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STRENGTHNING CONCRETE SPECCIMEN BY USING CFRP AND GFRP

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ABSTRACT

World wide a great deal of research is currently being conducted concerning the use of fiber reinforced polymer wraps, laminates and sheets in the repair and strengthening of reinforced concrete members. Fiber reinforced polymer (FRP) application is very effective way to repair and strengthen structures that have become structurally weak over their life span. FRP repair system provides an economical alternative to traditional repair systems and materials. Experimental investigations on the flexural behavior of plain concrete beams externally strengthened using carbon fiber reinforced polymer (CFRP) sheets and glass fiber reinforced polymer sheets carried out so that any structure can be repaired with less cost.

KEYWORDS: Fiber reinforced polymer (FRP).

INTRODUCTION

Day to day activities of human kind involve production of many things required for consumption and other purposes. Industries form very important units in manufacturing essentials goods. By product, which results from the process of making, invites care in the safe disposal. “Mass can neither be created nor destroyed” is the law of conservation of mass. According to the above law, total mass on the universe remains constant. As the water present in various forms (sea water, clouds, rainwater, ice, water vapour, surface water and groundwater) in the hydrological cycle, raw material used in the manufacturing process appears into product and by-product. The concept of reuse of waste/by-product has now-a-days become both environmental concern and resources management. Each year thousands of tones of waste materials are disposed on the valuable land which results in the occupation and degradation of valuable land. Decreasing of natural resources is a common phenomenon in developing countries like India due to rapid urbanization and industrialization involving construction of infrastructures.

REVIEW OF LITERATURE

P. Aggarwal, Y. Aggarwal, S. M. Gupta, (2007)

They had studied the effect of use Sand as a replacement of fine aggregate. The various strength properties studied consist of compressive strength, flexural strength and splitting strength. The strength development for various percentages (0 to 50%) replacement of fine aggregate with Sand can easily be equated to the strength development of normal concrete at various ages. The Sand concrete gains strength at a slower rate in the initial period and acquires strength at faster rate beyond 28 days, due to pozzolanic action of Sand. It is observed that which is equal to the 50% replacement of fine aggregate gives comparable flexural strength at the age of 90 days that can be used for pavement application. The rate of increases of splitting tensile strength decreases with the ages.

B. Ahmadi, W. Al-Khaja, (2000)

They had studied the physical and chemical properties of the Sand were studied. Concrete mixes containing various contents of the waste were prepared and basic strength characteristics, such as compressive strength, splitting; flexural, water absorption and density were determined and compared with a control mix. Five concrete mixes containing various contents of the Sand, 0, 3, 5, 8 and 10% as a replacement to the fine sand were prepared with ratios of 1:3:6 by weight of cement, sand and aggregate. A maximum of 5% content of the Sand as a replacement to the fine sand in concrete mix can be used successfully as construction materials, such as in concrete masonry construction with a compressive strength of 8 MPa, splitting strength of 1.3 MPa, water absorption of 11.9%, with a density of 20 KN/m3.

L. Evangelista, J. De Brito, (2007)

They had studied on the use of Sand to partially or globally replace natural fine aggregates in the production of structural concrete. Six concrete mixes containing various contents of the fine recycled concrete 0, 10, 20, 30, 50, and 100% as a replacement to the fine sand were prepared. The results of the following tests are reported: compressive strength, split tensile strength, modulus of elasticity and abrasion resistance. From the result, it is reasonable to assume that the use of Sand does not jeopardize the mechanical properties of concrete, for the replacement ratios up to 30%.

Rafat Siddique, Geert De Schutter, (2009)

They had studied on the use of used Sand in large volume; research is being carried out for its possible large-scale utilization in making concrete as partial replacement of fine aggregate. They evaluate the mechanical properties of concrete mixtures in which fine aggregate was partially replaced with used Sand. Fine aggregate was replaced with three percentages 10, 20 and 30% by weight. Compressive strength, splitting, flexural strength and modulus of elasticity were determined at 28, 56, 91 and 365 days. Increased in compressive strength varied between 8% and 19% depending upon UFS percentage and testing age, whereas it was between 6.5% and 14.5% for splitting – tensile strength, 7% and 12% for flexural strength and 5% and 12% for modulus of elasticity.

