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Strengthening and Crack Prevention of Conventional Rc Structure by Retrofitting Technique

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Abstract

The project is about Strengthening and Crack prevention of Conventional RC Structure by Retrofitting Technique. Many of existing reinforced concrete structures throughout the world are in need of repair, rehabilitation or reconstruction because of deterioration due to various factors like corrosion, failure of bonding between beam and column joints and increase in service loads etc. In our project we use the retrofitting technique as a strength improvement technique in the early construction stage. In this study twenty-seven cylinders were casted and few were cracked to Retrofit with two and four layers of Glass Fiber Reinforced Polymer (GFRP) Wrap and few were simply Wrapped for strengthening aspect before the Specimen becomes deteriorated and each were tested to failure in axial compression. A simple analysis for circular cylinders reveals that the confining effect of the Wrap is not engaged until the concrete actually starts failing and dilating. The behavior of conventional concrete cylinders strengthened using Glass Fiber Reinforced Polymer Wrap (GFRP) subjected to loading and the results obtained have been compared. As a result, the objective of this laboratory work is to improve the structural integrity and increase the compressive strength and stiffness of the cracked cylinders after Wrapping.

Keywords: *Retrofitting Technique, Glass Fiber Reinforced Polymer (GFRP), Wrap.*

1. Introduction

Cracks in the concrete structures were early signs of distress which have to be diagnosed properly, otherwise the repair of same crack takes place again and again causing loss of time, money and endangering the safety of the structure. The structural cracks need more attention than non-structural cracks. The repair materials and methodology were different depending upon types of cracks, their locations such as joints, structural members etc. and conditions dry or moist. The loss of cementitious materials, as well as the corrosion-induced reduction in cross-section areas of steel reinforcement leads to drastic reductions in the structural integrity and load-carrying capacity of columnar supporting elements. To make a remedy for insufficient capacity, the structures need to be replaced or strengthened. Different types of strengthening materials are available in the market. Examples of these are Ferro cement, Steel plates; Fiber reinforced Polymer (FRP) laminate, Latex and Epoxy resin. Fiber Reinforced Concrete (FRC) is a concrete made primarily of hydraulic cements, aggregates and discrete reinforcing fibers. This project is about Strengthening and Crack prevention of Conventional RC Structure by Retrofitting Technique. Retrofitting method is followed for Concrete structures when the cracks are formed. In our project we use the retrofitting technique as a strength improvement technique in the construction stage [1-5]. This could improve the strength of the structure and due to use of the fiber reinforced polymer it reduces the deterioration of cement cover and the structure remains strengthened and long lasting. Depending on the selected strengthening

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technique, the behavior of the structure can be improved by means of increasing its strength and/or stiffness thereby boosting its deformation capacity or allowing more effective energy dissipation. On the order hand, a reduction of the seismic risk can be obtained by lowering the seismic demand during an earthquake.

2. Literature Review

Ahmed Khalifa et al. (2017): Fibre reinforced polymer (FRP) materials were continuing to show great promise for use in strengthening reinforced concrete (RC) structures. The objective of this study was to review the current research on shear strengthening with FRP and propose design algorithms to compute the contribution of FRP to the shear capacity of RC flexural members. Methods for computing the shear capacity based on the stress level to cause tensile fracture of the FRP sheet (which may be less than ultimate due to stress concentrations) and based on delimitation of the sheet from the concrete surface were presented. Areas which have the potential for further development were also discussed.

S.Eshghi and V.Zanjanizadeh (2018): This paper explains an experimental research program on the use of GFRP (Glass Fiber-Reinforced Polymer) for retrofitting small-scale slender R/C columns to enhance seismic performance. An important deficiency in many existing non-ductile reinforced concrete frames was the inability of the columns to undergo significant deformations while maintaining their load-carrying capacity. As a result, relatively brittle modes of column failure, accompanied by soft storey structural failure mechanisms, were possible. Providing additional confinement to the columns allows them to behave in a more ductile manner Three columns were tested after being retrofitted with GFRP Wrapps at the potential plastic hinge zone, while three others were tested in the "as-built" condition [6]. In general, the common mode of failure for the "as-built" samples was a brittle failure due to bond deterioration of the lap-spliced longitudinal reinforcement. Test results suggest that GFRP Wrapps can significantly increase the flexural strength and ductility of slender rectangular reinforced concrete columns.

E. Senthilkumar(2019): In the last few decades, moderate and severe earthquake have struck different places in the world, causing severe damage to reinforced concrete (RC) Structures. Retrofitting of existing structures was one of the major challenges that modern civil engineering structures has demonstrated that most of them will need major repairs in the near future This external confinement of concrete by high strength fiber reinforced polymer (FRP) composite can significantly enhance the strength and ductility and will result in large energy absorption capacity of structural members. FRP material, which were available in the form of sheet, were being used to strengthen a variety of RC elements to enhance the flexural, shear, and axial load carrying.

