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EXPERIMENTAL STUDY ON FLEXURAL STRENGTHENING OF RC BEAMS USING GEONET FERROCEMENT LAMINATES

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ABSTRACT

The flexural behavior of reinforced concrete beams strengthened with thin Geonet Ferro cement laminates attached to the tension face was investigated. Worldwide a great deal of research is currently being focused on the use of effective material for repair and strengthening of existing reinforced concrete structure and the research is also concern about the effective utilization of fiber in construction industries. This paper reviews the articles of strengthening the reinforced concrete elements with Ferro cement laminate. This paper is mainly concern about the types of meshes, number of layers of meshes, mortar mix ratio, usage in laminates that are used in the research works to strengthen the reinforced concrete elements. The M_{30} grade of concrete are tested to find out the fresh and hardened properties of concrete. RC Beams where prepared and tested in flexural strength at 28 days curing period.

Keywords: M-sand, Geonet, Ferro cement Laminates, Compressive strength, Flexural strength, Curing, Fine Aggregate, layers.

CHAPTER 1

INTRODUCTION

1.1 GENERAL

The main aim of this experimental work is to investigate and gather knowledge on RC Beam elements strengthened externally with Geonet ferrocement laminates. The ferrocement laminates are cast with M-sand. Due to the scarcity of river sand and increasing cost, River sand is replaced by M-sand. Strengthening has become the acceptable way of improving their load carrying capacity and extending their service lives.

Ferrocement is a versatile construction material formed by filling hydraulic cement mortar into closely spaced layers of small sized Geonet mesh. Ferrocement has proven to be less polluting technology that uses all resources in a more sustainable manner. It handles waste products in a more acceptable manner than other construction technologies. Ferrocement generally having high tensile strength and a high modulus of rupture.

Figure 1.1 : Ferrocement Laminates

Concrete is a mixture of basically three components namely water, aggregate and cement. Reinforced concrete in one of the most abundantly used construction material not only in the developed world, but also in the remotest parts of the developing world. In the rural areas of the developing world, however, due to transference of expertise and technology know how, reinforced concrete poses threat due to its abuse rather than use, and majority of the houses still being are constructed in traditional manner using indigenously developed techniques preferably following simpler and economical procedures. Ferrocement is a type of thin wall reinforced concrete commonly constructed of hydraulic cement mortar reinforced with closely spaced layers of continuous and relatively small size wire mesh.

1.2 Objectives

- To study the properties of materials (M-sand ,Cement & Geonet).
- To study the basis of strengthening.
- To study the flexural strengthing of RC beam elements.
- To determine the flexural strength of ferrocement laminates by varying number of layers of Geonet.
- To conduct the test on RC beams.
- To conduct the test on strengthened beam.

CHAPTER 2

2.1 LITERATURE REVIEW

structural strengthening of reinforced concrete structures is an important task in the field of structural maintenance. The aim of strengthening is to increase the load carrying capacity of an existing structural element. Strengthening may be required due to many difference situations.

Strengthening methods

- Adding reinforcement steel bars to the main steel without increasing the beams cross sectional area.
- Section enlargement.
- Sprayed concrete.
- Steel plate bonding.
- Ferrocement laminate span shortening strengthening.

Table 2.1 : Summary of literature review (Reference : Internet)

AUTHOR	SPECIMEN (mm)	FERROCEMENT LAMINATE	ADHESIVE	TYPE OF LOAD	TYPE OF TESTING	RESULT
Ganapathy.L (2015)	RC BEAM Size:1000x 150x150 Grade of concrete: M20	Mesh : wire mesh Mortar mix : 1:2, w/c : 0.4 No. of layers :3,4	Epoxy resin	Static load Two point loading condition	Flexural test	The strength of beam using fibrous Ferro cement laminated was increased.
Ezz-Eldeen (2015)	RC BEAM Size:1250 x 160 x 100 Grade of concrete: M20	Mesh : galvanized steel wire mesh	Epoxy resin	Static load Two point loading condition	Flexural test	The deformation of retrofitted beams decreases by increasing the wire mesh piles
R. Malathy (2014)	RC BEAM Size:1220 x 100 x 150 Grade of concrete: M20	Mesh : galvanized steel wire mesh Mortar mix : 1:2, w/c : 0.4 FA : 30% steel slag No. of layers : 1,2	Epoxy resin	Static load Two point loading condition	Flexural test	Overall performance of RC beam strengthened with Vf of mesh reinforcement 2.35 % and replacement of fine aggregate with steel slag by 30% are found to be high

S.U.Khan (2013)	RC BEAM Size:1800 x 150 x 200 Grade of concrete: M20	Mesh : woven square wire mesh Mortar mix : 1:2, w/c : 0.5 Cast in situ and precast laminates No. of layers : 2,3	Epoxy resin	Static load Two point loading condition	Flexural test	Performance of RC beams strengthened by three layer of Wire mesh using both technique was found to be better in terms of maximum increase in stiffness.

