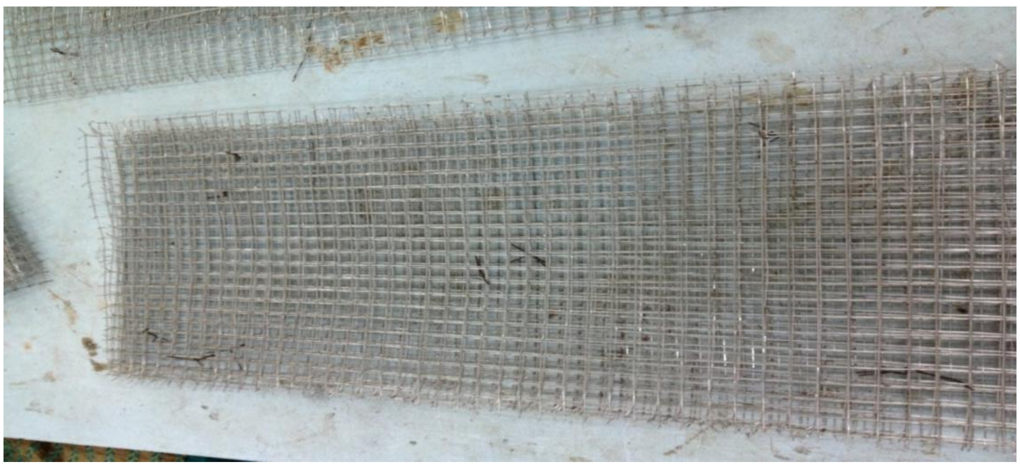


Fig 3.4 View of Square Welded Wire mesh Reinforcement Layers Using Binding Wires

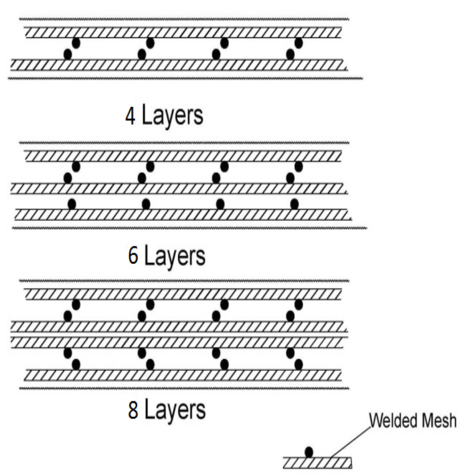


Fig 3.5 : Reinforcement Gauge with 2,3 and 4 Layers Square Welded Mesh Top and Bottom layers

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The required number of layers of welded mesh were tied together and wrapped with a layer of mesh on either side. The mesh was also securely tied to the welded mesh using binding wires.

4.3 CASTING AND TESTING

4.3.1 Casting of the slabs specimen

Closed mould system: the ferrocement slabs were cast using the closed mould system. The mortar is applied from one side through several layers of mesh, held in position against the surface of a closed mould. The mould is treated with mould releasing agents. In this method, the mortar is applied from one side.

4.3.2 Curing

The day old ferrocement slabs and mortar specimens were cured in a fresh water tank for a period of 28 days and 3, 7 and 28 days respectively. The slabs were laid to rest vertically in the upright position, resting on the longer side. The slabs were laid for curing after the specimens were marked legibly with a permanent marker for identification.

4.3.3 Preparation for testing

The specimens after the requisite number of days of curing were dried and cleaned. The surface dried specimens were then whitewashed and dried for an entire day. Marking lines were drawn across the midsection of the slabs along the longitudinal and transverse directions. Additionally the line of action of loads and the line of supports were marked for easy setup for testing.

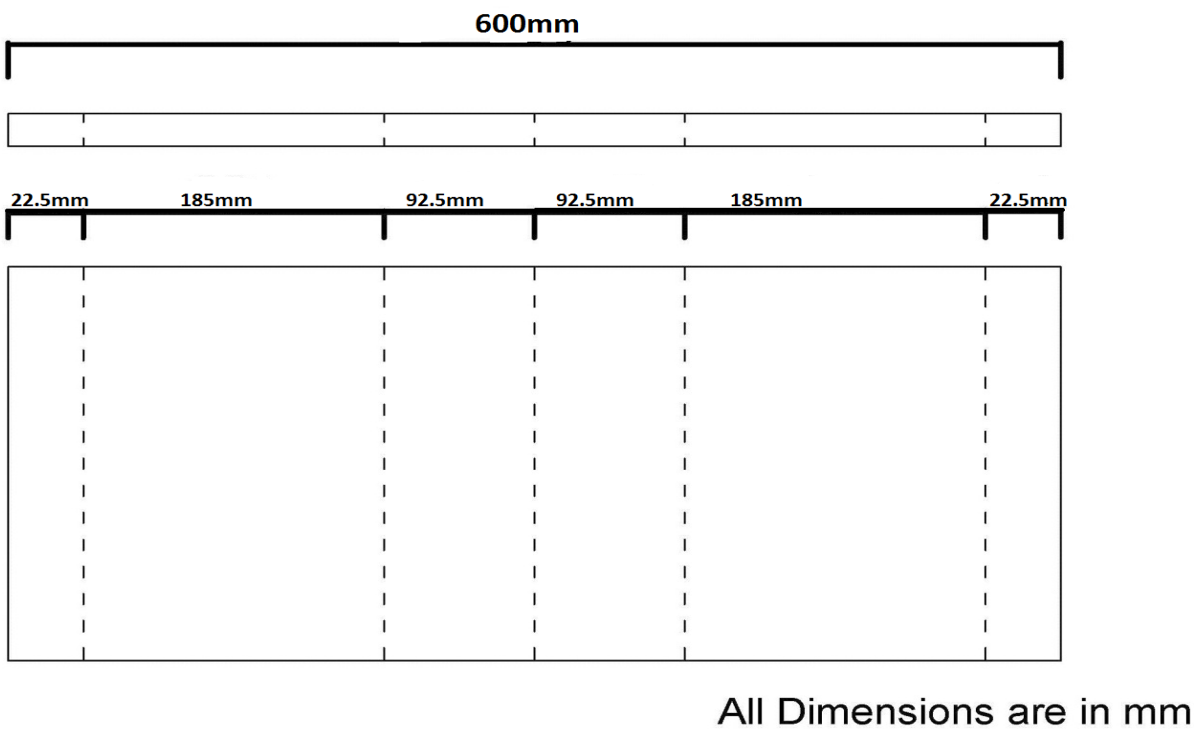

Fig 4.1: Marking on Ferrocement slab for Flexural Test

4.4 Flexural Testing of Slabs

The main objective of this test is to determine the flexural strength, deflection, toughness energy, ductility and energy ductility. The following procedure is adopted. Slabs of size 600 mm x 300 mm x 25 mm are cast and are placed along with the test setup on the Universal Testing Machine. Two point loads are applied on the slab 92.5 mm on either side of the centre line. Arrangements are made such that the two simply supported edges are at 22.5 mm distance from the edges of the slabs, such that the span between the supports (span) is 555 mm. Fig 4.1: shows the markings on slab specimen for Flexural test .The deflection at the centre of the slab is measured using a deflectometer supported on a magnetic stand.

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Flexural test setup with deflectometer.The load is applied using Universal Testing Machine, at suitable intervals of load, deflection and numbers of cracks are measured. The load corresponding to the first crack and the ultimate load are also noted, along with the respective number of cracks. The cracks formed on the slabs are traced with Black felt tip pen for easy identification of the cracking pattern.

