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Strengthening of RC Beam Using Ferro Cement Laminates

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Abstract: Strengthening of reinforced concrete structure improves the load carrying capacity and extends their service life. To extend the life span of damaged RC beam, strengthening is required and this can be effectively achieved using Ferro cement. Ferro cement 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. Ferro cement is a construction material that proved to have superior qualities of crack control impact resistance. In recent years, the use of Ferro cement laminates has become a subject of great interest in structural engineering community. The mesh may be made of metallic or other suitable materials. Ferro cement is a composite material of woven mesh and weld mesh embedded in mortal with various volume fractions. The main objectives of this research work are to study the flexural behavior of per damager RC beam with varies Ferro cement configuration under two-point loading, to compare the experimental results of strengthened pre damaged RC beam for the parameters likes first crack load, ultimate load carrying capacity, stiffness and energy dissipation. In the current research, an experimental implementation will be done by casting and testing of beams. Five reinforced concrete beam of size 100 x 150 x 1100 mm are cast. Out of which four beams were pre damaged under load at one third with 60% of point ultimate load of the beam. The strengthen of damaged beams were with Ferro cement laminates constitutes chicken mesh and weld mesh with 2 and 3 layers were made. An analytical model was created with ANSYS. Further, the experiment result was compared with analytical results.

Keywords: Cement, Coarse aggregate, Fine aggregate, Strengthening of RC beam.

I. INTRODUCTION

Concrete is widely used and attached various applications in construction Arena. In the First World War, barges and ships were made with reinforced concrete, due to shortages of materials, particularly steel This was again attempted during the Second World War. Now a days Ferro cement is widely utilized. Technical information on Ferro cement is the International Ferro cement Centre (IFIC), RILEM, the American Concrete Institute, IASSS and many national canter's. The journal of Ferro cement, is published at the Asian Institute of Technology in Bangkok, presents regular advances in research, standards and applications related to Ferro cement. Ferro cement is a thin composite material made of cement mortar reinforced with uniformly distributed layers of continuous, relatively small diameter, wire meshes. mesh is made of metallic. It is used to construct relatively thin, hard, strong surfaces in many shapes such as shell roof, water tanks.

II. EXPERIMENTAL PROGRAM

2.1 Materials

The materials used in this research are ordinary Portland cement, natural fine aggregate, coarse aggregate, steel and reinforcing mesh. One of the essential components of Ferro cement is wire mesh. Different type of wire mesh is available almost everywhere, these generally consist of thin wires either woven or welded into the mesh but main requirement is that it must be easily handled and if necessary, flexible enough to be bent around sharp corners.

The function of wire mesh and reinforcing rod is to provide the form and to support the mortar in its green state. In the hardened state, its function is to absorb the tensile stresses on the structure, which the mortar on its own would not be able to withstand.

The cement used should confirm to IS specifications. There are several types of cements available commercially in the market of which Portland cement is the most well-known & available everywhere. Cement of Portland variety produced today is satisfactory enough to serve the purpose of Ferro cement construction. The most common aggregate used in Ferro cement is sand. Sand should comply with IS standard for fine aggregate. Aggregate is the term given to the inert material and it occupies 60 % to 80 % of the volume of mortar. Aggregates to be used for the production of high-quality mortar for Ferro cement structure must be strong enough, impermeable and capable of producing a sufficiently workable mix with minimum water / cement ratio to achieve proper penetration of wire mesh.

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The quality of mixing water for mortar has a visual effect on the resulting hardened Ferro cement. Impurities in water may interfere with setting of cement and will adversely affect the strength of cause staining of its surface and may lead to its corrosion of Ferro cement. Usually water that is piped from the public supplies is regarded as satisfactory.
Galvanized square welded steel wire mesh of 2.4mm diameter with square grids was used in ferrocement jacket. The grid size of mesh was 12mm X 12mm. Cement used for the specimen were ordinary Portland cement. The cement used was in standard gunny bags and transferred to latter to air tight steel drums to avoid deterioration of the quality. The specific gravity of cement was determined by 576-1964(10) and found to be 3.15. HYSD steel of grade Fe-415 of 10mm diameter bars will be used as main reinforcement and 8mm bars will be as shear stirrups. Galvanized square welded steel wire mesh of 2.4mm diameter with square grids was used in ferrocement jacket. The grid size of mesh was 12mm X 12mm. M20 grade concrete mix is designed as per standard design procedure using the properties of materials as discussed and provided. The water-cement ratio which will be used is 0.45. The mix proportion of material comes out to be 1:1.5:3 (cement: sand: aggregate).
Before bonding the fabricated ferrocement laminates on the soffit (tension side) to the concrete beam, surface was made rough using sand blasting and cleaned with an air blower to remove all dirt and debris. Once the surface is prepared to the required standard, the epoxy resin was mixed in accordance with manufacturer's instruction. Mixing was carried out in a metal container is based to hardener ratio of 1:2 and was continued until the mixer obtained uniform colour. Then it was applied both on laminate and beam surface and bonded properly without any air gap. The strengthen beam with ferrocement laminates is shown in Figure 4.7