CHAPTER 3

3.1 METHODOLOGY

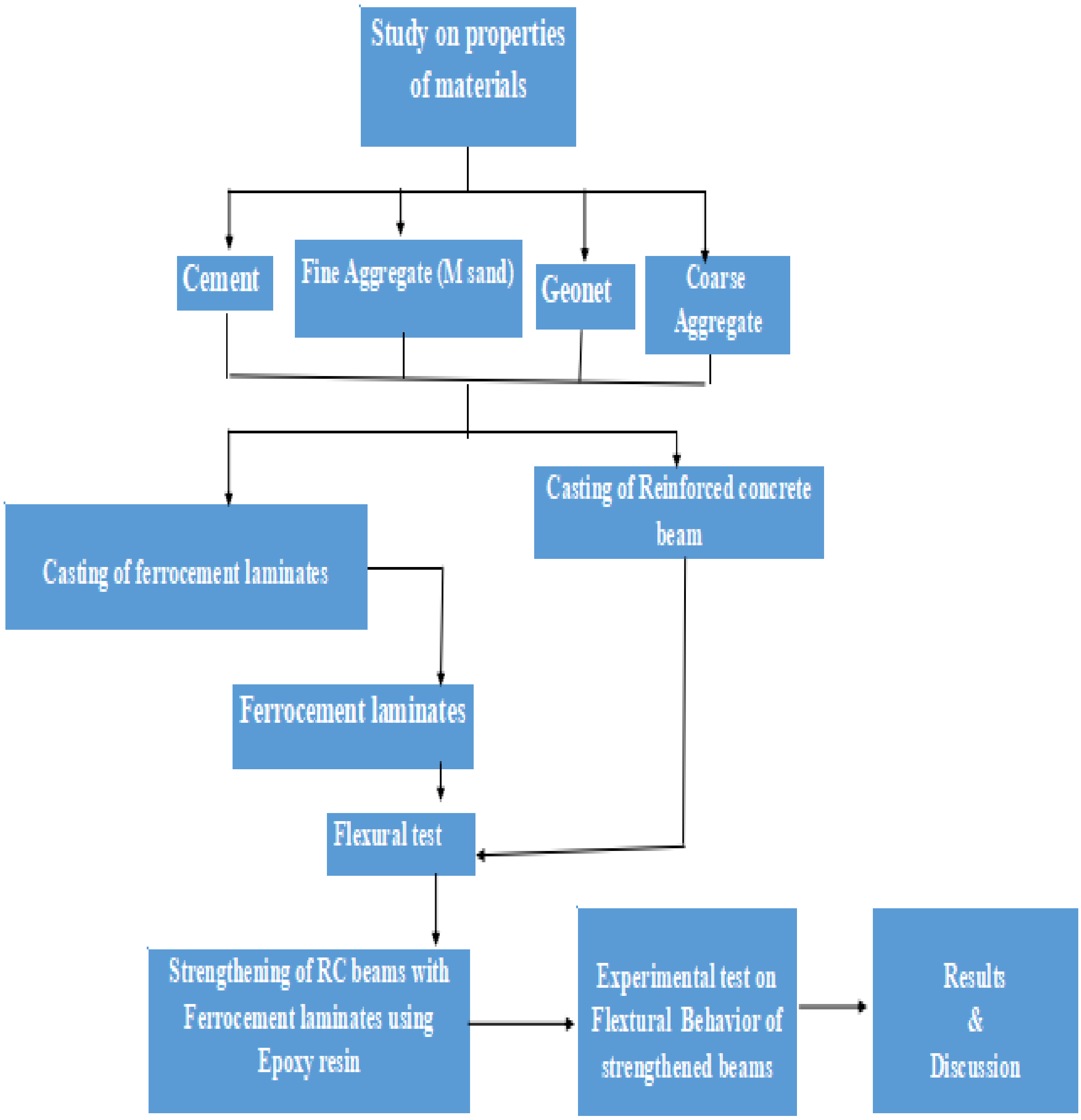

Figure 3.1 : Methodology

3.2 WORK PLAN

SI.NO	Activities	Monitorable Milestones
1.	Literature survey	10%
2.	Collections of raw materials & preliminary test	25%
3.	Casting of laminates & beams	50%
4.	Testing on laminates & beams	65%
5.	Strengthening of beams and testing	90%
6.	Discussion of results and report preparation	100%

Table 3.1 : Work Plan

CHAPTER 4

4.1 INVESTIGATION OF MATERIALS

4.1.1 Materials

M-Sand is crushed aggregates produced from hard granite stone which is cubically shaped with ground edges, washes and graded with consistency to be used a substitute for natural river sand. It is also referred to as crushed rock sand, stone sand, crusher sand and crushed fine aggregate. M-sand consists of the graded mix of coarse sand, medium sand and fine particles, known as filler grade.