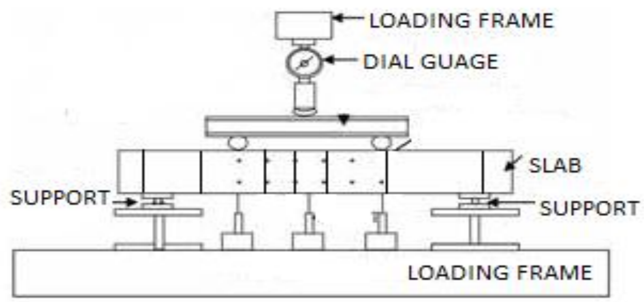


Fig 4.2: Schematic representation of the Flexural Test Set up for Ferrocement Slabs

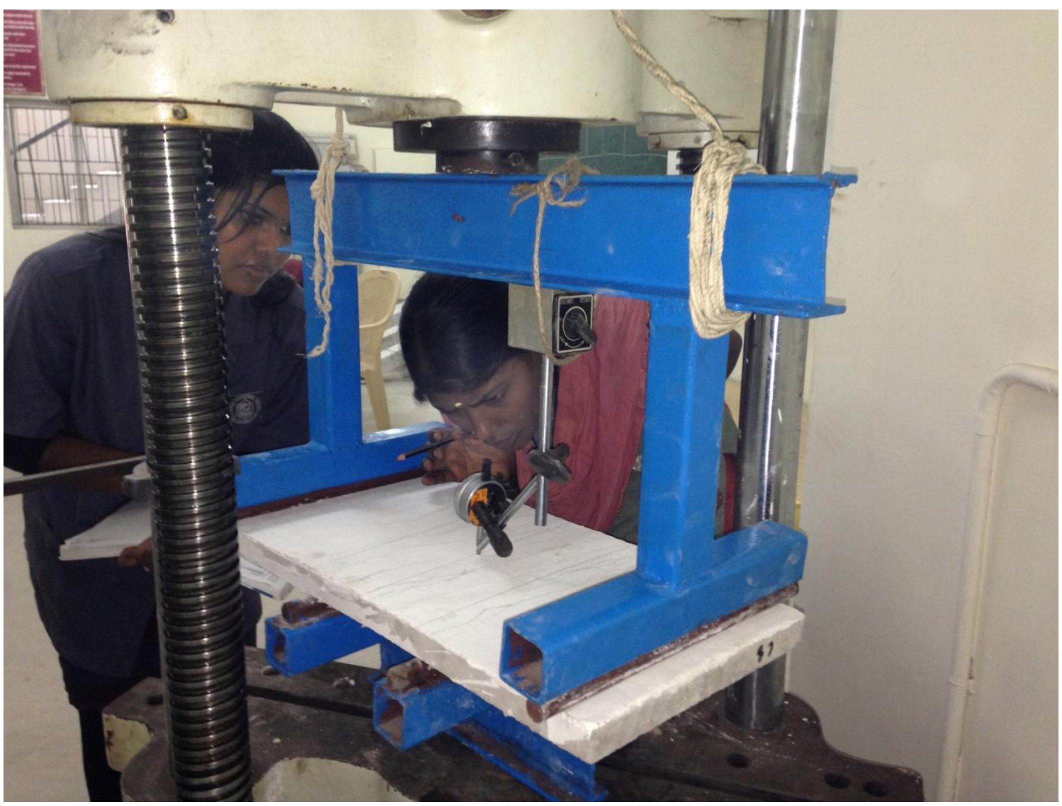
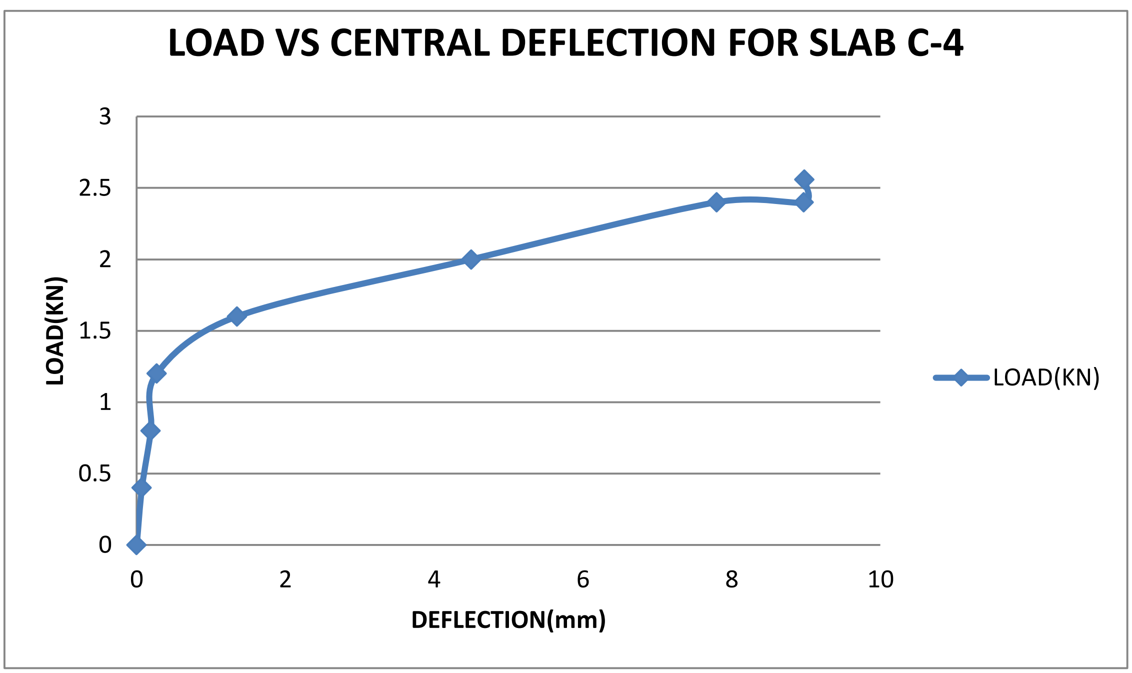


Fig 4.3: View of Flexural Test Setup for Ferrocement of Slab

4.5 Test data
4.5.1 Conventional ferrocement slab

Table 4.6: Central Deflection Values for C-4

SLAB DESIGNATION:C-4(STATIC LOADING) DATE:2/4/13						
Sl.No	**LOAD (KN)**	**DEFLECTION (mm)**	**ACTUAL DEFLECTION (mm)**	**ACTUAL DEFLECTION*LC (mm)**	**NO OF CRACKS**	**SPACING (mm)**
1	0	140	0	0	-	-
2	0.4	147	7	0.07	-	-
3	0.8	159	19	0.19	-	-
4	1.2(cr)	167	27	0.27	-	-
5	1.6	275	135	1.35	2	2.7
6	2	590	450	4.50	4	2.1
7	2.4	920	780	7.80	6	4.7
8	2.4	1037	897	8.97	8	2.7
9	2.56	1038	898	8.98	9	2.1



Graph 4.1: Load- Central Deflection of C-4 under Flexure

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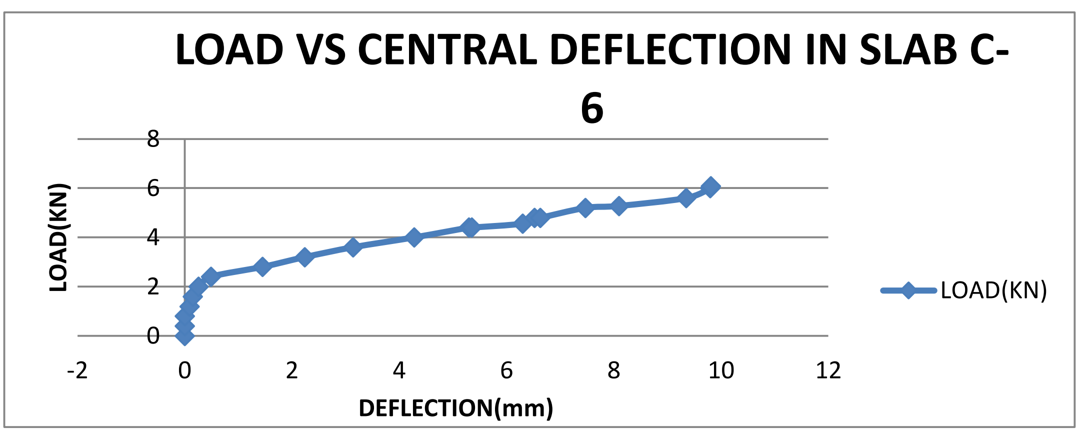
Table 4.7: Central Deflection Values for C-6

SLAB DESIGNATION:C-6(STATIC LOADING) DATE:2/4/13						
Sl. No	LOAD(KN)	DEFLECTION (mm)	ACTUAL DEFLECTION (mm)	ACTUAL DEFLECTION*LC (mm)	NO OF CRACKS	SPACING (mm)
1	0	65	0	0	-	-
2	0.40	65	0	0	-	-
3	0.80	65	0	0	-	-
4	1.20	74	9	0.09	-	-
5	1.60	80	15	0.15	-	-
6	2.00	91	26	0.26	-	-
7	2.40(cr)	114	49	0.49	2	3.4
8	2.80	210	145	1.45	3	3.4
9	3.20	289	224	2.24	4	3.4
10	3.60	379	314	3.14	7	3
11	4.00	493	428	4.28	10	3.7
12	4.40	595	530	5.30	11	3.3
13	4.40	600	535	5.35	14	3.3
14	4.56	695	630	6.30	15	3.6
15	4.80	717	652	6.52	16	3.2
16	4.80	738	663	6.63	17	3.1
17	5.20	812	747	7.47	19	3.3
18	5.28	875	810	8.10	20	3.4
19	5.60	1000	935	9.35	21	3.2
20	6.00	1045	980	9.80	23	3.3
21	6.08	1046	981	9.81	23	3.3