2.2 Experimental setup
Two-point loading system was adopted for this test. The specification for the beam is shown in table 4.1. At the end of each load increment, deflection, ultimate load was carefully observed and recorded. The ultimate load for the control beam was found out. Then the other two beams were tested for service load and rehabilitated with Ferro cement laminates. The strengthened beams were again tested by two-point loading and at the end of each load increment, the deflection was carefully observed and recorded.

Table 1.1 Specification for the beam

S.NO	BEAM SPECIFICATION
1	Conventional Beam
2	RC beam strengthened with 2 layer weld mesh using Ferro cement laminates
3	RC beam strengthened with 3 layer weld mesh using Ferro cement laminates
4	RC beam strengthened with 2 layer chicken mesh using Ferro cement laminates
5	RC beam strengthened with 3 layer chicken mesh using Ferro cement laminates

III. DESIGN REQUIREMENTS FOR FERRO CEMENT

(a) Reinforcement
The total volume of reinforcement in Ferro cement ranges 5-8 % by volume of structural elements. The reinforcement used in Ferro cement is of two types- skeletal steel and wire mesh. skeletal steel comprises relatively large diameter (about 3 to 8 mm) steel rods spaced typically at 70 to 100 mm. Skeletal reinforcement consists either welded mesh or mild steel bars. The skeletal steel frame is made confirming exactly to the shape and geometry of the structure and is used for holding the wire mesh in position and shape of the structure. The wire meshes are usually 0.5 mm to 1.5 mm in diameter and spaced 5 mm to 25 mm apart and volume of mesh ranges from 0.2 % to 3 % of total volume of structural element. The wire mesh may be galvanized or un galvanized. If the wire mesh is galvanized and used along with un galvanized mild steel bars, then chromium trioxide at the rate of 100 to 300 parts per million by weight of water should be added in preparing the mortar. This effectively reduces the reaction between the galvanized mesh and the un galvanized spacing between the layer of mesh. Wire mesh reinforcement should confirm to the ASTM standard A-185.Welded wire mesh have a higher Young's Modulus and hence higher stiffness and less cracking early state of loading. The minimum yielding strength of wire should be 450 N/mm^2 for smooth wires & 480 N/mm^2 for deformed wires.

(b) Matrix
The matrix is a particulate composite consisting of fine aggregate bonded by the hydrated cement. Generally the matrix with cement sand ratio of 1:1.5 or 1:2 is desirable for the Ferro cement applications. Use of 1:3 ratio ,even lean mixes is also reported.

(c) Coatings
surface coating, it may be protected To increase durability of fibrocement, such As Acrylic, Latex, Polyester and cement based paints.

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(d) Cover
Minimum cover 2 mm to 5 mm to the outer most mesh layer is required.

(e) Water /Cement Ratio
Between 0.35 and 0.5 Water /Cement ratio are required.

IV. TESTING

In the present work ANSYS is used to study the analytical behaviour of strengthened RC beams. ANSYS, Inc. is an American computer- aided engineering software developer headquartered south of Pittsburgh in Cecil Township, Pennsylvania, and United States. ANSYS publishes engineering analysis software across a range of disciplines including finite element analysis, structural analysis, computational fluid dynamics, explicit and implicit methods, and transfer.