Figure 4.1 : M-Sand

Geonet is the one of the Geosynthetics materials. It is a planar product, consist of ribs in two directions. Apertures are of diamond shape. It`s also referred to as Geospacers. It's one of the soil reinforcing element in highways for retaining wall construction. All are made from high density polyethylene. Two layers of stands are called “bi-planar”. Three layers are called "tri- planar".

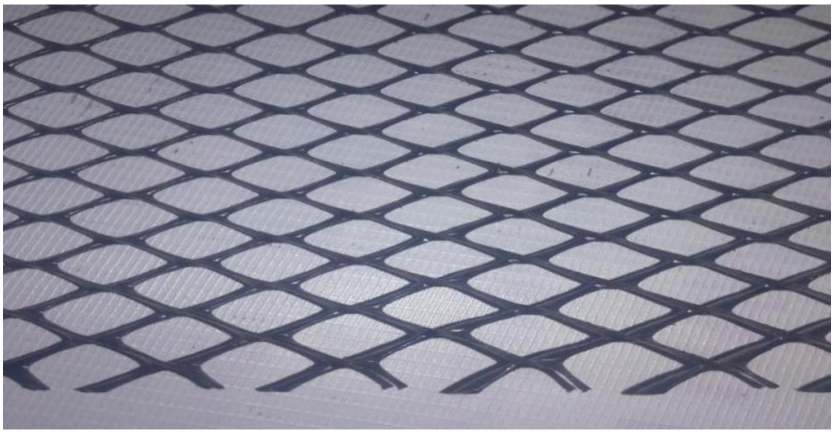

Figure 4.2 : Geonet

Table 4.1: Tensile Strength of Geonet (Reference : Internet)

Type	Thickness (mm)	Mass per unit area (gsm)	Tensile strength (kN/m)	Elongation (%)	Apparent opening size (mm)
Geonet	3.0 - 10.0	100 - 1000	10 - 200	5 - 25	5 - 15

4.1.2 SPECIFIC GRAVITY TEST

CEMENT

Empty weight of specimen (w_1) = 97 grm's Empty
weight of specimen + cement (w_2) = 297 grm's Empty
weight of specimen+cement +kerosene (w_3) = 435 grm's Empty weight of
specimen + kerosene (w_4) = 289 grm's Weight
of specific gravity of specimen+water (w_5) = 344 grm's

Specific gravity of kerosene = $(w_4-w_1) / (w_5-w_1)$

= (289-97) / (344-97)

= 0.77

Specific gravity = $(w_2-w_1) / [(w_4-w_1)-(w_3-w_2)*0.77]$

= (297-97) / [(289-97)-(435-297)*0.77]

= 3.12

COARSE AGGREGATE

Empty weight of specimen(w_1) = 719 grm's

Empty weight of specimen + coarse aggregate (w_2) = 919 grm's Empty wt.of specimen+coarse aggregate+water(w_3) = 1685 grm's Empty weight of specimen + water(w_4) = 1561 grm's

Specific gravity = $(w_2-w_1) / [(w_4-w_1)-(w_3-w_2)]$

= (919-719) / [(1561-719)-(1685-919)]

= 2.63

M-SAND (FINE AGGREGATE)

Empty weight of specimen (w_1) = 719 grm's Empty weight of specimen + M-sand (w_2) = 919 grm's Empty wt.of specimen + M-sand+ water (w_3) = 1685 grm's Empty weight of specimen + water (w_4) = 1561 grm's

Specific gravity = $(w_2-w_1) / [(w_4-w_1)-(w_3-w_2)]$

= (919-719) / [(1561-719)-(1685-919)]

= 2.3

4.2 MIX DESIGN

4.2.1 Proportioning of Concrete mix for M30 Gradeof Concrete (Without admixture):

A1. DESIGN STIPULATION FOR PROPORTIONING

Grade designation : M30

Type of cement : OPC 43 Grade

Maximum nominal size of aggregate (mm) : 20 mm Minimum cement content (kg/m^3) : 320 kg/m^3 Maximum water cement ratio : 0.45 Workability (in terms of slump value,mm) : 100 mm

