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INVESTIGATION REPORT ON PRELIMINARY TESTS ON FAILURE OF STRUCTURE AND MONITORING

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Abstract - *In this Research, various details for structural failures like Faulty Design, Inferior quality of materials, Poor Workmanship, Weathering conditions, Natural calamities etc., have been discussed. It is also discussed about the various methods of doing the repair woks that is remedial measures. To know better about the nature of concrete elements, ten (10) concrete beams with nominal reinforcement have been cast. All the beams were subjected to loading test in Loading Frame at Nova Engineering College, Jangareddygudem, Eluru (District), Andhra Pradesh, India. Three beams were kept as control specimens. Allthe beams were first tested up to initial crack condition. The control specimens were tested up to ultimate failure. The values of load and deflections were obtained and tabulated. The repair materials used are GPRF of 225 GSM, 300 GSM, 400 GSM, Jute Fiber and Steel Jacket. After curing they were tested up to failure. The values of Load and Deflections were noted. Load Cells are used for noting down the Deflections. From the values obtained it was noted that, out of all the methods applied Steel Jacketing is found to be the most effective and also most economical. So that method is recommended for the concrete repairing work.*

Key Words: Rehabilitation Materials, Tensile Test on Steel, Strength Test on Concrete, Jute Fiber, Comparison of Load Vs Deflection Curve.

1. INTRODUCTION

In early days man used to live in huts which were constructed with the materials available in abundance in nature. They could build their huts in safe places which were not affected by natural calamities by experience. If anything happened like failure they could repair them withthe least cost materials available in nature. But due to increase in population and the invention of new building materials, it becomes important to know about structural failures in a building and remedial measures to be done. Failures in engineering construction are caused by deterioration of various building materials with age due to various causes. Awareness about various agencies causing deterioration is essential to understand the problem and to find out the solution. All Civil constructions are subjected to failures in one or other way at a particular time except some important monuments like The TajMahal, The KutubMinar, The Great Wall at China, The White House etc., The failures of buildings are broadly divided into two types. Structural failures and the other is nonstructural failures. Structural failure affects the structures in a noticeable way and also the life of the occupants. Structural failure means the failure of a concrete construction to fulfill the purpose for which it was constructed. Nonstructural failures includes defects in brickwork, defects in plaster work, defects in plumbing work, and defects in electrical work etc., which do not affect the safety of structure to a greatextent in grand manner. The past of failure of structures happening from very olden time from 300A.D. and lasts till date. Figure 1.1 shows the strong of a tall structure into two portions in a vertical manner at Oogue at Siberia.

Fig -1: Splitting of a tall structure into two portions in a vertical manner atOogue at Siberia

1.1 Types of Failure and the Reason for Failure

General structural failures are Cracks, Damping, Leakage and Spalling etc. and these show weakness of buildings. The reason for these failures may be

1. Inferior quality of materials
2. Poor workmanship

3. Improper study
4. Weathering actions
5. Effect of chemicals
6. Fire Hazards
7. Faculty construction
8. Faculty system of maintenance
9. Environmental aspects
10. Biological growth

2. METHODOLOGY

2.1 Objectives

The objectives of the thesis are

- To find the failure mode (development of crack) on the beam when it reached thecracking load and ultimate load.
- To carryout different Rehabilitation Methods.
- To identify the best method of rehabilitation in aspect of strength and deflection.

2.2 Specimen Preparation

The beam size is 150mm X 200mm with span of 1500mm. The grade of concrete is M25 and steel is Fe415 TMT bars. The beam has been castby using OPC 43 grade cement with the water-cement ratio of 0.4. For Tension and compression Reinforcement two numbers of 12mm diarod areprovided, 8mm dia rod is provided as shear reinforcement at 100mm c/c distance. Shear reinforcement is provided with two legs, with a leg length of 35mm. For beam specimen typical cross section drawing of beam is shown in Figure 3.2 with the details of its size and reinforcement details and its longitudinal section in Figure 3.3.