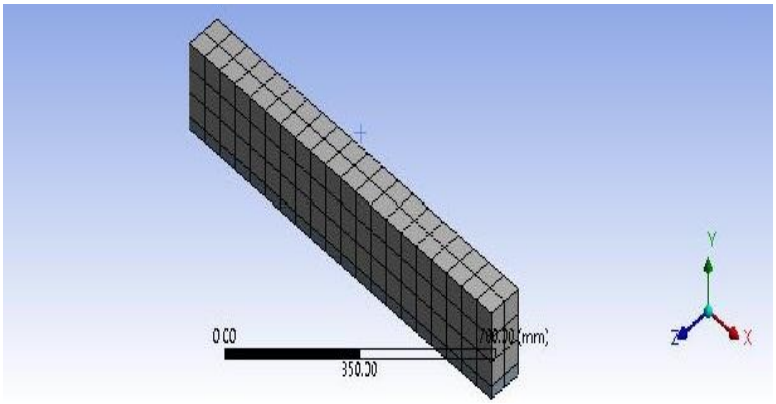
4.1 ANSYS

ANSYS is an easy to use virtual- proto typing and modular simulation system that extends to meet our needs, making it a low risk investment we can expand as value is demonstrated. It is scalable to all our organizational levels, degree of analysis complexity and stage of product development. ANSYS is a finite element analysis tool for structural analysis, including linear, nonlinear and dynamic studies. This computer simulation product provides finite elements to model behavior, and support material models and equation solver for a wide range of mechanical design problems. ANSYS also includes thermal analysis and couple-physics capabilities involving acoustics, piezoelectric, thermal-structural and thermo electric analysis. ANSYS is a general nonlinear multiphasic and thermodynamic analysis, continuum flow analysis, analysis of electromagnetic fields and acoustic analysis.

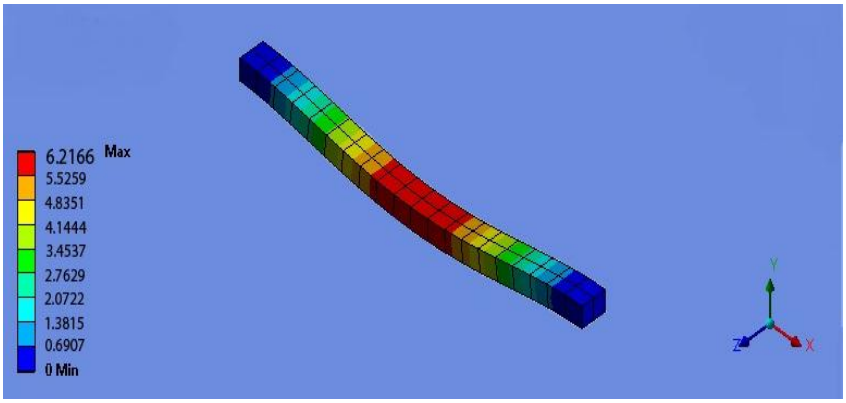
V. MODEL DESCRIPTION

ANSYS is used to construct the Finite Element Model for conventional beam, strengthened RC beam using Ferro cement which is shown in Figure 5.1. The fixed end conditions are used for this analysis. The deflections of conventional beam, strengthened RC beam using Ferro cement.

a) Design of beam



b) Conventional Beam



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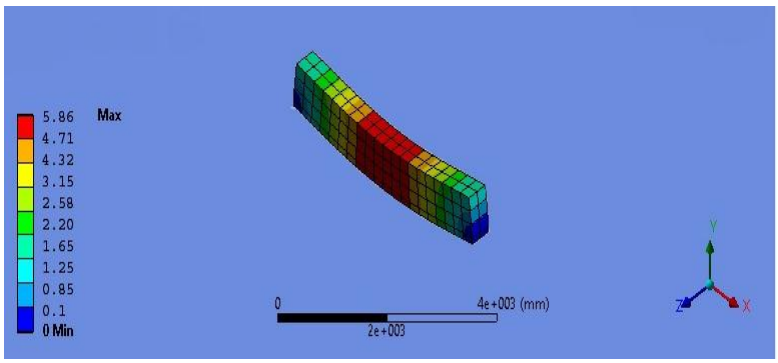
c) Three-layer weld mesh



d) Three-layer chicken mesh

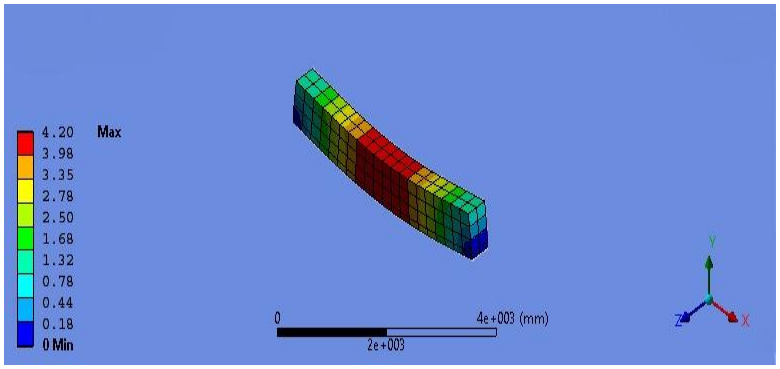


Figure 1.1 Modeling of RC beam

VI. RESULTS AND DISCUSSION

6.1 Load – deflection curve

From the analytical results the load – deflection curve of specimens is drawn.