Graph 4.2: Load- Central Deflection of C-6 under Flexure

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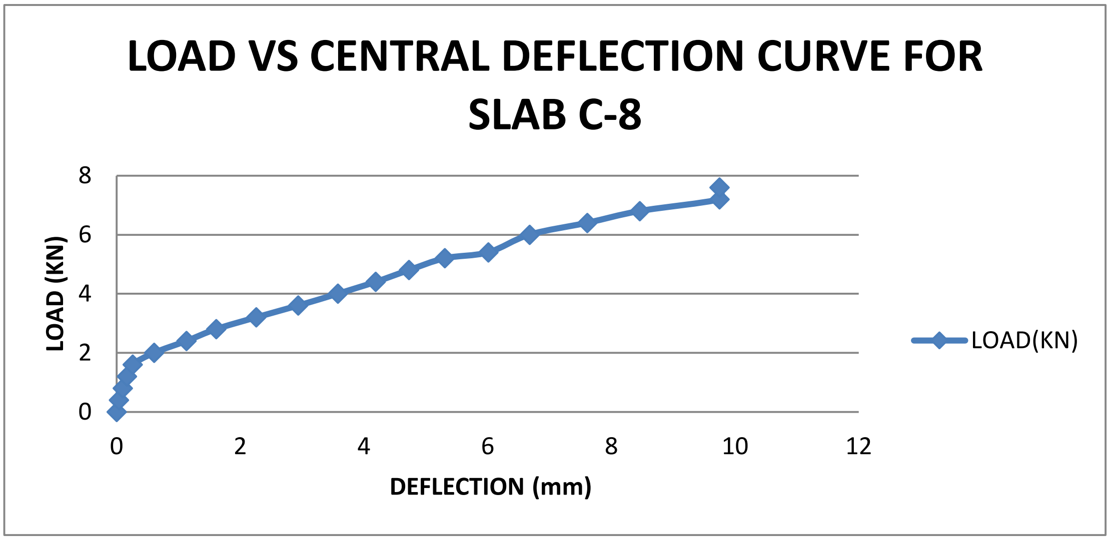
Table 4.8: Central Deflection Values for C-8



SLAB DESIGNATION:C-8(STATIC LOADING) DATE:2/4/13						
Sl.No	LOAD (KN)	DEFLECTION (mm)	ACTUAL DEFLECTION (mm)	ACTUAL DEFLECTION*LC (mm)	NO OF CRACKS	SPACING (mm)
1	0	69	0	0	-	-
2	0.4	73	4	0.04	-	-
3	0.8	79	10	0.10	-	-
4	1.2	86	17	0.17	-	-
5	1.6	95	26	0.26	-	-
6	2.0	130	61	0.61	-	-
7	2.4	182	113	1.13	-	-
8	2.8(cr)	230	161	1.61	6	2.8
9	3.2	295	226	2.26	8	2.0
10	3.6	363	294	2.94	11	1.5
11	4.0	427	358	3.58	14	2.0
12	4.4	488	419	4.19	14	2.0
13	4.8	542	473	4.73	15	3.0
14	5.2	600	531	5.31	16	3.5
15	5.4	670	601	6.01	17	4.7
16	6.0	737	668	6.68	18	4
17	6.4	830	761	7.61	19	2.7
18	6.8	915	846	8.46	21	3.5
19	7.2	1044	975	9.75	23	3.5
20	7.6	1044	975	9.75	24	3.5

Graph 4.3: Load- Central Deflection of C-8 under Flexure

4.5.2 Polymer Modified Ferro Cement slabs

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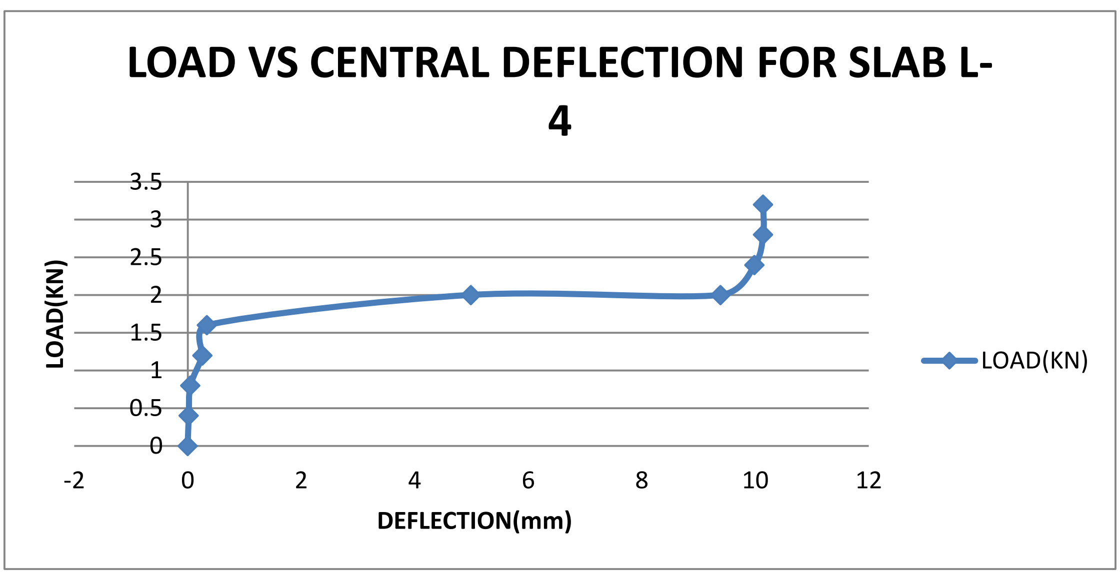
Table 4.9: Central Deflection Values for L-4

SLAB DESIGNATION:L-4(STATIC LOADING) DATE:2/4/13						
S.NO	LOAD(KN)	DEFLECTION (mm)	ACTUAL DEFLECTION (mm)	ACTUAL DEFLECTION*LC (mm)	NO OF CRACKS	SPACING(mm)
1	0	31	0	0	0	0
2	0.4	33	2	0.02	0	0
3	0.8	36	5	0.05	0	0
4	1.2	57	26	0.26	1	2.2
5	1.6(cr)	65	34	0.34	3	2.1
6	2	530	499	4.99	3	2.4
7	2	970	939	9.39	4	2.3
8	2.4	1030	999	9.99	4	2.2
9	2.8	1045	1014	10.14	5	2.2
10	3.2	1045	1014	10.14	5	2.2



Graph 4.4: Load- Central Deflection of L-4 under Flexure

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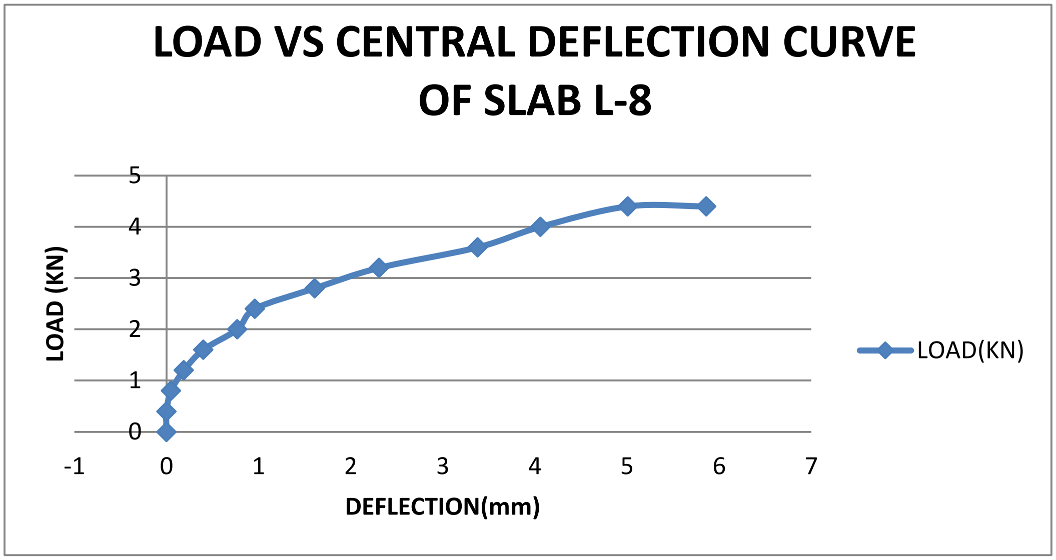