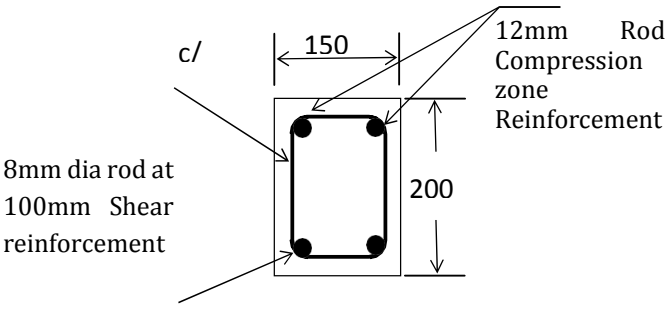

Fig -2: Cross Section of Beam

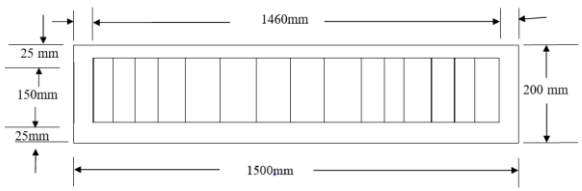

Fig -3: Longitudinal Section of Beam

2.2 Testing

The beams of eighteen numbers were casted. After curing they were tested with the Loading Frame. Three beams were kept as control specimens and tested for Ultimate Load and the corresponding Deflection was noted. The average value is calculated. Similarly other beams were grouped into five groups each containing three beams. All the beams are first tested up to initial crack condition. To the cracked beams five methods of retrofitting or rehabilitation was done. The Rehabilitation methods consisted of Wrapping Technique using GFRP of 225GSM,400 GSM, 300 CSM and Jute Fiber and Steel Jacketing was done for them. Then the repaired beams were tested up to ultimate failures. To cross check the experimental work, theoretical calculation is done for control Specimen in Limit State Design Method by the clauses which is stated under IS 456-2000 code and compared with the ultimate load which was obtained from the experimental test. With the testing results comparison of Ultimate Load Carrying Capacity and Deflections atthat Load were done for all the five methods of Retrofitting with the Control Specimen. From the result the conclusion was arrived.

3. PRELIMINARY TESTS

As this thesis mainly concentrates on study of structural failures, mainly cracks, it hasbeen decided to cast beams which are main component of any construction. So the materials used for casting should be tested for their properties. Then the beams are casted. As preliminary work all base materials are tested for necessary properties like specific gravity, water absorption, sieve analysis, initial setting time-final setting time for cement, cube test for concrete and cement are done as per prescribed IS codes. For this project, 20mm Size aggregate is used as Coarse aggregate and natural sand is used as fine aggregate. And the size of aggregate both fine and coarse is within limits as stated in**IS 383**.

Cement used for this specimen is OPC 43 grade conforming to **IS 8112 -1969**. It istested according to **IS:460 - 1962** and the results were summarized as follows:

Fineness Modules of cement	of=	3 %
Specific Gravity of cement	of=	2.46
Consistency of Cement	=	35%
Initial setting time	=	30 Min. IS: 4031 (Part 6)
Final setting time	=	600 Min.

3.1 Test Results for Fine Aggregate

Fine Aggregate used for this specimen is tested according to **IS:2386(Part 3) -1963** andthe results were summarized as follows:

Specific Gravity of Fine Aggregate is = 2.55
Water Absorption of Fine Aggregate is= 1.23 %

Percentage of Fineness modulus is 5.349 **(Zone III) (IS: 2386 (Part -1) - 1963)**

3.2 Test Results for Coarse Aggregate

Specific Gravity 20mm Aggregate	=	2.887
Gradation of Aggregate	=	5.28%
Water Absorption	=	1%
Flakiness Index	=	14.26%
Elongation Index	=	24.36%
Impact value of Aggregate	=	11.41%

IS: 2386(Part 4) -1963

3.3 Strength Test on Concrete

For checking the concrete strength with the design mix, cubes are casted and tested forcompression strength and Tensile strength.

Compressive Strength of Concrete Cube	=	27.8N/ mm^2
Tensile strength of Concrete	=	2.56N/ mm^2 (10% of f_{ck})
Flexural strength of concrete	=	31.6N/ mm^2

Fig -1: Compression Test on Cube

3.4 Chopped Strand Mat

Chopped Strand Mat is also shortly known as CSM. It will have chopped glass fiber which is 3 to 4 inches in length and the fiber runs in multi-directions. Usually chopped strand fiber mat is compatible only with the resin like polyester and vinyl ester. Epoxy resin will not have compatibility with the chopped strand mat. Chopped strand mats can be torn by using hand; these mats are used in specific region to increase the strength of the area.

