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STRENGTHENING OF CONCRETE STRUCTURES USING FRP LAMINATES

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Abstract:

This paper focuses on the use of emerging technologies for the strengthening of RCC structures. A number of structures like Bridges, building, jetties, silos etc. has been strengthened for various load requirements that were not incorporated during the original designs. Strengthening of concrete members with externally bonded fiber reinforced polymer (FRP) system received remarkable attention. The design and construction principles for use in practice have been finalized by the American Concrete Institute (ACI). On the application side, FRP materials have been used in some multi-million dollar projects for strengthening bridges, parking garages, multi-purpose convention centers, office buildings and silos etc. The drivers for this technology are several, but perhaps the most relevant ones are the ease and speed of installation. In the repair/upgrade arena, one of the most important unresolved questions remains that of durability. Addressing this issue will increase the degree of confidence in the technology and allow for its full exploitation.

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1. INTRODUCTION

1.1 GENERAL

There is immense need to rehabilitate the existing old structures in many parts of the world. Strengthening or rehabilitation of the concrete structures is required to design flaws of construction, structural degradation of the structure, deterioration of steel due to corrosion and ageing of the reinforced concrete members. Many new techniques have been in order to strengthen the deteriorating structures, out of which the external strengthening utilizing the FRP is the most widely used method.

Polymer composites have enjoyed wide spread use in the construction industry for many years in non-critical applications such as baths and vanities,Cladding, decoration and finishing.

In recent times fibre composite materials have been increasingly considered themselves as a viable and competitive option for rehabilitation and retrofit of existing civil structures. Fibres are used to reinforce the polymer and improve mechanical properties such as stiffness and strength. High strength fibres of glass, aramid and carbon are used as the primary means of carrying load, while polymer resin protects the fibre and binds them into a cohesive structural unit.

1.2. Scope of the project

Fibres can be oriented to reinforce against specific stresses, increasing the durability and safety. It is possible to increase the strength of the structural members even after they have been severely damaged due to loading conditions. Strengthening of the damaged structures can be achieved through the GFRP sheets with the help of epoxy resin.

2. MATERIAL AND MIX DESIGN

2.1 MATERIALS

2.1.1 CEMENT

Cement can be defined as the bonding material having cohesive & adhesive properties which makes it capable to unite the different construction materials and form the compacted assembly. Today ordinary Portland cement is the most widely used building material in the world. The commonly used Portland cement in India is branded as 33 grade [IS: 269-1989], 43 grade [IS: 8112-1989], 53 grade [IS: 12269-1987] having 28 days mean compressive strength exceeding 33 MPa, 43 MPa, and 53 MPa respectively. Here we used 43 grade Ordinary Portland cement conforming IS 12269:1987.

2.1.2 FINE AGGREGATE

Those particles passing the 9.5 mm (3/8 in.) sieve, almost entirely passing the 4.75 mm sieve, and predominantly retained on the 75 μm sieve are called fine aggregate.Usually, the natural river sand is used as fine aggregate. The moisture content of fine aggregate is determined to apply field correction in design mixes. Ordinary river sand conforming IS 383-1970.

2.1.3 COARSE AGGREGATES

Those particles that are predominantly retained on the 4.75 mm sieve, are called coarse aggregate. The particle shape of the aggregate contributes to the effectiveness of producing a high performance concrete. Crushed rock creates a much better bond between the paste and the aggregate than a gravel does. The properties of the coarse

aggregate used in a concrete mixture affects the modulus for a few reasons. One property is the modulus of elasticity of the coarse aggregate. A higher aggregate modulus will result in a concrete having a higher modulus. As expected, a lightweight aggregate will have a lower modulus than the mortar paste.

It should be hard, strong, dense, durable, clean and free from clay or loamy admixture or quarry refuse or vegetable matter. The pieces of aggregate should be granular or crystalline or smooth non powdery surface. Aggregate should be properly screened and if necessary washed clean before use.coarse aggregate containing flat, elongated or flaky pieces or mica should be rejected. The grading of coarse aggregate as per as specification of IS 383-1970.

2.1.4 FIBRE REINFORCED POLYMER

FRP is a composite material made of a polymer matrix reinforced with fibres. The fibres are usually glass, carbon, aramid or basalt. Rarely other fibres such as paper or wood or asbestos have been used.

2.1.5 Glass fibre reinforced polymer

Glass fibre is a material consisting of numerous extremely fine fibres of glass. Glass fibres are used as a reinforcing agent to form a very strong and relatively light weight fibre reinforced polymer composite material, it is called glass reinforced polymer. GFRP is a strong light weight material and it used for many products. Although it is not as strong and stiff as composites based on carbon fibre, it is less brittle and its raw materials are much cheaper. Although fibre glass used in many applications like swimming pools, septic tanks, water tanks and also in rehabilitation of concrete structures.

