RETROFITTING OF PCC BEAM

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ABSTRACT

The awareness on strengthening of structures came into being in the minds of engineers and scientists during the 1960s. Strengthening technique was essentially originated and developed keeping the bridge structures in mind. This technique was particularly a dire need for bridges because alternate solutions may affect the traffic conditions very seriously for a prolonged or unacceptable span of time. Further, it is always desirable to strengthen the structures rather than rebuild them. As long as effective techniques are available it is preferable to strengthen the structures to derive environmental and economic benefits out of such ventures.
Retrofitting is making changes to an existing building to protect it from flooding or other hazards such as high winds and earthquakes. You have already seen an example of these changes, and you'll learn more in the following chapters. But you may be wondering at this point why retrofitting is necessary.
One reason is that construction technology, including both methods and materials, continues to improve, as does our knowledge of hazards and their effects on buildings. Many houses existing today were built when little was known about where and how often floods and other hazardous events would occur or how buildings should be protected, and houses being built today may benefit from improvements based on what we learn in the future. As a result, retrofitting has become a necessary and important tool in hazard mitigation.

Keywords: *Retrofitting, damage detection, strengthening, hazard prevention.*

1. INTRODUCTION

Retrofitting is the modification of existing structures to make them more resistant to external force quantities. The objectives like Upgraded loading requirements; damage by accidents and environmental conditions, rectification of initial design flaws, change of usage can be achieved by retrofitting. The solutions adopted are generally based on successful prior practice. It is necessary to take a decision whether to demolish a distressed structure or to restore the same for effective load carrying system. Many a times, the level of distress is such that with minimum restoration measure the building structure can be brought back to its normalcy and in such situation, retrofitting is preferred. One of the techniques of strengthening of the RC structural members is through confinement with a composite enclosure. FRP material, which are available in the form of sheet, are being used to strengthen a variety of RC elements to enhance the flexural, shear, and axial load carrying capacity of these elements.

The proposed technique consists of applying Glass Fiber Reinforced polymer (GFRP) & Carbon Fiber Reinforced polymer (CFRP) to the bottom surface and sides of the concrete beam (PCC & RCC) to increase its stiffness and flexural strength. This study clearly demonstrated the effectiveness of the proposed technique in retrofitting of reinforced concrete beam. Structures deteriorate due to problems associated with reinforced concrete. Natural disasters like earthquakes have repeatedly demonstrated the susceptibility of existing structures to seismic effect and hence implements like retrofitting and rehabilitation of deteriorated structures are important in high seismic regions.

The challenge of SHM gets bigger when it is not possible to excite the structure with active sources due to weight or power constraints and also when the operational condition is not known. In these cases, the SHM must be carried out using only the vibration responses. On the other hand, when some knowledge about the physics of the system is available, its behavior can be simulated theoretically or numerically. However, physics-based assessment approaches are usually computationally intensive. In order to overcome this difficulty, data-based techniques can be used. They rely only on previous measurements performed on the healthy system and should be able to indicate changes in the material and/or geometric properties, boundary conditions, and system connectivity. Some methodologies combine these two approaches (physics-based and data-based) to reach a better confidence level in SHM processes. Due to the drawbacks of the physics-based techniques, the present work deals with the use of data-based assessment procedure.

1.1 METHODOLOGY

The full wrapping technique around all the four sides of the beam is used as the method of retrofitting. At the time of bonding of fiber, the concrete surface is made rough using a wire brush and then cleaned with water to remove all dirt and debris. The beams are allowed to dry for 24 hours. The fibre sheets are cut according to their size. After that, the epoxy resin primer is mixed in accordance with manufacturer's instructions. The mixing is carried out in a plastic container (Base: Hardener = 4Kg: 2 Kg). After uniform mixing, the epoxy resin primer is applied to the concrete surface. The beams are allowed to cure for 8 hours.