Degree of supervision : Good

Type of aggregate : Crushed Angular Aggregate Maximum cement content (kg/m^3) : 450 kg/m^3

Chemical admixture (% by wt. of cement) : -----

A2. TEST DATA FOR MATERIALS

Cement used : OPC 43 Grade

Specific gravity of

- Cement : 3.12
- Coarse Aggregate : 2.63
- Fine Aggregate : 2.63
- Admixture : -----

Water absorption

- Coarse Aggregate : 0.5
- Fine Aggregate : 0.1 Free

(surface) moisture

- Coarse Aggregate : NIL
- Fine Aggregate : NIL

Sieve analysis

- Coarse Aggregate : 3.70
- Fine Aggregate (M-sand) : 2.41

B1. TARGET STRENGTH FOR MIX PROPORTIONING

$$f'_{ck} = f_{ck} + 1.65 (S)$$

Where

f'_{ck} = Target avarage compressive strength at 28 days, F_{ck} = Characteristic compressive strength at 28 days, S = Standard deviation

From Table 1, standard deviation (s) = 5 N/mm^2

Therefore target strength = 30 + 1.65 (5) = 38.25 N/mm^2

B2. SELECTION OF WATER CEMENT RATIO

Table 5, IS 456:2000

Max. Water cement Ratio = 0.45

Adopt, Water cement Ratio = 0.43 0.43 < 0.45

B3. SELECTION OF WATER CONTENT

From Table 2,

Max. Water Cement for 20 mm = 186 lit's

Estimated Water Content (100 mm slump) = 186 +(6/100)*(186)

= 198 kg/m^3

B4. CALCULATION OF CEMENT CONTENT

Water Cement ratio = 0.43

Cement content = (Water quantity/Water Cement ratio)

Cement content = (198/0.43) = 460.46 kg/m^3

B5. PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT

Proportion (%) of volume of coarse aggregate = 0.62*0.9 = 0.56

Proportion (%) of volume of fine aggregate = 1- 0.56

= 0.44

B6. MASS OF ADMIXTURE (% BY WEIGHT OF CEMENT)

Mass of admixture = % dosage * Weight of cement

= -----

MIX CALCULATION (NORMAL MIX WITHOUT ADMIXTURE)

The mix calculations per unit volume of concrete shall be as follows

A) Volume of concrete = 1m^3

B) Volume of cement = (mass of cement/spe.gravity of cement)*(1/1000)

= (450/3.12)*(1/1000)

= 0.144 m^3

C) Volume of water = (water content/spe.gravity of water)*(1/1000)

= (198/1)*(1/1000)

= 0.198 m^3

D) Volume of Admixture = (Admixture/spe.gra of admixture)*(1/1000)

= 0 m^3

E) Volume of all in aggregate

= A-(B+C+D)

= 1-(0.144+0.198+0)

= 0.658 m^3

F) Volume of coarse aggregate

= (E*% age of volume of CA*spec.gravity of CA*1000)

= (0.658*0.56*2.63*1000)

= 969.1 kg/m^3

G) Volume of fine aggregate

= (E*% age of volume of FA*spec.gravity of FA*1000)

= (0.658*0.44*2.63*1000)

= 761.14 kg/m^3

B8. MIX PROPORTIONS FOR TRIAL NUMBER (1):

Cement = 450 kg/m^3

Water = 198 lit's/m^3

Fine aggregate = 761.14 kg/m^3

Coarse aggregate = 969.1 kg/m^3

Water Cement ratio = 0.43

Admixture = ----

Hence the ratio is = **(1:0.75:1.5)**

Table 4.2 : Mix Proportions of concrete (Mix ratio: 1:1.7:2.1)

Trial Mix	Cement (kg/m3)	W/C Ratio	F.A (kg/m3)	CA (kg/m3)	Water (lit's/m3)	Admixtue (kg/m3)
NORMAL MIX	450	0.43	761.14	969.1	198	0

Keywords:

NM : Normal Mix
W/C Ratio : Water Cement Ratio
FA : Fine Aggregate
M.S : M-Sand
CA : Coarse Aggregate

CHAPTER 5

5.1 Experimental Programme

The properties of different materials to be used are determined by standard laboratory tests. The M_{30} mix design details are given in the Annexure and referred from the codal provision as per IS 456:2000 and IS 10262:2009.