Her-Yung Wang, (2009)

They had studied the use of Sand as the Partial replacement of fine aggregate in concrete. The different mix designs were regulated by the ACI method with 0, 20, 40, 60 and 80% Sand replacements investigation: their engineering properties were determined. Test results revealed that, when compared to the design slump 15cm, the 20% glass sand concrete for the three different mix designs kept good slump and slump flow. Furthermore, a slump loss ranging from 7 to 11 cm was observed for specimens with 60% and 80% glass sand replacements were higher of 28 and 35 MPa. The test results indicate that the addition of 20% Sand to concrete satisfies the slump requirements and improves the strength and durability of concrete.

Farid Debieb, Said Kenai, (2008)

They had studied recycling and reuse of Sand present interesting possibilities for economy on waste disposal sites and conservation of natural resources. Either natural sand, coarse aggregates or both were partially replaced 25, 50, 75 and 100% with crushed brick aggregates. Compressive and flexural strengths up to 90 days of age were compared with those of concrete made with natural aggregates. Porosity, water absorption, water permeability and shrinkage were also measured. The result indicates that it is possible to replace 25% of coarse aggregate and 50% of fine aggregate gives results similar to natural aggregate

Khalifa S. Al-Jabri, Makoto Hisada, Salem K. Al- Oraimi, Abdullah H. Al-Saidy, (2009) They had studied the use Sand as a replacement of sand on the properties of high performance concrete. Eight concrete mixtures were prepared with different proportions of Sand ranging from 0% to 100%. Concrete mixes were evaluated for workability, density, compressive strength, tensile strength, flexural strength and durability. The results indicate that there is slight increase in the (HPC) density of nearly 5% with increase of Sand content. The workability increased rapidly with increase in Sand percentage. Addition of 50% of copper slag as sand replacement yielding comparable strength with that of the control mix. At the 80% and 100% replacement gives 16% lower than the strength of control mix. The results also shows that water absorption decreased as copper slag quantity increased up to 40% replacement. Therefore it is recommended that 40% of Sand can used as replacement of sand in order to obtain HPC with good durability and strength.

MATERIALS AND METHODOLOGY

Materials

Cement: Cement is a binder, a substance that sets and hardens and can bind other materials together. Though all cement conforming to various IS code is suitable, selection of cement should be based on their compressive strength, fineness and compatibility with other ingredients.

Properties of cement

Property of Cement	Value
Fineness of cement	7.5%
Grade of cement	53 Grade (OPC)
Specific gravity of cement	3.15
Initial setting time	30 min
Final setting time	600 min
Normal consistency	35%

Fine aggregate: Sand is an extremely needful material for the construction but this important material must be purchased with all care and vigilance. Sand which is used for the construction purpose must be clean, free from waste stones and impurities.

Propertyies	**Value**
Specific Gravity	2.63
Fineness Modulus	2.56
Silt content	0.78%

Coarse aggregate: Coarse aggregate are used for making concrete. They may be in the form of irregular broken stone or naturally occurring gravel. Material which are large to be retained on 4.75mm sieve size are called coarse aggregates. Its maximum size can be up to 63mm.

Properties of Coarse aggregate

Properties	**Values**
Specific Gravity	2.68
Size Of Aggregates	20mm
Fineness Modulus	5.96
Water absorption	2.0%
Impact Test	15.2%
Crushing Test	22.5%

Water: Water plays an important role in the formation of concrete as it participates in chemical reaction with cement. Due to the presence of water the gel is form which helps in increase of strength of concrete. Almost any natural water that is drinkable and has no pronounced taste or odour can be used as mixing water. Water from lakes and streams that contain marine life are also usually suitable.

Sand: Locally available sand passed from 4.75mm IS sieve. The specific gravity is 2.63.