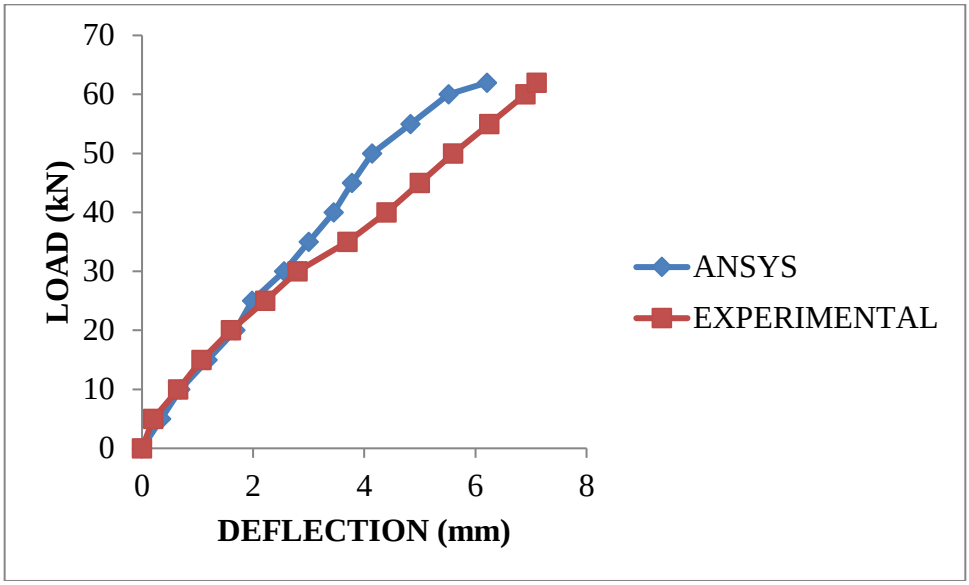


Figure 1.2 comparison of Conventional Beam

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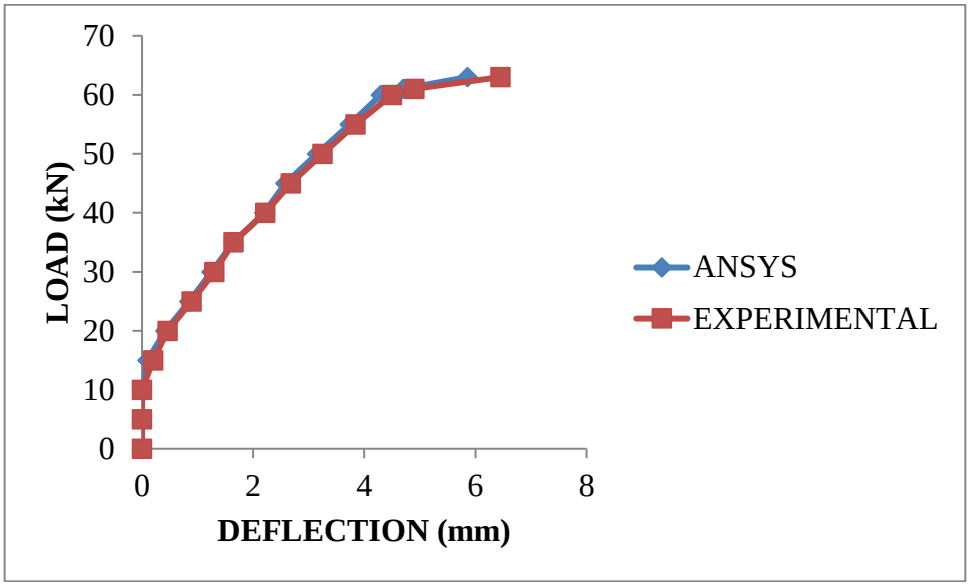