Mix proportion was confirmed by trial mixes. Target slump value is 50-85 mm. The achieved slump value is 75 mm. Slump test is conducted on the fresh concrete. The cube moulds of required size (150x150x150 mm) shall be made in such a manner as to facilitate their separation into two parts. Cube moulds shall be provided with a base plate and they shall be as per IS: 10086-1982. The remixed concrete is filled the mould in three layers and each layer is damped with damping rod. As per IS: 10086-1982, the damping rod shall be 16±0.5 mm dia and 600 ±2 mm long with a rounded working end and shall be made of mild steel.

From the results 1m RC Beam were casted . The test specimens shall be stored in a place, free from vibration at a temperature of 27 ±2 C for 24 hours ± ½ hour from the time od addition of water to the dry ingredients. After this period, the specimens shall be marked and removed from the mould and, unless required for test within 24 hours, immediately submerged in clean, fresh water.

After the curing time period the beam element is tested on Universal Testing Machine (UTM). After load applying,cracks formed on the beam element. The ferrocement laminates are prepared by using Geonet. The test specimens shall be stored in a place After this period, the specimens shall be marked and removed from the mould and, unless required for test within 24 hours, immediately submerged in clean & fresh water.

After the curing period the ferrocement laminate is bonded on the beam by using epoxy resigns. After the bonding period the beam where conduct to the test on strengthened beam.

CHAPTER 6
CONCRETE PREPARING

6.1 CASTING OF CUBES

After finishing the fresh concrete tests, the concrete is filled in the cube moulds of size 150mm x 150mm x150 mm. The moulds are greased using a combination of white grease and diesel oil for an easy removal of the hardened cube. The casting of cube is done by filling the mould in three layers with 25 times of tamping in each layer. The compaction is done by using tamping rods. Compaction plays a major role in the strength of the concrete. A total of 3 specimens are casted. 3 cubes which are meant to be tested on 7 and 28 days of curing period. The casted cubes are left to harden for 24 hours and then it is cured shown in Figure 6.1.

Figure 6.1 Casted Cubes

6.2 CURING

Curing is the process of keeping the concrete moist and warm enough so that the hydration of cement can continue. It can be also described as theprocess of maintaining satisfactory moisture and favorable temperature in concrete during the period immediately following placement, so that hydration of cement may continue until the described properties are developed to a sufficient degree to meet the requirement of service. The Specimens are remoulded after 24 hours (one day) and cured for 7 to 28 days in curing tank shown in Figure 6.2. After curing period the specimens (cubes) are kept for drying and then tested.

Figure 6.2 Cubes left for curing

6.3 TESTING OF HARDENED CONCRETE PROPERTIES

One of the purpose of testing hardened concrete is to confirm that the concrete used at the site has developed the required strength. Cube compressive strength test is the most common test conducted on hardened concrete, partly because it is easy to perform and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. The specimens are placed in the 2000kN capacity of compression testing machine as shown in figure 6.3, 6.4. The axis of the specimen is carefully aligned of the testing machine. The maximum load applied to the specimens is recorded and appearances of the cracks are noted and the strength of cubes as follows table 6.1, 6.2,.

Figure 6.3 CTM Test Machine

Figure 6.4 Compressive Stress acting on cubes

Table 6.1 : Test Results on concrete cubes in 7 days curing period

S.NO	TEST DAYS	COMPRESSIVE STRENGTH (N/mm^2)
1.	7	24.8
2.	7	23.11
3.	7	25.55

Table 6.2 : Test Results on concrete cubes in 28 days curing period

S.NO	TEST DAYS	COMPRESSIVE STRENGTH (N/mm^2)
1.	28	31.02
2.	28	32.14
3.	28	35.11

CHAPTER 7

7.1 DESIGN OF REINFORCED CONCRETE BEAM

Assume Beam width 150 mm

Step 1: Beam details

Clear span = 1000 mm

Wall thickness = 150 mm

Concrete grade = 30 N/mm^2

Steel grade = 415N/mm^2

Step 2: Depth of Beam

Effective depth (deff) = span /15 = 66.66 mm

deff ≈ 150 mm

Over all depth (D) = 200 mm

Clear cover (D') = 25 mm

D = D - d' = 200-25 = 175 mm

D ≈ 200 mm

deff = 150 mm

Step 3: Effective span

Leff = Clear Span + [(2*Wall Support)/2]

= 1000 + [(2*150)/2]