Fig -2: Chopped Strand Mat

3.5 Jute Fiber

Jute Fiber is one of the easily available materials in India. The manufacturing process of the jute fiber is much easy and it is the done as a homemade business in many of the small villages in India. When jute fiber is compared with the glass fiber in the aspect of the cost it is much cheaper material. But in the aspect of the strength jute will not perform as much as glass fiber, still jute is used for rehabilitation work because of its availability and low cost of the material.

Fig -3: Jute Fiber

4. PRELIMINARY TESTS

The beam size is 150mm X 200mm with span of 1500mm. The grade of concrete is M25 and steel is Fe415 TMT bars. The beam has been castby using OPC 43 grade cement with the water-cement ratio of 0.4. For Tension and compression Reinforcement two numbers of 12mm dia. rod are provided, 8mm dia. rod is provided as shear reinforcement

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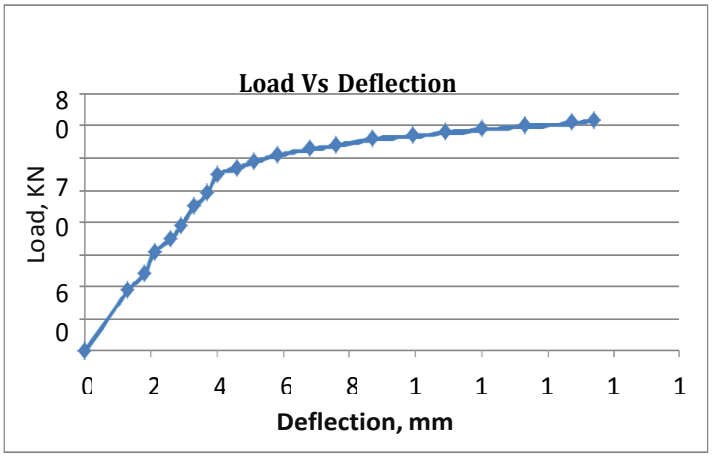

Chart -1: Load vs Deflection curve-control specimen

Fig -4: GFRP Wrapped Beam - 225GSM

Fig -5: After applying Polyester Resin for bonding – 225 GSM

Fig-6: GFRP Wrapped Beam – 400GSM

5. EXPERIMENTAL WORK

During the experimental work it was observed that when the beam reaches the cracking load the initial cracks are formed. After formation of initial cracks, continous applying of theload, the initial crack has been developed into broader and deeper crack, which makes the beam incapable to carry loads, thus ultimate load is attained by the beam. As a flexural member, due to deflection crack is formed at the middle 1/3 portion of the beam. This beam is designed as an under-reinforced beam so that the failure of the concrete takes place first by the formation of crack. This kind of beam is safe, because we can get warning of stress in beam by the crack appearance. If the beam is reinforced as over reinforced beam steel will fail first due to failure of steel, concrete will fail immediately, therefore we can't get any kind of warning from the beam member.

Fig-7: Crack Due to Ultimate Load

6. CONCLUSIONS

The problem of structural failure has been taken with intention of providing remedial methods to solve the problem. Though there are so many structural failures like cracks, leakage, dampness, spalling and others, the thesis dealt with cracks in beams. Beams are the most important part of any structure. With the detailed study and survey of literature related to structural failures and retrofitting methods, practical work to be done was decided. Before casting beams the base materials were selected and their properties were tested confirmed with IS Codes. Totally Eighteen beams were casted and tested. The report was presented.

- For the control specimens the mean cracking load is 65.33kN. The mean deflection is 14.1mm.
- For the beam rehabilitated by GFRP 225 GSM the average ultimate load taken by the beam is 72kN. So the load bearing capacity is increased by 10% . The deflection is 15.37mm which is increased by 9.7%.
- For the beam rehabilitated by GFRP 400 GSM the average ultimate load taken by the beam is 85.67kN. The load bearing capacity is increased by 31% . The deflection is 16.73mm which is increased by 18%.
- For the beam rehabilitated by GFRP 300 GSM the average ultimate load taken by the beam is 71kN. The load bearing capacity is increased by 9% . The deflection is 13.27mm which is more than 0.83mm when compared with control specimen.
- For the beam rehabilitated by Jute Fiber the average ultimate load taken by the beam is 68.33kN. The load bearing capacity is increased by 5% . But the deflection is 12.43mm which is less than 14% when compared with control specimen.
- For the beam rehabilitated by the Steel Jacketing method the mean value of Ultimate loadis 111kN. The ultimate load carrying capacity is increased by 70% and the deflection is 11.9mm which is also decreased by 16%.

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