Graph 4.5 : Load- Central Deflection of L-6 under Flexure

Table 4.10: Central Deflection Values for L-6

SLAB DESIGNATION:L-6(STATIC LOADING)DATE:2/4/13						
S.NO	**LOAD(KN)**	**DEFLECTION (mm)**	**ACTUAL DEFLECTION(mm)**	**ACTUAL DEFLECTION*LC(mm)**	**NO OF CRACKS**	**SPACING**
1	0	98		0	-	-
2	0.40	100	2	0.02	-	-
3	0.80	100	2	0.02	-	-
4	1.20	113	15	0.15	-	-
5	1.60	126	28	0.28	-	-
6	2.00	160	62	0.62(CR)	2	10.5
7	2.40(cr)	375	277	2.77	5	4.5
8	2.80	524	426	4.26	7	5.2
9	3.20	635	537	5.37	9	2.5
10	3.60	782	630	6.3	12	3
11	4.00	955	857	8.57	13	2.7
12	4.40	1040	942	9.42	14	3.2
13	4.40	1040	943	9.43	16	3
14	4.56	1077	979	9.79	16	3
15	4.80	1380	1282	12.82	18	3

Table 4.11 : Central Deflection Values for L-8

SLAB DESIGNATION:L-8(STATIC LOADING)					DATE:2/4/13	
S.NO	LOAD(KN)	DEFLECTION (mm)	ACTUAL DEFLECTION(mm)	ACTUAL DEFLECTION*LC(mm)	NO OF CRACKS	SPACING
1	0	147	0	0	-	-
2	0.40	147	0	0	-	-
3	0.80	152	5	0.05	-	-
4	1.20	166	19	0.19	-	-
5	1.60	187	40	0.4	-	-
6	2.00	224	77	0.77	-	-
7	2.40	243	96	0.96	-	-
8	2.80	308	161	1.61	-	-
9	3.20(cr)	378(cr)	231	2.31	5	2.3
10	3.60	485	338	3.38	6	3.3
11	4.00	553	4.6	4.06	10	2.7
12	4.40	648	501	5.01	12	3
13	4.40	733	586	5.86	14	3
SLAB DESIGNATION:L-8(STATIC LOADING)					DATE:2/4/13	

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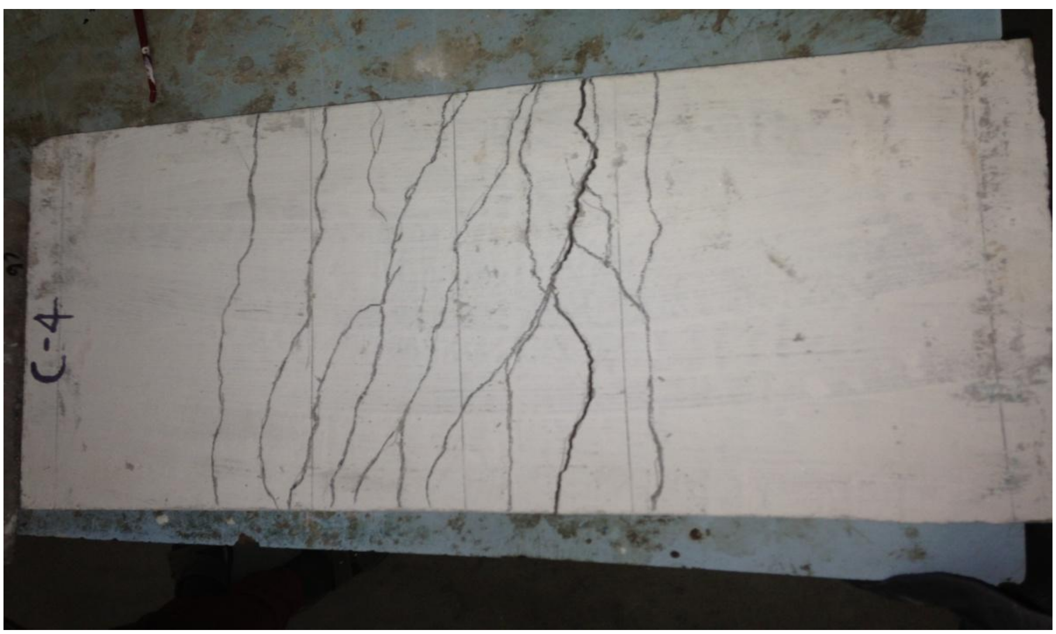
S.NO	LOAD(KN)	DEFLECTION (mm)	ACTUAL DEFLECTION(mm)	ACTUAL DEFLECTION*LC(mm)	NO OF CRACKS	SPACING
1	0	147	0	0	-	-
2	0.40	147	0	0	-	-
3	0.80	152	5	0.05	-	-
4	1.20	166	19	0.19	-	-
5	1.60	187	40	0.4	-	-
6	2.00	224	77	0.77	-	-
7	2.40	243	96	0.96	-	-
8	2.80	308	161	1.61	-	-
9	3.20(cr)	378(cr)	231	2.31	5	2.3
10	3.60	485	338	3.38	6	3.3
11	4.00	553	4.6	4.06	10	2.7
12	4.40	648	501	5.01	12	3
13	4.40	733	586	5.86	14	3



Graph 4.6: Load- Central Deflection of L-8 under Flexuree

Fig 4.4: Crack Pattern for C-4 after testing up to Ultimate Load

Fig 4.5: Crack Pattern for C-6 after testing up to Ultimate Load

Fig 4.6: Crack Pattern for C-8 after testing up to Ultimate Load

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Fig 4.7: Crack Pattern for L-4 after testing up to Ultimate Load

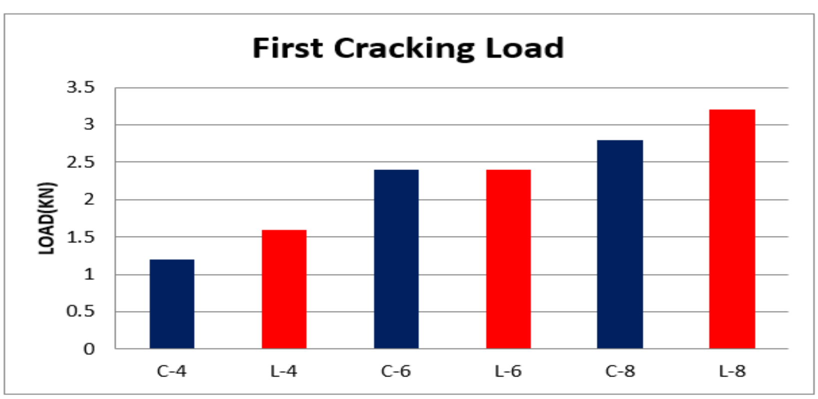
Fig 4.8: Crack Pattern for L-6 after testing up to Ultimate Load

Fig 4.9: Crack Pattern for L-8 after testing up to Ultimate Load

4.5.3 COMPARSION OF FIRST CRACKING LOADS

Table 4.12 : First Cracking Load for Various Specimens

Slab	C-4	C-6	C-8	L-4	L-6	L-8
Load (kN)	0.8	2	1.6	2.72	3.2	3.92



Graph 4.7 : First Cracking Load for Ferrocement slabs and Polymer- Modified Ferrocement slabs

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CALCULATION

5.1 Energy, Ductility, Energy Ductility

The energy, Ductility and the energy ductility for each of the slabs are determined according to the following formula