The epoxy matrix is mixed in a plastic container in accordance with the manufacturer's instructions to produce a uniform mix of base and hardener (Base: Hardener = 3.7 : 1.3). The coating is applied on the beams and fibre sheets for effective bonding of the sheets with the concrete surface. Then the fibre sheet is placed on top of epoxy resin coating and the resin is squeezed through the roving of the fabric. Air bubbles entrapped at the epoxy/concrete or epoxy/fabric interface are eliminated, during hardening of the epoxy, a pressure is applied on the composite fabric surface in order to extrude the excess epoxy resin and to ensure good contact between the epoxy, the concrete and the fabric. This operation is carried out at room temperature. Concrete beams strengthened with fiber sheets are cured for 3 days at room temperature before testing. procedure for the all the specimens was same. The beams were cured for a period of 28 days. The surface of control beams is cleaned and washed for clear visibility of cracks and the surface of the retrofitted beams is cleaned with cotton. The two-point loading arrangement is used for testing of beams. This has the advantage of a. substantial region of nearly uniform moment coupled with very small shears, enabling the bending capacity of the central portion to be assessed. The load is transmitted through a load cell.

The test beam was supported on roller bearings acting as supports. The specimen was placed over the two steel rollers bearing leaving 50 mm from the ends of the beam. Two-point loading arrangement was done. Loading was done by hydraulic jack. Dial gauge was used for recording the deflection of the beams. The deflections of the beams were noted till the appearance of the first crack using dial gauge. The dial gauge was removed after the appearance of crack and the load was further applied till fracture load. The ultimate load or fracture load was taken as the load at which the needle of load dial on the UTM returned back.

1.2 CONCRETE MIX DESIGN

The process of selecting suitable ingredients of concrete and determine their relative amounts with the objective of producing a concrete of the required strength, durability and workability as economically as possible, is termed the concrete mix design the proportioning of ingredient of concrete is governed by the required performance of concrete in two states, namely plastic and hardened states if the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability therefore becomes of vital importance. The compressive strength of hardened concrete which concrete which is generally considered to be index properties depends upon many factors, for example quality of cement, water and aggregate, batching and mixing, placing, compaction and curing. The cost of concrete is made up of cost of materials, plant and labour.

The variations in the cost of materials arise from the fact that the cement is several times costly then the aggregate, thus the aim is to produce as lean a mix as possible. From technical point of view the rich mixes may lead to high heat of hydration in mass concrete which may cause creaking. The actual cost of concrete is related to the cost of material required for producing a minimum mean strength called characteristic that is specified by the designer of the structure. It is depending on the quality control measures but there is no doubt that the control adds to the cost of concrete.

The extent of quality control is often an economic compromise and depends on the size and type of job. The cost of labour depends on the workability of mix, example concrete mix inadequate workability may result in a high cost of labour to obtain a degree of compaction with available equipment.

The requirement which form the basis of selection and proportioning of mix ingredients are:

- The maximum compressive strength required from structural consideration.
- The adequate workability necessary for full compaction with the compacting equipment available.
- Maximum water cement ratio or maximum cement content to give adequate durability for the particular site conditions.
- Maximum cement content to avoided shrinkage cracking due to temperature cycle in mass concrete.

1.3 CALCULATION

The flexural strength of the specimen shall be expressed as the modulus of rupture F_b, which, if 'a' equals the distance between the line of fracture and the nearer support, measured on the center line of the tensile side of the specimen in cm, shall be calculated to the nearest 0.5kg/sq.cm as follows:

(1) When 'a' is greater than 20.0 cm for 15.0 cm specimen, or greater than 13.3 cm for a 10.0 cm specimen, or

$$F_b = \frac{P \times L}{bd^2}$$

(2) When ‘a’ is less than 20.0 cm but greater than 17.0 cm for 15.0 cm specimen, or less than 13.3 cm but greater than 11.0 cm for a 10.0 cm specimen

$$F_b = \frac{3P \times a}{bd^2}$$

(3) If ‘a’ is less than 17.0 cm for a 15.0 cm specimen, or less than 11.0 cm for a 10.0 cm specimen, the results of the test shall be discarded.

Where,
b = measured width in cm of the specimen,
d = measured depth in cm of the specimen at the point of failure,
l = length in cm of the span on which the specimen was supported,
p = maximum load in kg applied to the specimen.