3. Properties of Materials

- Cement
- Fine Aggregate
- Course Aggregate
- Water
- Glass Fiber Reinforced Polymer

3.1 Cement

Ordinary Portland cement (OPC) is by far the most type of cement. As BIS requires the minimum, compressive strength of 43 grades OPC is 43 Mpa. OPC shared the following usages;

- P.C.C works
- Brick works
- Plastering works etc.,

3.2 Fine Aggregate

Manufactured sand is artificial sand obtained from crushing hard stones into small sand-sized angular-shaped particles, washed and finely graded to be used as construction aggregate. It is an alternative to River Sand used for construction purposes.

3.3 Coarse Aggregate

Coarse aggregate hare massive structure entirely crystalline of wholly, glassy of in combination in between, depending upon the rate at which they were cooled during formation. Aggregates are the important constituent in concrete. They give concrete to, reduce shrinkage of the concrete [7].

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3.4 Water

Water is an important ingredient of concrete as its activity participated in the chemical reaction with cement. Since it helps to form the strength giving the cement get, the quantity and the quality of water is required to be looked into very careful.

3.5 Glass Fiber Reinforced Polymer

GFRP was weaved in fabric form and unidirectional. E-Glass provides good overall strength at low cost. It accounts for about 90% of all glass fiber reinforcements. It has good electrical resistance, and it was used in radar antennas because of its radio frequency transparency.

4. Types of Tests

- Compressive test
- Water Absorption test
- Impact test

Glass Fiber Reinforced Polymer (Gfrp): GFRP was weaved in fabric form and unidirectional. E-Glass provides good overall strength at low cost. It accounts for about 90% of all glass fiber reinforcements. It has good electrical resistance, and it was used in radar antennas because of its radio frequency transparency. The properties of GFRP were given in Table 1.

Table 1 Properties of GRPF

S.no	Properties	Value
1	Fiber orientation	Unidirectional
2	No of Wraps	4
3	Young’s modulus of elasticity	75,900 N/mm2
4	Effective fiber sheet thickness	1.25mm
5	Density of wrap	900 g/cm
6	Tensile strength in unidirectional	2060MPa

Saturant: Epoxy was used as the saturant. Epoxy resin was an excellent bonding material which provides high bond strength with high temperature resistance. The Unsaturated Polyester resin with accelerator of Cobalt 6% and catalyst of .01% was added with the resin. Various properties of saturant were given in Table 2.

Table 2 Properties of Saturant

S.no	Properties	Value
1	Colour	Pale yellow to amber
2	Application Temperature	15 – 40 degree centigrade
3	Viscosity	Thixotropic
4	Pot life	2hrs at 30 degree centigrade
5	Curing time	5days at 30 degree centigrade
6	Storage Condition	Ware house condition < 35 degrees

General: The object of any mix proportion method is to determine an economical combination of concrete constituents that can be used for a first trial batch to produce a concrete that is close to that which can achieve a good balance between the various desired properties of concrete at the lowest possible cost.

Mix Design Procedure- M20: Mix ratio for the M20 Grade Concrete is taken as

0.5: 1:1.5 :3

Cracking The Specimen: Cracking of concrete is a random process, highly variable and influenced in many factors. However, one process is insured the longer the `crack, the higher the stress concentrations induced by it. The cylinders of different curing period were placed at the Compression Testing Machine and the Load is applying gently and the formation of cracks at every phase are keen noted [8]. The load applying should be stopped immediately as the desired cracking pattern and desired depth of the crack is achieved. Generally optimum cracks were successfully achieved with a load of around 50KN to 80KN for 7day curing and 70KN to 100KN for 14day curing and around 80KN to 150KN for 21day curing period

5. Results and Discussions

General: Conventional concrete cylinders were cast for M20 grade and kept for curing and the cylinders were then wrapped by Glass Fibre Reinforced Polymer (GFRP) with the use of Epoxy resin binder. After the specimens were wrapped, they are cured and after it were tested and then the results were compared with conventional concrete cylinders.

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Test Conducted On Conventional Cylinders: Concrete cylinders of dimension 20cm x 10cm, circumference area 30cm was subjected to hydraulic axial compressive strength test loading as shown in fig. The axial compressive strength test was done after 28days of water curing. The average of three results was taken.

Conclusion

General Conclusion: From the experimental study it is evident that the usage of Glass Fibre Reinforced Polymer wrap helps to improve structural integrity and it also proved to be effective and showed increase in compressive strength than conventional concrete cylinders [9]. Comparison of % Increase in Strength with Specimen Cylinders shown in Table 3. Hence we can suggest GFRP Wrapp in the construction stage itself for avoiding future cracking considering the Quote that

"*PREVENTION IS BETTER THAN CURE*"

Table 3 Comparison of % Increase in Strength with Specimen Cylinders

Curing Period	Specimen Cracked And Wrapped	Specimen Wrapped without Cracking	
		2 Wrapp	4 Wrapp
7 Days	1.19%	1.08%	1.62%
14 Days	1.35%	1.348%	1.57%
21 Days	0.97%*	1.065%	1.186%

Indicates Decrease in Strength: The result for Cracked and Retrofitted Specimen may vary in many cases since the Cracks self-induced were uncontrolled where few specimen are induced with minor hair line cracks some were induced to deep cracks while a few specimen were totally disintegrated. Hence methods adopted to controlled cracking for the research to take place more specifically can give more accurate results.

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