ENERGY = AREA UNDER THE LOAD - DEFLECTION CURVE

DUCTILITY = $LOAD$ / $FIRSTCRACKLOAD$

ENERGY DUCTILITY = AREA UNDER THE LOAD- DEF.CURVE UPTO YIELD LOAD

TOTAL AREA UNDER LOAD –DEF.CURVE

5.1.1 Cement Mortar Cube

5.1.1.1 Slab C-4

Energy = area under the curve = 432.77 KN mm

Ductility = 2.6 / 1.2 = 2.16

Energy Ductility = 5.812 / 432.77 = 0.0134

5.1.1.2 Slab C-6

Energy = area under the curve = 465.71 KN mm

Ductility =6.08 / 2.0 = 3.04

Energy Ductility = 10.295 / 465.71 = 0.0221

5.1.1.3Slab C-8

Energy = area under the curve = 651.242 KN mm

Ductility = 7.84/2.8 = 2.8

Energy Ductility = 10.739 / 651.242 = 0.0168

5.1.1.4 Slab L-4

Energy = area under the curve = 335.132 KN mm

Ductility = 2.08 /1.6 = 1.3

Energy Ductility = 6.3940 / 335.132 = 0.0190

5.1.1.5 Slab L-6

Energy = area under the curve = 658.488 KN mm

Ductility = 5.2/2.0 = 2.6

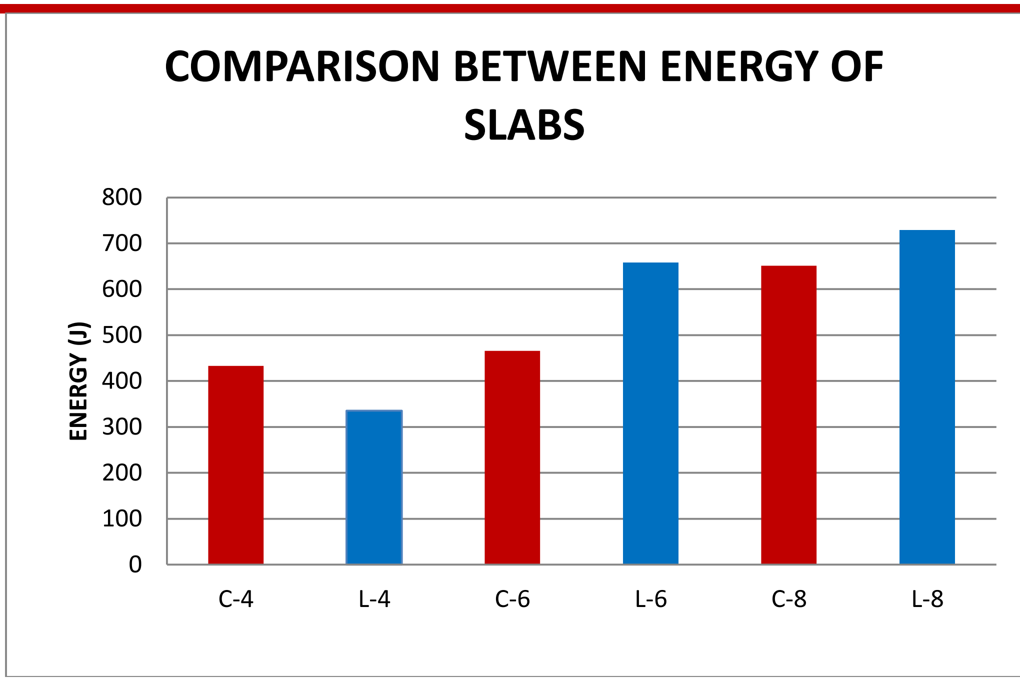
Energy Ductility = 11.2014/ 658.488 = 0.0170

5.1.1.6 Slab L-8

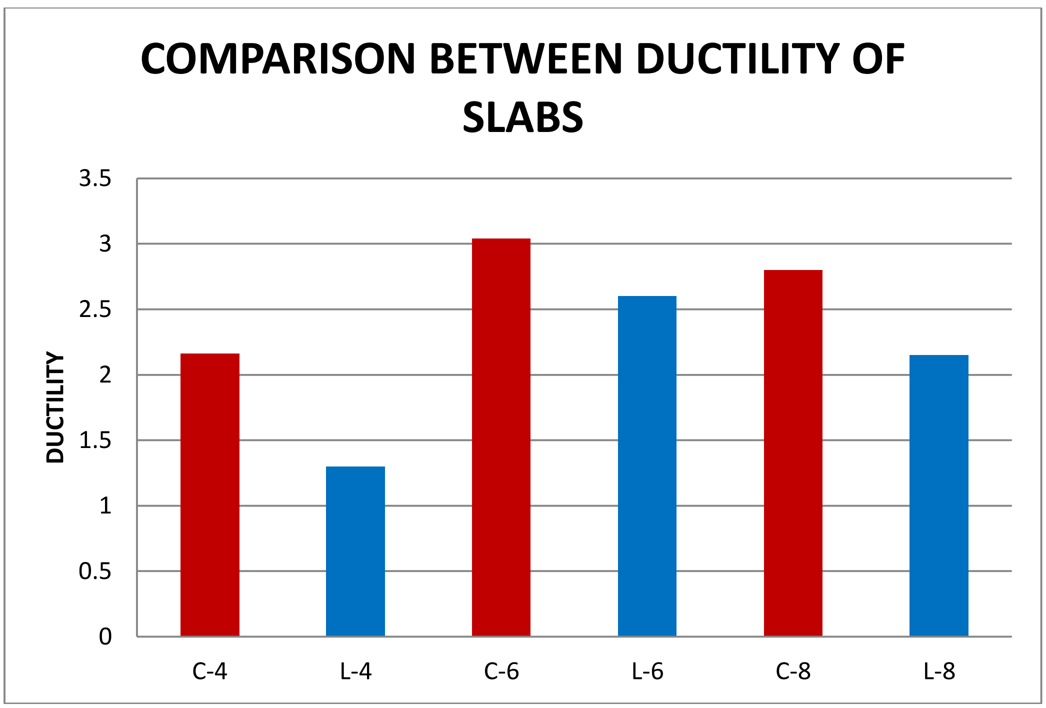
Energy = area under the curve = 729.156 KN mm

Ductility = 6.88/ 3.2= 2.15

Energy Ductility= 13.259/ 729.156 = 0.0181



Graph 5.1: Comparison of Energy Values of Ferrocement Specimens



Graph 5.2: Comparison of Ductility Values of Ferrocement Specimens

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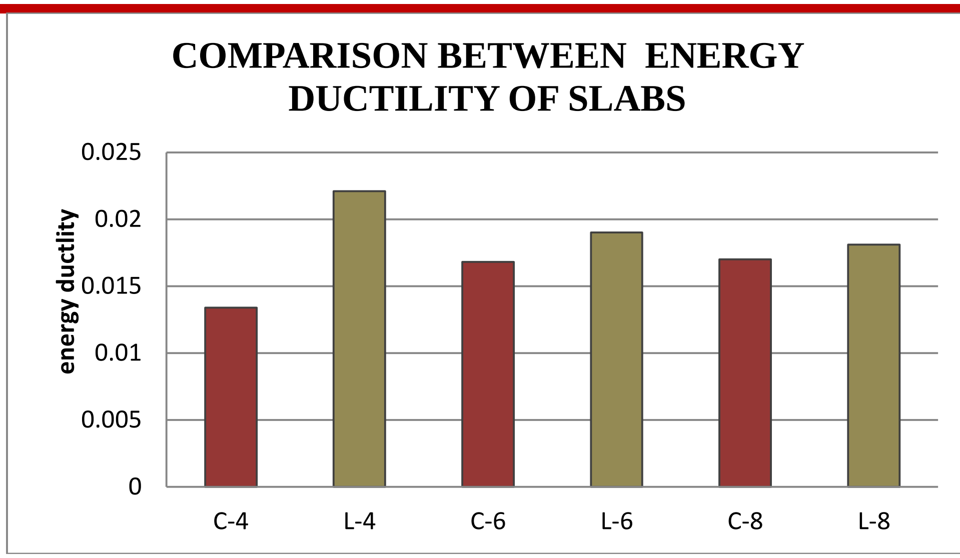


Graph 5.3: Comparison of Energy Ductility Values of Ferrocement Specimens

5.2 TOUGHNESS

5.2.1 DEFINITION

The amount of energy a material can absorb before it breaks.