Leff = 1150 mm

Leff = Clear Span + deff

= 1000 + 150

Leff = 1150 mm

Provide, (Leff) = 1150 mm

Step 4: Load calculation

Self-weight of Beam = b*D*ɣ

= 0.15*0.2*25

= 0.75 kN/m

load = 30.25 kN/m

Total load = 30.1 kN/m

Factored load = 45.15 kN/m

Step 5: Ultimate moment & shear force

Mu = $[Wu*(L(eff))^2]/8$

= $[45.15*(1.15)^2]/8$

Mu = 74.83 kNm

Shear force,

Vu = [Wu *(L(eff))]/2

= [45.15*(1.15)]/2

Vu = 24.83 kN

Limiting Ultimate Moment

Mu (lim) = $0.138*fck*b*d^2$

= $0.138*30*1000*(200)^2$

Mu (lim) = 165.6 kNm

74.83 kNm < 165.6 kNm

Mu < Mu (lim)

This beam is Singly Reinforced Beam. Hence, the section is Under-Reinforced

Step 6: Area of reinforcement (Ast)

Mu = (0.87 fy Ast d)*[(1)-(Ast 415)/(fck bd)]

Ast = 115.68 mm^2

No .of bars (n) = Ast/ast

Use, 12 mm ϕ bar

= 115.68 / (π/4)*(122)

No .of bars

= 1.86 = 2

2 bar's @ 12 mm ϕ bar

Step 7: Check for shear

Nominal shear, τv = Vu / (b*d)

= (24.83*103) / (150*200)

τv = 0.82 N/mm2

Pt = (100* Ast) /(b*d)

[IS 456:2000] (table 19)

= (100*115.68) / (150*200)

Pt = 0.38 N/mm^2

τc = 0.91 N/mm2

τv = 0.82 N/mm2

τv < τc

Hence, it's Safe

Step 8: Check for Deflection

[IS 456:2000] (Page 38, 39)

Modification factor for tension reinforcement (Kt) = 1.1

Modification factor for compression reinforcement (Kc) = 1.0

Reduction factor for ratios of span to eff.depth (Kf) = 1.4

(L/d) max = (L/d) basic*Kt*Kf*Kc

= 20*1.1*1.4*1.0

(L/d) max = 3.8

(L/d) act = (1000 / 200) = 5

(L/d) max <(L/d) act

Hence, it's safe

Step 7: Reinforcement Detail

Spacing,

Sv = (Asv*0.87*fy)/ (0.4*b)

= {[(π/4)*(d)2]*0.87*415}/(0.4*150)

Use, 6 mm ϕ bar's

Sv = 170.05 mm = 150 mm

6 mm ϕ bars of stirrups @ 150 mm c/c

7.2 CASTING OF BEAMS

After finishing the fresh concrete tests, the concrete is filled in the beam moulds of size 150 mm x 200 mm x 1000 mm. The moulds are greased using a combination of white grease and diesel oil for an easy removal of the hardened beams. The casting of beams is done by filling the mould in three layers and tamping in each layer. The compaction is done by using tamping rods. Compaction plays a major role in the strength of the concrete. A total of 3 specimens are casted. Each beams are meant to be tested on 28 days of curing period. The casted beams are left to harden for 24 hours and then it is cured shown in Figure 7.1, 7.2, 7.3,.

Figure 7.1 : RC Beam mould preparation

Figure 7.2 : Casting of RC Beams

Figure 7.3 : Remoulded RC Beam

7.3 CURING OF RC BEAMS

Curing is the process of keeping the concrete moist and warm enough so that the hydration of cement can continue. It can be also described as the process of maintaining satisfactory moisture and favorable temperature in concrete during the period immediately following placement, so that hydration of cement may continue until the described properties are developed to a sufficient degree to meet the requirement of service. The Specimens are remoulded after 24 hours (one day) and cured for 28 days in curing tank. After curing period the specimens (RC Beams) are kept for drying and then tested.

7.4 TEST OF RC BEAMS

One of the purpose of testing hardened concrete is to confirm that the concrete used at the site has developed the required strength. RC Beams where tested in flexural strength test at Universal Testing Machine (UTM). The Universal Testing Machine (UTM) is used for performing shear, compression and tension. There are two types of UTM.

- Screw type
- Hydraulic type

Details of UTM,

- Capacity : 500 KN
- Range

Three set of RC beams of the same dimension (width 150 mm, thickness 200 mm and span 1000 mm) are tested up to ultimate load by two point loading system as a simply supported beam.

0 to 500 KN the maximum load applied to the specimens is recorded and appearances of the cracks are noted by using dial gauge and the strength of RC Beams as follows in table 7.1 and figure 7.4, 7.5, 7.6,.