Properties of sand

Properties	**Values**
Specific Gravity	2.60
Silt content	0.78%
Fineness Modulus	2.54

FRP

Fiber Reinforced Polymer (FRP) Composites consist of two components: fibers and matrix. The fibers possess high strength and modulus and are the main source of load resistance in any composite material. The matrix is the medium in which the fibers were embedded, protecting them from harsh environmental conditions.

Types of FRP

Carbon fibers: Carbon fibers consist of small crystaline turbostratic graphite. Carbon atoms are arranged in hexagonal arrays and held together by bonds therefore it produce high strength fiber and high modulus.

Glass fibers: These fibers are made of silicon (sio2) with a tetrahedral structure (sio4) some aluminum oxides and other metallic ions are added to ease the working operations.

Properties	Carbon	Glass
Modulus Of Elasticity	235 KN/mm^2	70 KN/mm^2
Tensile strength	3850 KN/mm^2	3500 KN/mm^2
Density	1,65 gm/cm^3	2.70 gm/cm^3
ἐ Ultimate %	1.55%	4.50%

Methodology

Grade of concrete- M-20, M-25 and M30

Design-IS 456:2000 and IS 10262:2009

Moulding of specimen:

Cube-30 no.s(150x150x150mm)

Beam-20 no.s (750x150x150mm)

In this experimental work, a total of 90 numbers of concrete specimens were casted. The mix desgn of concrete was done according to IS guidelines for M-20, M25 and M-30 grade.
The experimental work has been carried out on the test specimen to study the strength properties as a result of applying externally FRP.

The control mixture was designed to have a target 28 day compressive strength of 25 N/mm^2 using a water cement ratio 0.5 and the samples were tested for compressive testing, flexural trength testing and tensile strength testing at 7, and 28 days of curing.

RESULT AND DISCUSSION

I. Tests

Tests to be conducted

Fresh state

i) Slump Cone test

ii) Compaction Factor test

Hardened state

i) Compressive strength test

ii) Split tensile strength test

i) Slump Cone test

The concrete test is an empirical test that measure workability of fresh concrete. It is performed to check consistency of freshly made concrete. Consistency refers to the ease with which concrete flows.

The slum test is used to ensure uniformity for different batches of a concrete under field condition.

The slump test was conducted on fresh concrete for various percentage replacement of fine aggregate with copper slag.

Slump values are increasing with increase in percentage of copper slag.

Fig 1: Slump cone test.

ii) Compaction Factor test

Compacting factor of fresh concrete is done to determine workability of fresh concrete by compacting factor test.

The test is sufficiently sensitive to enable difference in workability arising from the initial process in the hydration of a cement to be measure.

Fig 2: Compaction factor test.

Hardened state

i) Compressive Strength Test

For each mix 3 standard cubes were cast to determine 7-days,14day and 28 days compressive strength after curing. Also nine no. of cube was casted to know the compressive strength of concrete. The size of the cube is as per the IS 10086 – 1982.

One of the most important properties of concrete is the measurement of its ability to withstand compressive loads. This is referred to as a compressive strength and is expressed as load per unit area. One method for determining the compressive strength of concrete is to apply a load at a constant rate on a cube (150×150×150 mm), until the sample fails. The compression tests performed in this project were completed in accordance with IS standard 516 "Methods of Tests for Strength of Concrete". The apparatus used to determine the compressive strength of concrete in this project was a testing machine. For this study samples were tested for compression testing at 7, and 28, days of curing.

The compressive strength of the concrete in terms of pressure was then calculated using the Equation: fc= P/A Where,

fc = Compressive Strength of Concrete,

P = Maximum load applied (KN), and

A = The cross-sectional area of the sample (mm2).