Thus, retrofitting and strengthening of existing reinforced concrete structures has become one of the most important challenges in Civil engineering. Engineers often face problems associated with retrofitting and strength enhancement of existing structures.

Commonly encountered engineering challenges such as increase in service loads, changes in use of the structure, design and/or construction errors, degradation problems, changes in design code regulations, and seismic retrofits are some of the causes that lead to the need for rehabilitation & retrofitting of existing structures.

Complete replacement of an existing structure may not be a cost-effective solution and it is likely to become an increased financial burden if upgrading is a viable alternative. In such occasions, repair and rehabilitation are most commonly used solutions. Reinforcement corrosion and structural deterioration in reinforced concrete (RC) structures are common and prompted many researchers to seek alternative materials and rehabilitation techniques. While many solutions have been investigated over the past decades, there is always a demand to search for use of new technologies and materials to upgrade the deficient structures. In this context, strengthening with Fibre Reinforced Polymers (FRP) composite materials in the form of external reinforcement is of great interest to the Civil engineering community.

The conventional strengthening methods of reinforced concrete structures attempt to compensate the lost strength by adding more material around the existing sections. Thus, retrofitting and rehabilitation of structures can be concluded to be the best alternative. Seismic retrofitting is the modification of existing structures to make them more resistant to seismic ground activity, ground motion or soil failure due to earthquakes.

1.4 NUMERICAL STUDIES

For this test the beams of dimension 100mmX100mmX750mm were casted. Flexural strength, also known as modulus of rupture, bend strength, or fracture strength, [dubious – discuss] a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a rod specimen having either a circular or rectangular cross-section is bent until fracture using a three-point flexural test technique.

The flexural strength represents the highest stress experienced within the material at its moment of rupture. The beam tests are found to be dependable to measure flexural strength.

TITLE OF PROJECT	RETROFITTING OF PCC BEAMS
GRADE OF CONCRETE	M25
DIMENSIONS OF SPECIMEN IN MM	700 x 150 x 150 MM
DATE OF CASTING	02/02/2019
SAMPLE TESTED ON	28 DAYS – 04/03/2019
TECHINICAL REFERENCE	IS 516-1959 (REAFFIRMED 2011)

S.NO	SAMPLE IDENTIFICATION DETAILS	FLEXTURAL STRENGTH RESULTS AT CURING OF 28 DAYS	
		FAILURE LOAD, kN	FLEXTURAL STENGTH, (N/MM)
1	Nominal concrete	24.6	4.37
2	Carbon Fibre, 200 GSM/ S1	39.4	7.00
3	Glass Fibre, 200 GSM/ S1	32.1	5.71

Therefore by seeing the above values Carbon fibre provides high load bearing capacity than that of glass fibre but the cost of carbon fibre is found to be very high be very high compared to that of glass fibre so comparing the flexural strength of two fibres ,glass fibre can be adopted and used for construction for construction because it provides considerable flexural strength as well as its cost efficient

2. CONCLUSION

In this experimental investigation the flexural behaviour of reinforced concrete beams externally strengthened by carbon, glass sheets are studied. From the test results and calculated strength values, the following conclusions are drawn:

- The deflections of the beams are minimized due to full wrapping technique around all the four sides of the beam.
- The initial cracks in the strengthened beams appear at a higher load compared to the un-strengthened control beam.
- The flexural strength and ultimate load capacity of the beams improved due to external strengthening of beams.
- The strengthening of beams using carbon fibre sheets is found to be more effective in improving the flexural strength and ultimate load capacity of beams.
- The ultimate load capacity of the beams strengthened using carbon fibre sheets is increased by 38 % when compared to that of nominal beam.
- The increase in ultimate load capacity is least for the beams retrofitted with glass fibre sheets and is increased by only 23.46%.
- Even though the beams retrofitted with CFRP sheets have the maximum ultimate load capacity, the cost of the material is high.
- Retrofitting using GFRP sheets prove to be economical since its cost is only Rs.300/m2 and showed 23.46 % increase in ultimate load capacity.
- Retrofitting using carbon sheets is least recommended since its cost is high and increase in ultimate load capacity is less.
- Therefore, glass fibre is recommended for retrofitting purposes.

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