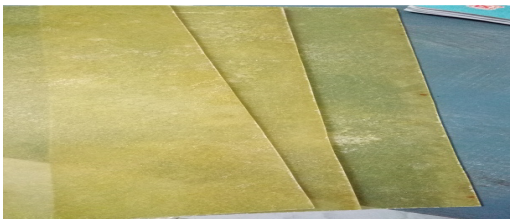

Fig 1 Frp laminates

2.1.6.BONDING AGENT

Araldite, produced this new synthetic resin adhesive for bonding metals, glass, porcelain and other materials. Araldite sets by the interaction of a resin with a hardener. Araldite is used to join together the two sections of composite. The use of araldite in architecture to bond thin joints of pre-cast concrete units. Hence, it is used as a bonding agent between concrete and GFRP laminates.

2.1.7 WATER

Water to be used in the concrete work should have following properties: It should be free from injurious amount of oil, acids, alkalis or other organic or inorganic impurities. It should be free from iron, vegetable matter or other any type of substances, which are likely to have adverse affect on concrete or reinforcement. It should be quite satisfactory for drinking purpose which is used in mixing of concrete.

2.2 MIXING DESIGNING

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. The main objective is to stipulate minimum strength and durability. It also reveals the relation between aggregate and paste. The other condition being equal, for workable mixes the strength of concrete varies as an inverse function of the water/cement ratio. Since the quantity of water depend upon the amount of paste, it important that as little paste as possible should be used and hence the importance of grading.

3. PREPARATION OF SAMPLES

All samples were prepared in the Concrete technology laboratory at our college campus. The samples for compression testing were cubes of size (15cm x15cm x15cm) while the beams of size (50cm x 10cm x 10cm) were used for flexure testing. The various steps involved in the sample preparation process are given below.

4. RESULTS

The results show the variation in Compressive strengths and Flexural strengths of various concrete mixes in which the fine and coarse aggregates were replaced by various percentages of glass waste and coconut shells respectively. The results of various tests on materials used in the project are also mentioned in this chapter.

3.1 COMPRESSION TEST ON CONCRETE CUBES

One of the purpose of testing hardened concrete is to confirm that the concrete used at site has developed the required strength. As the hardening of the concrete takes time, one will not come to know, the actual strength of concrete for some time. This is an inherent disadvantage in conventional test. But, if strength of concrete is to be know at an early period, accelerated strength test can be carried out to predict 28 days strength. But mostly

when correct materials are used careful steps are taken at every stage of the work, concrete normally given the required strength. The test also have a deterring effect on those responsible for construction work. The result of the test on hardened concrete, even if they are know later, help to reveal the quality of concrete and enable adjustments to be made in the production of further concretes. Tests are made by casting cubes from the representative design mix concrete. The standard compression tests give a measure of the potential strength of the concrete.

Compression test is the most common test conducted on hardened, partly because it is an easy test to perform, and partly because most of the desirable characteristic properties of concrete re qualitatively related to its compressive strength.

The Compression test is carried out on specimens cubical in shape. Prism is also sometimes used, but it is not our country. Sometimes, the Compression strength of concrete is determined using parts of a beam tested in flexure. The end parts of beam are left intact after failure in flexure and, because the beam is usually of square cross section, this part of the beam could be used to find out compressive strength.

Fig 2 Compression Test On Nominal

Table 1Compression Test

Mix ratio	**7 days strength (N/mm2)**	**28 days strength (N/mm2)**
Mix 0%	19.11	28
Mix10%	22.67	26.89
Mix20%	16.78	24.89
Mix30%	18.78	25.80
Mix40%	26	37.88

3.2 FLEXURAL TEST

The flexural strength would be the same as the tensile strength if the material were homogeneous. In fact, most materials have small or large defects in them which act to

Mix ratio	7 days strength (N/mm2)	28 days strength (N/mm2)
Mix 0%	2.63	3.68
Mix10%	2.64	3.68
Mix20%	2.11	3.76
Mix30%	3.19	5.78
Mix40%	2.89	4.68
Mix 0%	4.78	5.58

concentrate the stresses locally, effectively causing a localized weakness. When a material is bent only the extreme fibers are at the largest stress so, if those fibers are free from defects, the flexural strength will be controlled by the strength of those intact 'fibers'. However, if the same material was subjected to only tensile forces then all the fibers in the material are at the same stress and failure will initiate when the weakest fiber reaches its limiting tensile stress. Therefore, it is common for flexural strengths to be higher than tensile strengths for the same material.

Table2FlexuralTest

Conversely, a homogeneous material with defects only on its surfaces (e.g., due to scratches) might have a higher tensile strength than flexural strength.

If we don't take into account defects of any kind, it is clear that the material will fail under a bending force which is smaller than the corresponding tensile force. Both of these forces will induce the same failure stress, whose value depends on the strength of the material.

Fig 3 Flexural Test On Nominal Mortar

CONCLUSION

The study on the strengthening of RC structures using FRP laminates and there by the procedure of the compression test and flexural test that reveals that the FRP laminates can be increased the strength of the RC structures. From the present experimental study we conclude that FRP laminates strengthen the existing weak structures. Commonly concrete weak in tension so we can paste the FRP laminates paste in tension zone. The tensile properties of concrete is highly increased.

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