Fig 3: Compressive strength test.

ii) Split tensile strength

The split tensile strength of concrete casting cylinder of size 150mm x 300mm and is continuously cured for 28 days testing. Totally 35 cylinders were casted for normal M25 grade and for 30%,35%,40% and 45% partial replacement of copper slag for sand 5%,10%,15% and 20% partial replacement of Bagasse ash for cement and is cured for testing, for each mix 3 samples are tested and the average values is taken as tensile strength of concrete and it is tested for 7 days and 28 days for determining the split tensile strength for the optimum proportions of Bagasse ash and copper slag replacements.

The split tensile strength of the concrete is calculated by using an empirical equation:

Split Tensile strength (N/mm2)= (2P/ ¶dl)

Where P- maximum Load at failure,

L= Length of the cylindrical specimen in mm

D= Diameter of the cylindrical specimen in mm

iii) Flexural Strength test

Flexural strength of concrete is tested by casting beams with or without reinforcement. In concrete flexure is the bending moment caused by the applied load, in which a concrete beam has compression at top and tensile stress at the bottom side. Beams on testing will fail in tension due to its property and shear will appear on concrete.

It is the ability of a beam or slab to resist failure in bending. The flexural strength of concrete is 12 to 20 percent of compressive strength. Flexural strength is useful for field control and acceptance for pavement .but now a days flexural strength is not used to determine field control, only compressive strength is easy to judge the quality of concrete.

Flwexural strength of the concrete can be determined by following formula:

Flexural strength = PL/BD2.; Where P is load;L= Length of Prism;B = Breadth of Prism;D =Breadth of Prism.

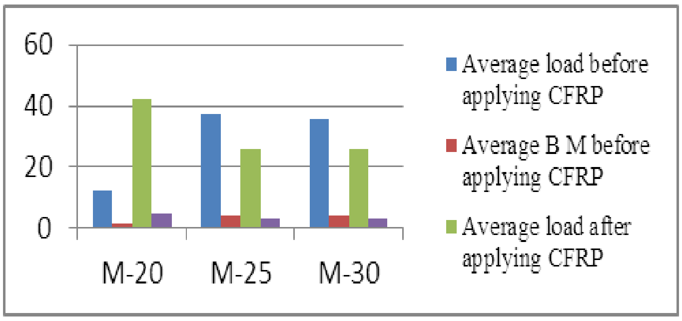
Fig 4: Flexural strength test.

II. Results

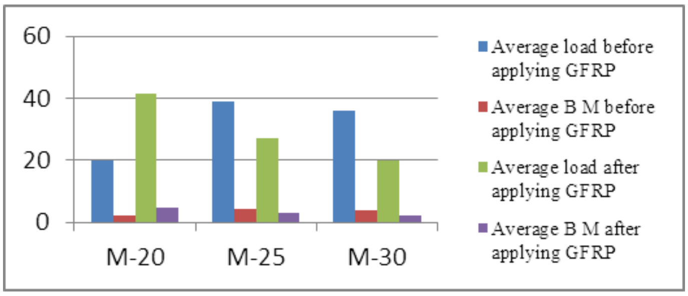
The main aim of the study is comparison of test result of flexural strength test of M-20, M-25 and M-30 grade of concrete in 28 days. It also compares between CFRP and GFRP.

The results obtained by tests of specimen as follows:

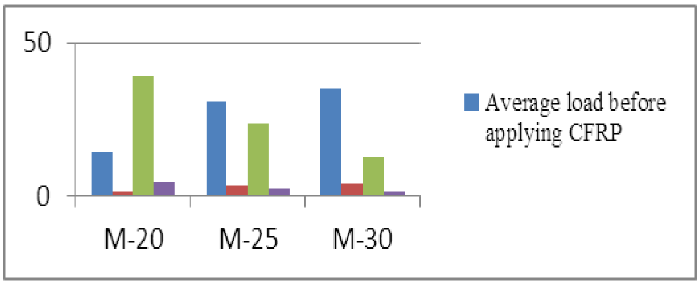
1. CFRP Long Strip



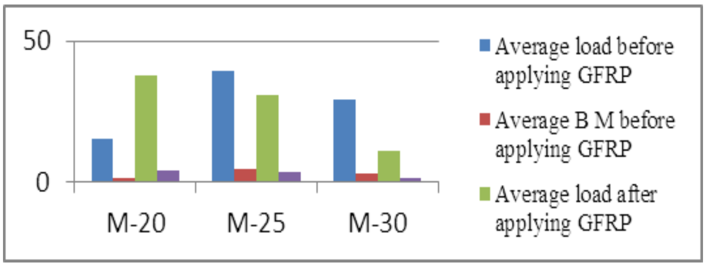
2. GFRP Long Strip



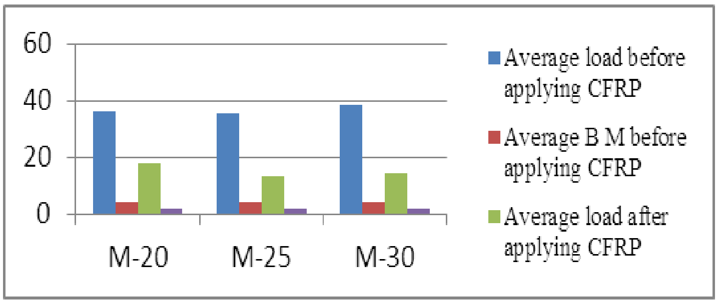
3. CFRP Short Strip



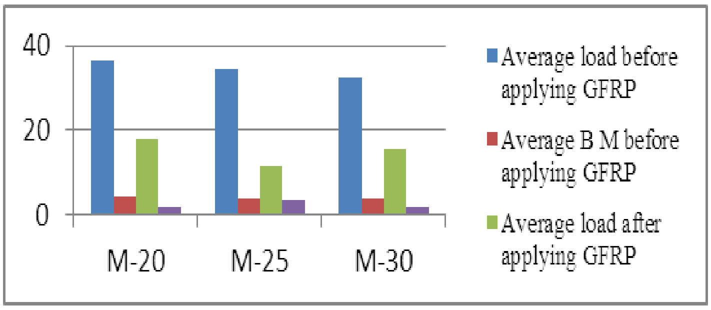
4. GFRP Short Strip



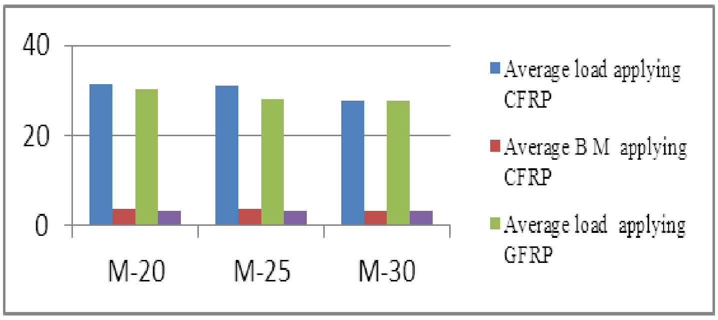
5. CFRP Applied on Crack



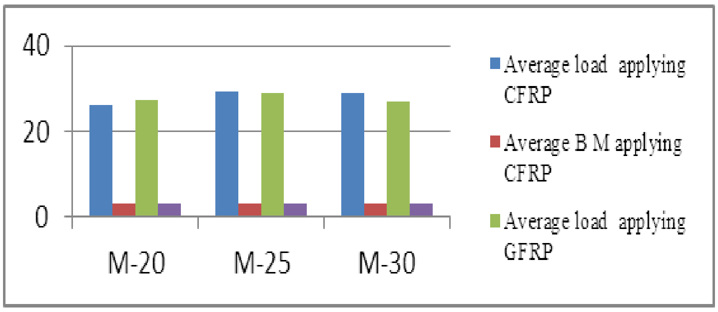
6. GFRP Applied on Crack



7. CFRP and GFRP Long Strip



8. CFRP and GFRP Short Strip



CONCLUSION

Based on the results and observations made in this experimental research study, the following conclusions made.

CFRP long strips gives better flexural strength as compared to short strips CFRP also it gives more strength than long and short strips GFRP.

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