Figure 7.4 : Cracked Beam

Figure 7.5 : UTM Test Machine

Table 7.1 : Test Results of RC Beams in 28 days curing period

S.No	Specimen (RC Beam)	Test days (curing)	Load (KN)	Deflection (mm)
1.			40	0
2.			50	0.5
3.			60	2
4.			70	3
5.	RC Beam - 1	28	80	4.5
6.			90	5
7.			100	6
8.			105	7
9.			110	8
10.			120	8.8
11.			5	0
12.			10	0.5
13.			30	1
14.			40	2
15.	RC Beam - 2	28	50	3
16.			80	4
17.			100	5
18.			110	6
19.			120	7
20.			130	8.5
21.			10	0.5
22.			20	2
23.			45	3
24.			60	4.5
25.	RC Beam - 3	28	85	5
26.			100	6
27.			125	8.5
28.			135	8.8
29.			145	9
30.			152.4	10

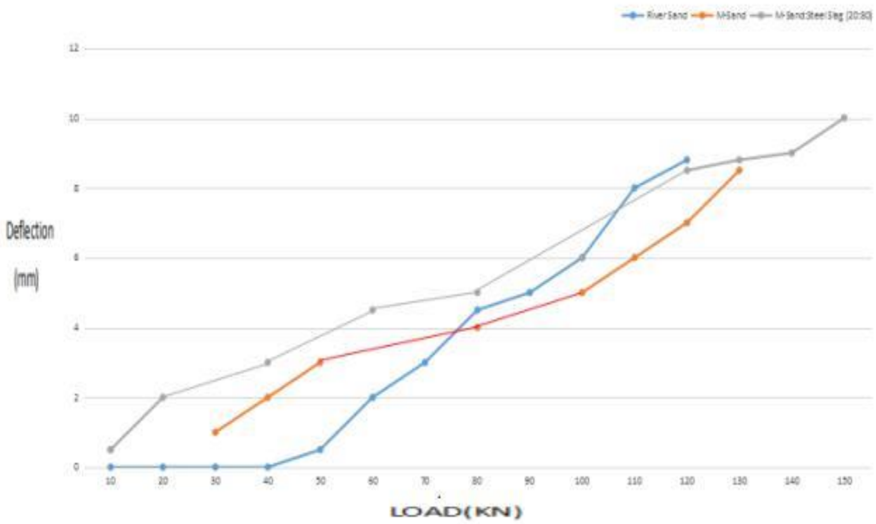

Figure 7.6 : RC Beam Test Results

CHAPTER 8

8.1 DEFINITION OF FERROCEMENT

Ferrocement is a thin walled concrete commonly constructed of hydraulic cement mortar reinforced with closely spaced layers of continuous and relatively small mesh. The mesh may be of Geonet (Geo synthetics materials).

8.2 CASTING OF FERROCEMENT

The mortar mix proportion was 1:2 with water cement ratio of 0.4. The Geonet (Geosynthetics Material) Mesh was used. Commercially available CERA BOND EP Epoxy resin was used for bonding purpose.

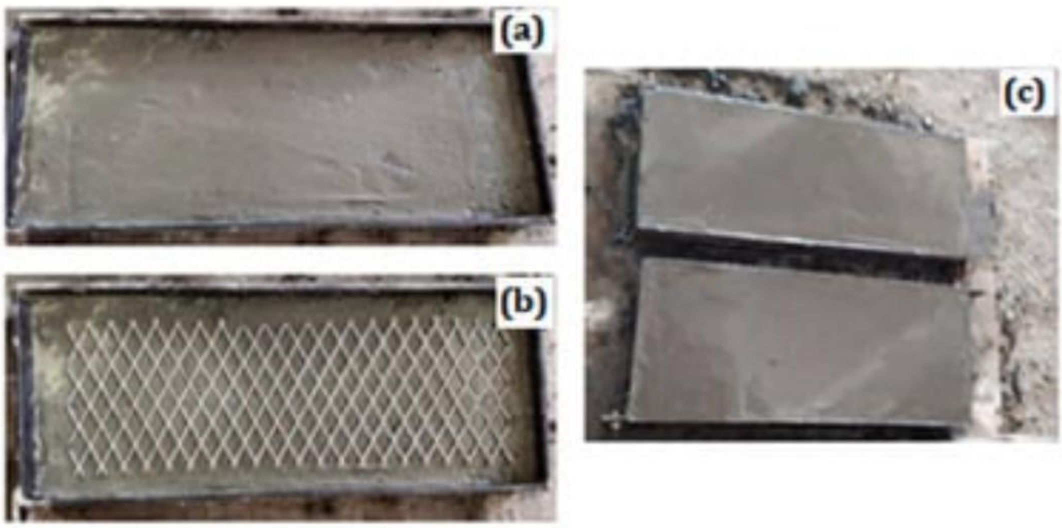

Figure 8.1 : Geonet Ferrocement Laminates

8.3 CURRING OF FERROCEMENT

The Specimens are remoulded after 24 hours (one day) and cured for 7 to 28 days in curing tank.

