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Effect of raw and re-engineered GFRP waste as an admixture in cement concrete

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ABSTRACT

Recent Scientific developments led to tremendous progress in infrastructure development to mankind but also led to negative impact on the environment. Generation of glass fibre reinforced plastic (GFRP) waste has been a source of concern. The increase in GFRP waste pollutes not only land and water but also the air. If GFRP is dumped on land it chokes the soil making it infertile and useless. Dumping glass fibre reinforced plastics in water endangers the lives of the aquatic animals thus effectively disrupting the balance in nature. Disposal of GFRP waste by incineration generates toxic gases which are harmful not only to the flora and fauna but also to the atmosphere. The problem is more serious with thermo set plastic which is neither recyclable nor bio-degradable.

In this paper an attempt is made to find an efficient way of utilizing the plastic waste as an admixture to cement concrete. To validate this, experimental investigations are carried out on concrete of M25 grade with raw GFRP and re-engineered GFRP in percentage ranging 0, 0.2, 0.3, and 0.4 which is designed as per IS standards. Tests on fresh concrete to determine the values of, compacting factor, Vee-Bee Consistency and slump are conducted. Compression, Tension and Flexure tests are conducted on hardened concrete. Conclusions are made from the results of fresh and hardened concrete properties by comparing with those of normal concrete.

KEY WORDS: raw GFRP, re-engineered GFRP, workability, compressive strength, admixture, concrete

1. INTRODUCTION

Though Plastics are one of the greatest inventions of man and a milestone for the human civilization over the years opened the way for a plethora of a new inventions and devices, it has also posed a serious threat to the environment. But commercial interest creates hindrance for effective legislation to remove plastics from goods where they can threaten the public health. More than 100 million tonnes of plastic is produced world-wide each year. The production of plastics is increasing year after year. In India the total production of plastics is around 4380,000 tonnes per year out of which 1678,900 tonnes come out as waste. Out of the total plastic production, about 43,000 tonnes of glass fibre reinforced plastic (GFRP) per year is produced in India. Out of which, 860 tonnes come out as waste. This resulted in enormous wastage of plastics, which ultimately made their disposal a major problem.

Thermosetting plastic is the general term applied to the plastic, which becomes rigid when moulded at suitable pressure and temperature. When they are heated in the temperature range of 1270C to 1770C, they set permanently and further application of heat does not alter their form or soften them. It is thus not possible to shape and reshape these plastics. Hence their disposal is much more. The GFRP offers a combination of properties not easily found in the traditional materials and it has come as a boon especially for the building and construction industry. GFRP is formed by using two materials of different properties. In GFRP glass fibres provide stiffness and strength while resins provide a matrix to transfer the load to fibres. The use of various additives imparts special properties to GFRP.

During incineration the resin burns to give toxic gases and pollutes the environment. During the burning process monomers are released which may lead to health hazard. During burial the plastic waste does not get decayed and remains in the land without decomposing for years. This leads to land wastage. A remedy is suggested in this investigation by embedding this waste into the concrete.

This paper focuses on the effective utilization of the GFRP waste in raw condition and also the waste is re-engineered by grinding to a fineness of 75microns, as an admixture to the concrete by adding the same to develop a concrete of increased workability, strength and durability. As the construction scenario is fast changing the need for improved performance of concrete has become essential, in addition to achieving high strength.

The GFRP waste is collected from Devi Polymers, Industrial Estate, Guindy, Chennai, Tamil Nadu and ground to a fineness of about 75microns. The raw as well as re-engineered GFRP are added to concrete in various percentages ranging from 0, 0.2, 0.3 and 0.4.