Figure 1.3 comparison of 3-layer weld mesh

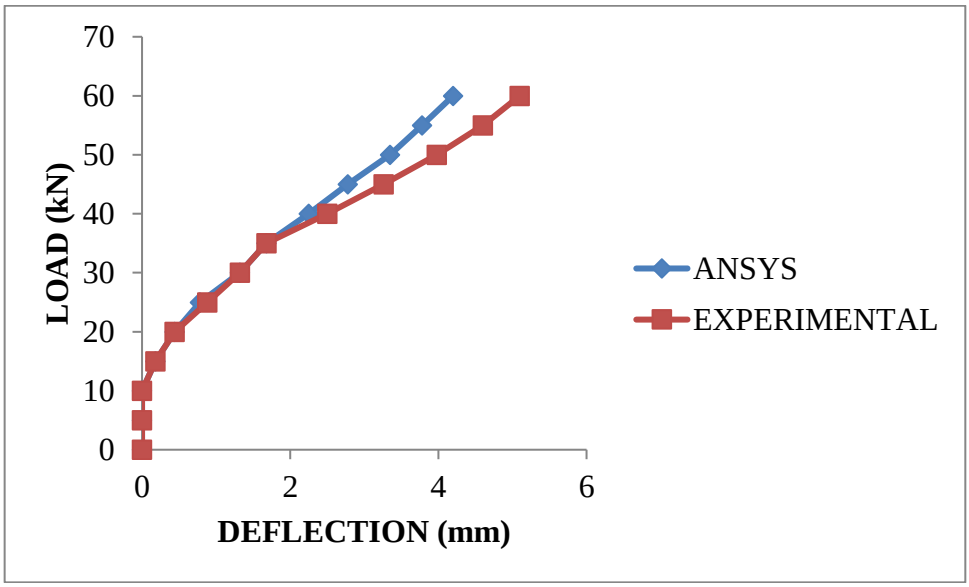

Figure 1.4 comparison of 3-layer chicken mesh

The load vs deflection behaviour of strengthened RC beam for Analytical and Experimental investigation as show in Figure 5.2, 5.3, 5.4. From the figure it is clear that load vs deflection behaviour of experimental investigation go in hand with analytical investigation.

VII. CONCLUSION

From the experimental and analytical investigation carried out to study the strengthening of pre damaged RC beams using Ferro cement laminates, following conclusion has been made

1. The first crack load for the Ferro cement laminates of 3 layer weld mesh of RC beam was 1.15 times greater than conventional RC beam. In the case of RC beams strengthened with Ferro cement laminates the first crack load was found to be increased by 13.67% for 2 layer of weld mesh, 30.33% for 3 layer of weld mesh, 1.6% for 2 layer of chicken mesh and 8.13% for 3 layer of chicken mesh with reference to control beam.
2. The ultimate load carrying capacity for the Ferro cement laminates of 3 layer weld mesh of RC beam was 1.00 times greater than conventional RC beam. The ultimate load was found to be enhanced by 1.21% for 2 layer of weld mesh, 14.42% for 3 layer of weld mesh, 0.22% for 2 layer of chicken mesh and 4.738% for 3 layer of chicken mesh with reference to control beam.
3. The stiffness for the Ferro cement laminates of 3 layer weld mesh of RC beam was 1.41 times greater than conventional RC beam. The stiffness for 2 layer of weld mesh, 3 layer of weld mesh, 2 layer of chicken mesh and 3

layer of chicken mesh beams are about 10.79%, 53.86%, 33.70% and 32.15% respectively more than that of conventional RC beam

4. The ductility value of the Ferro cement laminates of 3-layer weld mesh of RC beam was 1.29 times greater than conventional RC beam. The ductility factor was found to be increased by 53.15%, 68.07%, 52.10% and 54.14% for 2 layer of weld mesh, 3 layer of weld mesh, 2 layer of chicken mesh and 3 layer of chicken mesh respectively as that of control specimen
5. The energy absorption of the Ferro cement laminates of 3 layer of weld mesh of RC beam was 1.14 times greater than conventional RC beam. The energy absorption capacity was found to be increased by 22.61% for 2 layer of weld mesh, 33.57% for 3 layer of weld mesh, 3.233% for 2 layer of chicken mesh and 7.00% for 3 layer of chicken mesh as that of control specimen.
6. The analytical results of Ultimate load, Energy absorption and Stiffness go in hand with experimental investigation for all the RC beams.

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