8.4 STRENGTHENING OF RC BEAM

The beams and laminates were cured for 28 days. After curing, all the specimens were allowed to surface dry for 24 hours at room temperature. The tension side of the beams and bonding face of the ferrocement laminates were roughened using a wire brush to remove the surface laitance and to expose the rough surface. After surface preparation, the adhesive component, i.e., epoxy resin were mixed thoroughly and applied to the prepared surface of beams and ferrocement laminates using trowel. Then, ferrocement laminates were placed in position. The epoxy resin used for bonding the ferrocement laminates to the tension face of the RC beams.

The beams strengthened with ferrocement laminates were allowed to cure in the air for 7 days.

8.5 TESTING OF STRENGTHENED BEAM

After 7 days of air curing, the control beam and strengthened beams were subject to flexural test under two-point loading in Universal Testing Machine of 500 KN capacity. All the beams were simply supported with an effective span of 1000 mm. Hydraulic jack with 500 KN capacity was used to apply load. The load was applied in increments of 2 kN and at each stage mid span deflection was noted using a dial gauge having a least count of 0.01 mm. The initializations of flexural crack were carefully observed and corresponding load and deflection were noted. The ultimate load and the mode of failure of the specimen were noted. The detail of test setup is shown in Figure 8.2,.

Figure 8.2 : UTM Test on Strengthened Beam

Table 8.1 : Test Results of Strengthened Beams in 28 days curing period

S.No	Specimen (RC Beam)	Test days (curing)	Load (KN)	Deflection (mm)
1.			40	0
2.			50	0
3.			60	0.5
4.			70	2
5.	RC Beam - 1	28	80	3
6.			90	4.5
7.			100	5
8.			105	5.5
9.			110	6
10.			120	7
11.			5	0
12.			10	0
13.			30	0
14.			40	0.5
15.	RC Beam - 2	28	50	2
16.			80	3
17.			100	4.5
18.			110	5.5
19.			120	7.5
20.			130	8
21.			10	0
22.			20	0
23.			45	0
24.			60	2.5
25.	RC Beam - 3	28	85	4.5
26.			100	5
27.			125	6
28.			135	8.5
29.			145	8.8
30.			152.4	9

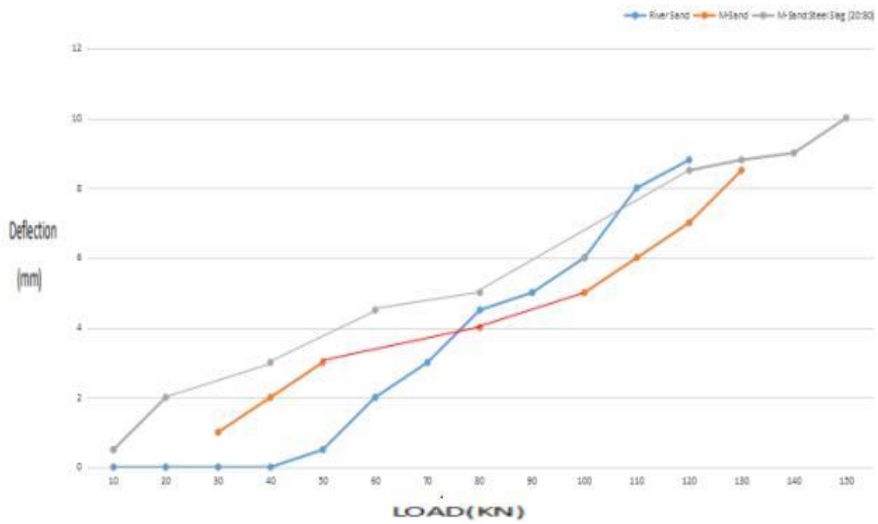

Figure 8.3 : Strengthened Beam Test Results

CONCLUSION

Within the scope of the flexural test of this research, the following conclusions are drawn:

The failure of the composite beam is characterized by development of flexural cracks over the tension zone. The spacing of the cracks is also reduced for strengthened beam. This indicates the better stress distribution.

From this test results, difference between the normal beams (table 6.3) and repaired beams (table 6.4), it was concluded that the beams with bottom layer of ferrocement overlay (repairing) gave comparatively good performance.

The strength of beam using Geonet Ferrocement laminated was increased.

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