5.2.2 FORMULA

Toughness = (A + B) / A J/m^2

A = Area upto cracking load

B = Remaining area under the deflection curve

5.2.3 CALCULATION

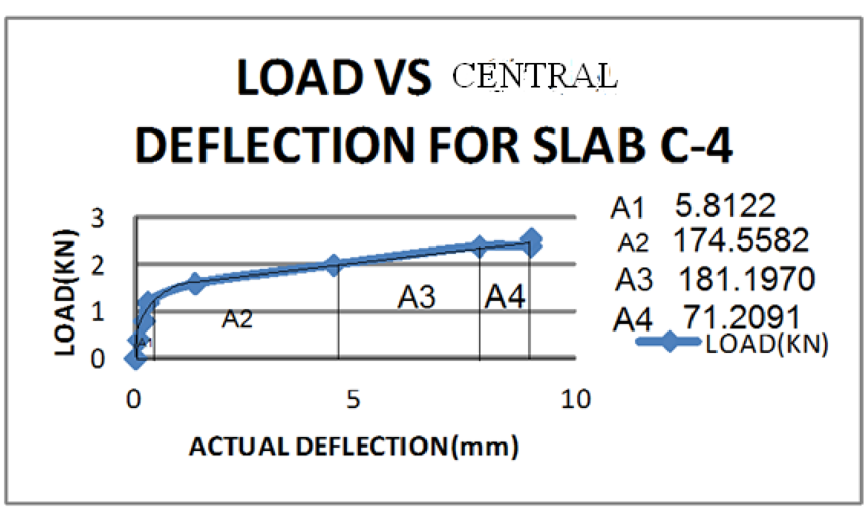
FERROCEMENT SLABS

5.2.3.1 SLAB C-4

Toughness = $A_1+A_2+A_3+ A_4 / A_1$

= 5.812+174.558+181.197+71.209 / 5.812

= **52.78 J/mm^2**



Graph 5.4 : Area of C-4 slab Under the deflection curve

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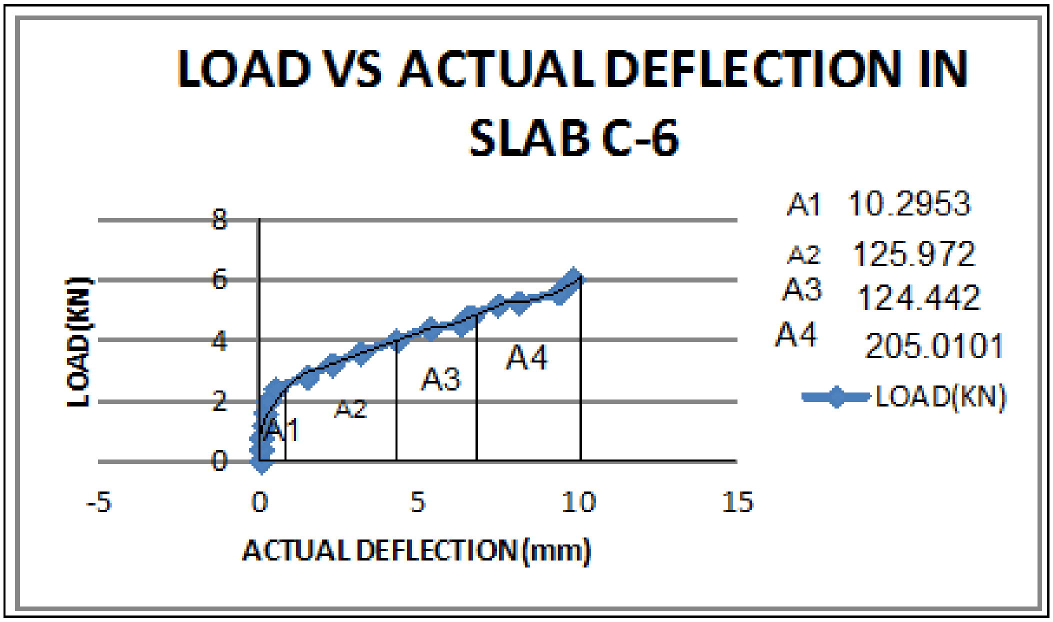
5.2.3.2 SLAB C-6

Toughness = $A_1+A_2+A_3+ A_4 / A_1$

= 10.295+125.972 +124.442+205.010/ 10.295

= **45.241 J/mm²**



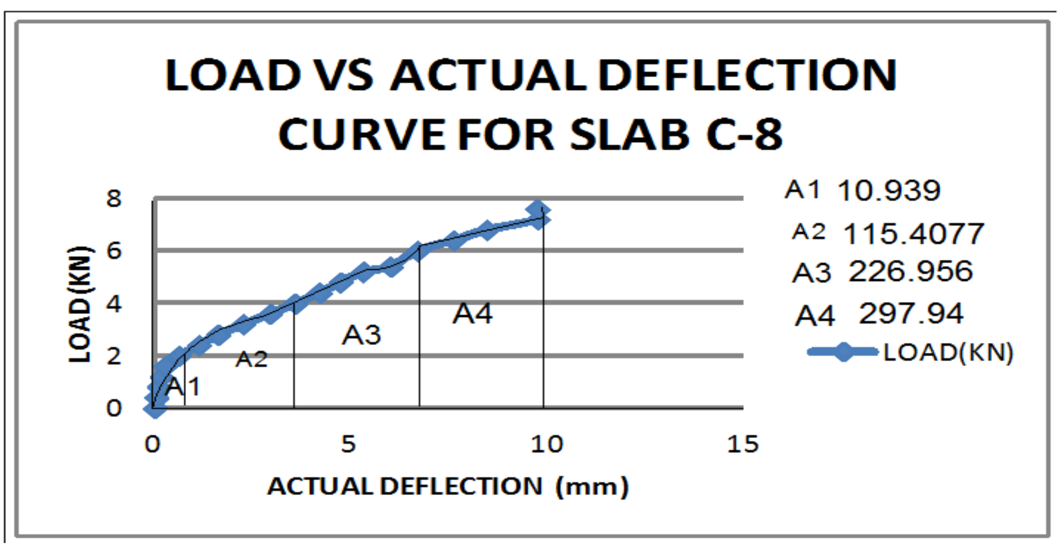
Graph 5.5 : Area of C-6 slab Under the deflection curve

5.2.3.3 SLAB C-8

Toughness = $A_1+A_2+A_3+ A_4 / A_1$

= 10.939+115.407+226.956+297.94/ 10.939

= **55.03 J/mm**



Graph 5.6 : Area of C-8 slab Under the deflection curve

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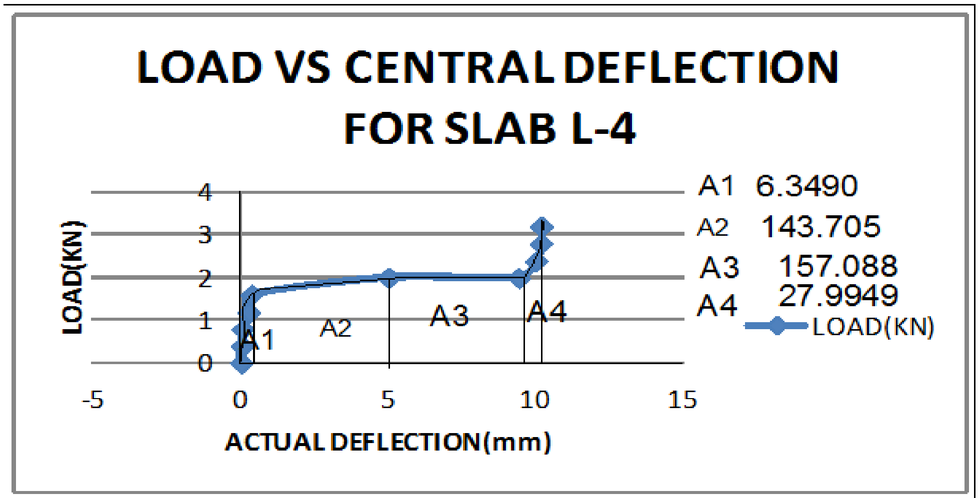
5.2.4 POLYMER – MODIFIED FERROCEMENT SLABS

5.2.4 .1SLAB L-4

Toughness = $A_1+A_2+A_3+A_4 / A_1$

= 10.939+115.407+226.956+297.94/ 10.939

= **55.03 J/mm^2**



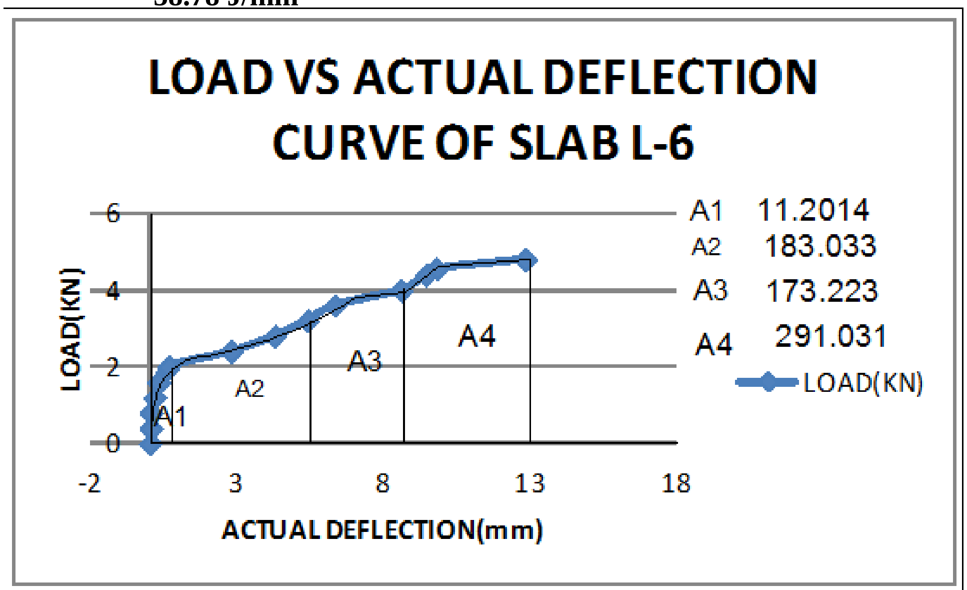
Graph 5.7 : Area of L-4 slab Under the deflection cur

5.2.4.2 SLAB L-6

Toughness = $A_1+A_2+A_3+A_4 / A_1$

= 11.201+183.033+173.223+291.031/ 11.2014

= **58.78 J/mm^2**



Graph 5.8 : Area of L-6 slab Under the deflection curve

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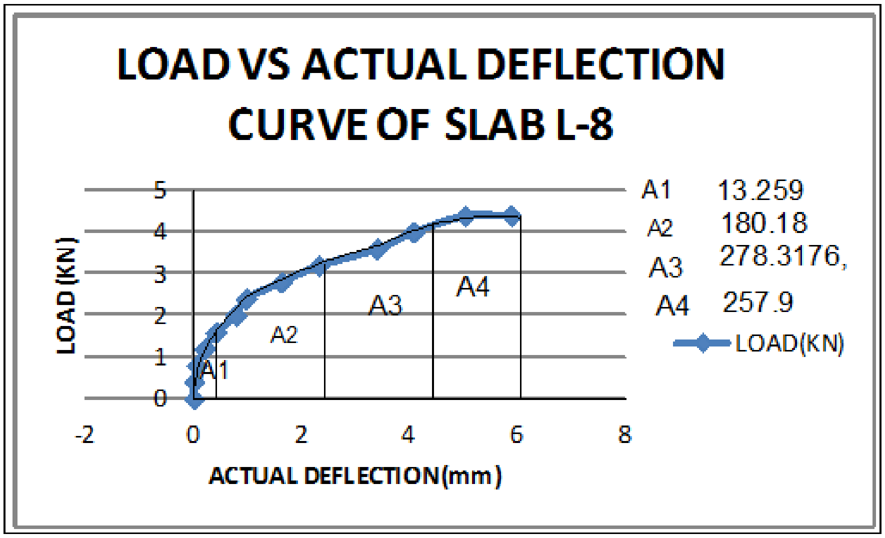
5.2.4.3 **SLAB L-8**

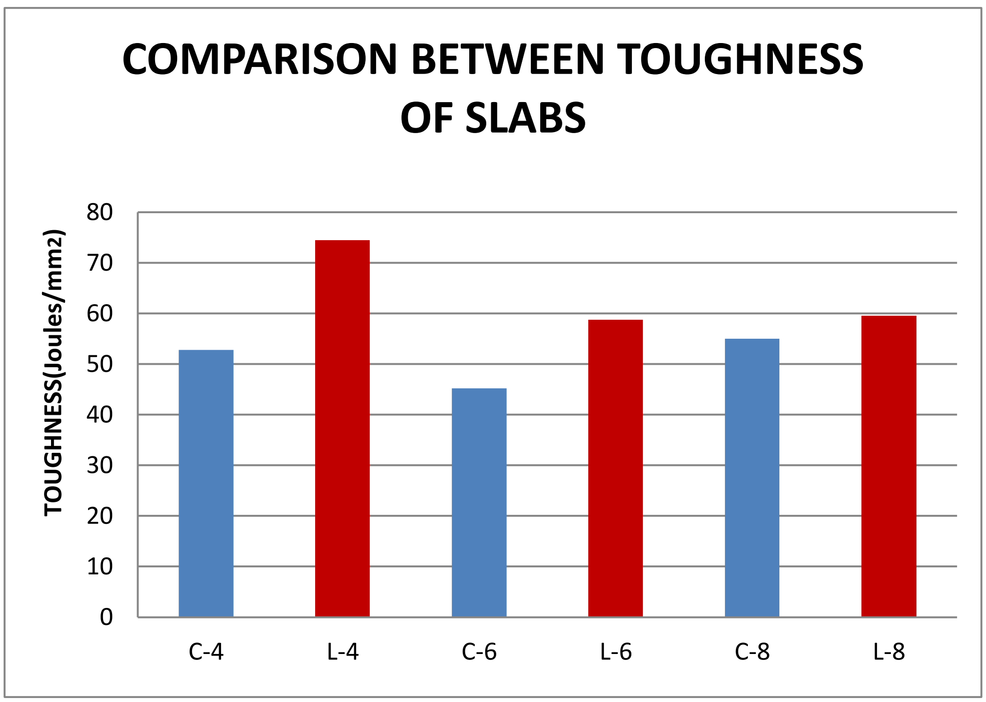
Toughness = $A_1+A_2+A_3+A_4 / A_1$

= 11.201+183.033+173.223+291.031/ 11.2014

= **59.53 J/mm^2**



Graph 5.9 : Area of L-8 slab Under the deflection curv



Graph 5.10 : Comparison of Toughness of the slabs

5.3 IMPACT TEST ON SLABS

It well known that, that the material behaviour of construction materials is dependent on Strain, strain rate and temperature. For many engineering applications, the mechanical impact Behaviour of materials and components also plays an essential role

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5.3.1FORMULA

Impact Force = W * H*No of drops

W = Wt of ball (g)
H =Ht b/w ball and slab(m)

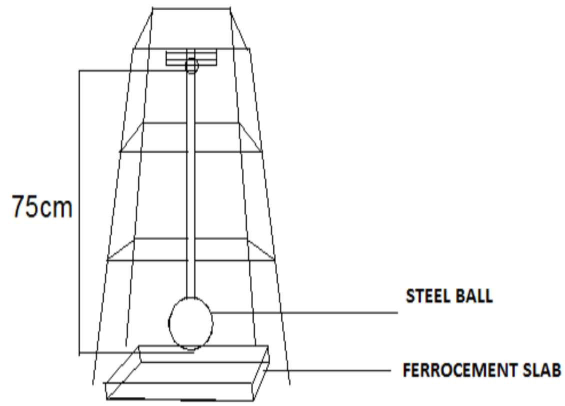


Fig 5.1 View of Impact Test Setup

5.3.2CALCULATION

5.3.2.1 IMPACT FORCE OF FERROCEMENT SLABS

C-4 = 4650*7.8*10 = 362.70 J

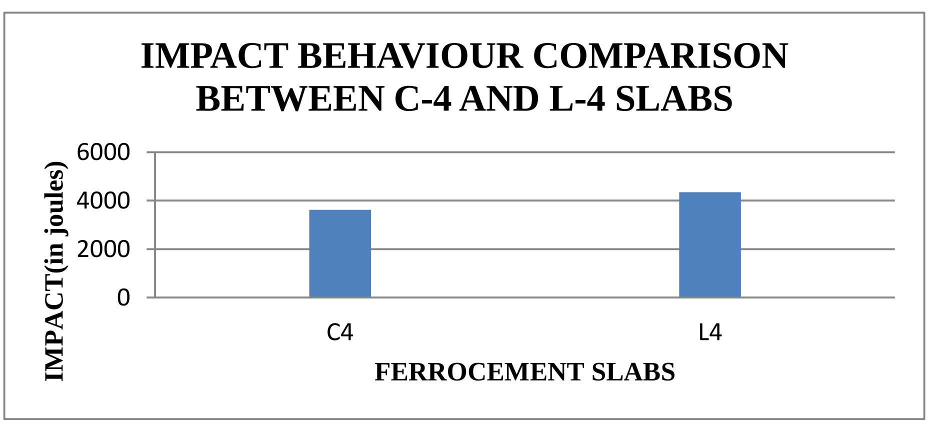
C-6 = 4650*7.8*12 = 435.24J

C-8 = 4650*7.8*15 = 544.05J
5.3.2.2 IMPACT FORCE OF POLYMER-MODIFIED FERROCEMENT SLABS

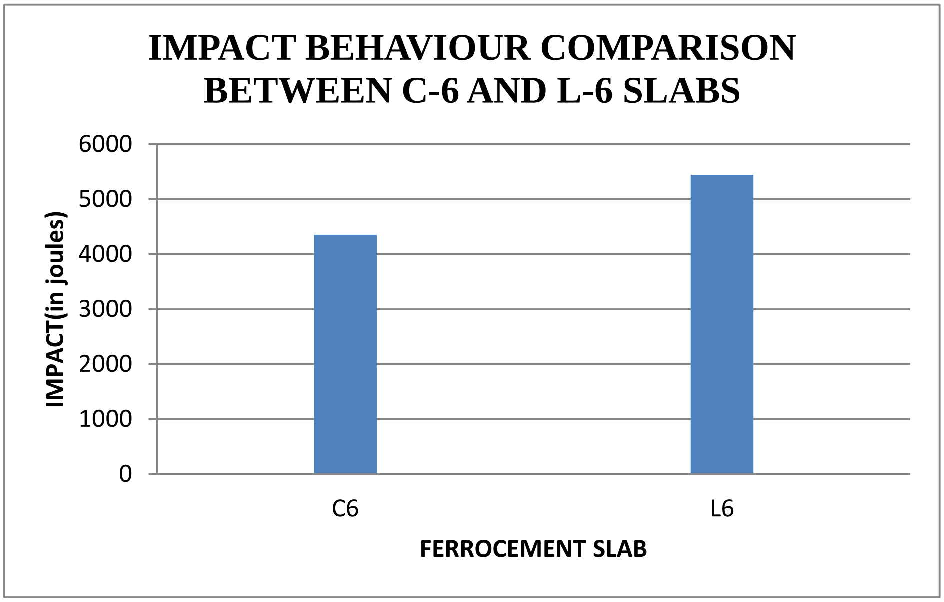
L-4 = 4650*7.8*12 = 435.24 J

L-6 = 4650*7.8*15 = 544.05J
L-8 = 4650*7.8*16 = 580.32

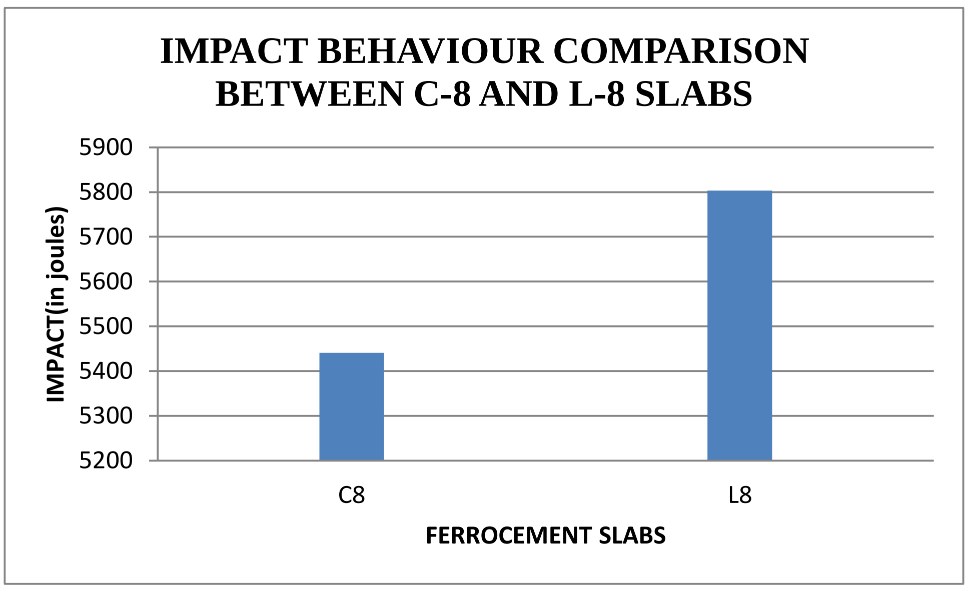
5.4 Impact Behaviour of slabs



Graph 5.11: Comparison of Impact behaviour of the slabs C-4 and L-4



Graph 5.12: Comparison of Impact behaviour of the slabs C-6 and L-6



Graph 5.13: Comparison of Impact behaviour of the slabs C-8 and L-8

Fig 5.2 View of crack pattern under impact force of slab C-4

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Fig 5.3 View of crack pattern under impact force of slab C-6

Fig 5.4 View of crack pattern under impact force of slab C-8

Fig 5.5 View of crack pattern under impact force of slab L-4

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Fig 5.6 View of crack pattern under impact force of slab L-6

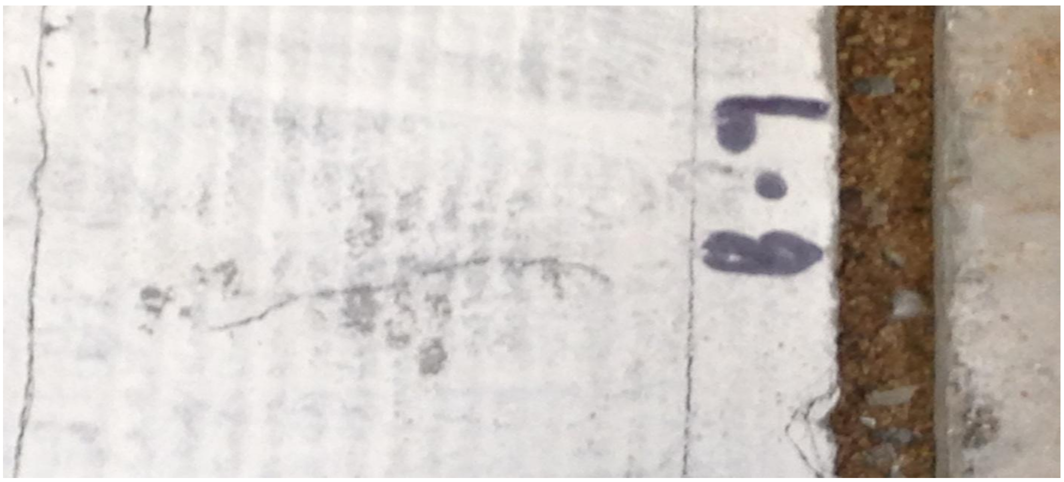

Fig 5.7 View of crack pattern under impact force of slab L-

5.5 Percentage of Reinforcemen

5.5.1 Formula

Percentage of Reinforcement = Noof layers x No of main rods x Area of the mesh
Area of cross - section

5.5. 2 Calculation

5.5.2.1Percentage of Reinforcement of slab C-4 and L-4

% of reinforcement = (4 x 22 x 0.384 x 100) = 0.451
300 x 25

5.5.2.2 Percentage of Reinforcement of slab C-6 and L-6

% of reinforcement = (6 x 22 x 0.384 x 100) = 0.677
300 x 25

5.5.2.3 Percentage of Reinforcement of slab C-8 and L-8

% of reinforcement = (8 x 22 x 0.384 x 100) = 0.903
300 x 25

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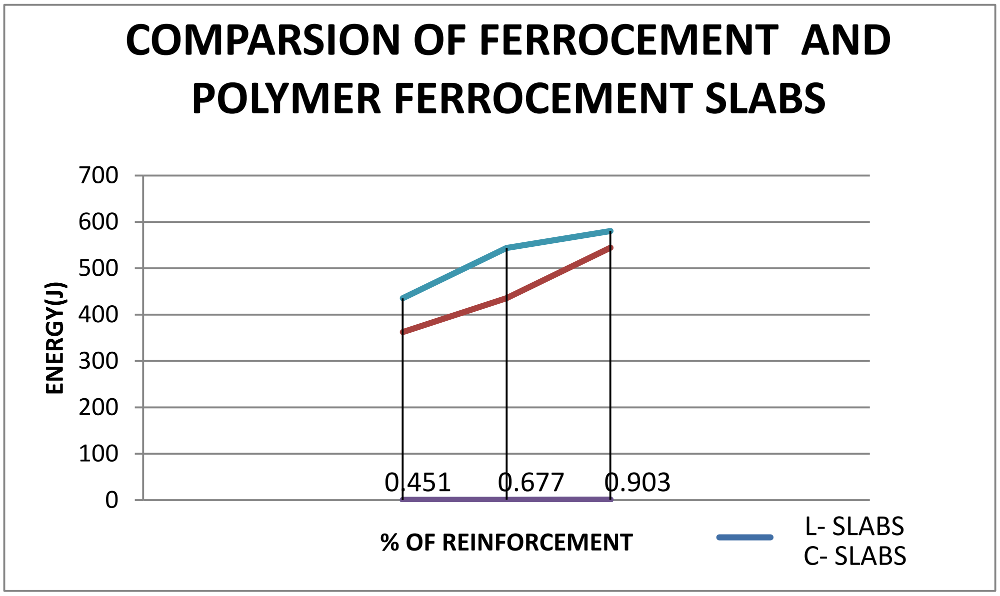

Graph 5.14 : Comparison of percentage of rft and Energy of the slabs

RESULTS AND DISCUSSIONS

The % of increase in compressive strength development at the age of 3 and 7 days compared to its 28 days strength 47.9 % and 61.71 % for normal cement mortar.

The % of increase in compressive strength development at the age of 3 and 7 days compared to its 28 days strength 64.72 % and 80.94 % for polymer modified cement mortar.

The % of increase in compressive strength development at the age of 3 and 7 days compared to its 28 days strength 74.72% and 76.24 % for cement mortar and polymer modified cement mortar.

The % of energy increased in slabs compared to C -4 & L-4 is 77.43% , C-6 & L-6 is 70.72 % and C-8 & L-8 is 89.30 % .It shows that the energy of the polymer modified ferrocement slabs are more than the ferrocement slabs.

The % of ductility increased in slabs compared to C -4 & L-4 is 60.08% , C-6 & L-6 is 85.50 % and C-8 & L-8 is 76.78% .It shows that the polymer modified ferrocement slabs are more ductile slab than the ferrocement slabs

The % of energy ductility increased in slabs compared to C -4 & L-4 is 70.50% , C-6 & L-6 is 70.92 % and C-8 & L-8 is 92.81 % .It shows that the energy ductility of the polymer modified ferrocement slabs are more than the ferrocement slabs.

The % of toughness increased in slabs compared to C -4 & L-4 is 95.91% , C-6 & L-6 is 76.96 % and C-8 & L-8 is 92.24 % .It shows that the toughness of the polymer modified ferrocement slabs are more than the ferrocement slabs.

The % of impact load resisting capacity increased in slabs compared to C -4 & L-4 is 83.30% , C-6 & L-6 is 80.00% and C-8 & L-8 is 93.75% .It shows that the impact load resisting capacity of polymer modified ferrocement slabs are more than the ferrocement slabs.

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