Mix design in accordance with IS-10262:

Design Stipulations: Characteristic compressive strength

Required in the field at 28 days	- 25N/mm^2
Maximum size of the aggregate	-20mm (angular)
Degree of workability	- 0.85 (compacting factor)
Degree of quality control	- good

Type of exposure - mild

Test data for materials:

Cement	-	OPC (53grade)
Specific gravity of cement	-	3.15
Specific gravity of coarse aggregate	-	2.82
Specific gravity of fine aggregate	-	2.65
Water absorption for coarse aggregate	-	1%
Water absorption for fine aggregate	-	Nil
Free surface moisture for coarse aggregate	-	Nil
Free surface moisture for fine aggregate	-	2%
Sieve analysis for coarse aggregate	-	confirms to IS: 383 - 1970
Sieve analysis for fine aggregate	-	confirms to grading of Zone II
Water cement ratio	-	0.44

The mix proportion is:

Water Content	Cement	Fine Aggregate	Coarse Aggregate
0.44	1	1.45	2.86

The comparison is made between the conventional concrete and raw GFRP concrete and re-engineered GFRP concrete by conducting various tests both in fresh and hardened state such as workability, compression and flexural tests.

2. EXPERIMENTAL INVESTIGATIONS

The tests namely specific gravity, fineness, consistency and setting time are conducted on cement, fine aggregate and coarse aggregates. The test results of the same are shown in table 1, table 2 and table 3 respectively.

Table.1. Test on Cement

Test	values
Specific Gravity	3.15
Fineness	96.56%
Consistency	31%
Initial Setting Time	35 min

Table.2. Test on Fine aggregates

Test	values
Specific Gravity	2.65
Free Surface Moisture	2%
Gradation	Zone II

Table.3. Test on Coarse Aggregates

Test	values
Specific Gravity	2.82
Aggregate Impact Value	24.46%
Aggregate Crushing Values	15.69%
Aggregate Abrasion Value (Los Angeles)	6%

Workability: Tests to determine the slump value, compacting factor and Vee-Bee Consistency are performed on conventional, raw GFRP concrete and re-engineered GFRP concrete and the results are shown in table 4 and table 5.

Table.4. Test on Fresh Concrete - Conventional and Raw GFRP

GFRP powder (%)	Slump, mm	Compacting Factor	Vee-Bee time, sec
0	10.00	0.822	22
0.2	13.33	0.826	20
0.3	19.33	0.854	17
0.4	30.24	0.855	13

Table.5.Test on Fresh Concrete - Conventional and Re-engineered GFRP

GFRP powder (%)	Slump, mm	Compacting Factor	Vee-Bee time, sec
0	10.00	0.822	22
0.2	19.33	0.826	20
0.3	20.67	0.855	18
0.4	22.67	0.860	11

Compressive Strength: The compression test on conventional concrete, raw GFRP concrete and re-engineered GFRP concrete cubes of size 15 x 15 x 15 cm are carried on 7 days and 28 days cured specimens and results are given in table 6 and 7.

Table.6. Compression test on Concrete cubes - Conventional and Raw GFRP

GFRP powder (%)	Comp. Strength, N/mm^2 (7 days)	Comp. Strength, N/mm^2 (28 days)
0	21.80	37.93
0.2	28.60	46.22
0.3	26.16	45.49
0.4	25.10	40.55

Table.7. Compression test on Concrete cubes - Conventional and Re-engineered GFRP

GFRP powder (%)	Comp. Strength, N/mm^2 (7 days)	Comp. Strength, N/mm^2 (28 days)
0	21.80	37.93
0.2	24.63	38.51
0.3	24.63	39.24
0.4	22.28	36.33

Flexural Strength: The flexural strength test on conventional concrete, raw GFRP concrete and re-engineered GFRP concrete cubes of size 10 x 10 x 50 cm are carried on beam specimens of both 7 days and 28 days age. The results are given in table.8 and 9.

Table.8. Flexure test on Concrete beams - Conventional and Raw GFRP

GFRP powder (%)	Flex. Strength, N/mm^2 (7 days)	Flex. Strength, N/mm^2 (28 days)
0	3.92	5.52
0.2	3.95	5.43
0.3	4.02	5.72
0.4	4.59	4.98

Table.9. Flexural test on Concrete beams - Conventional and Re-engineered GFRP

GFRP powder (%)	Flex. Strength, N/mm^2 (7 days)	Flex. Strength, N/mm^2 (28 days)
0	3.92	5.52
0.2	3.29	6.13
0.3	3.5	5.57
0.4	4.29	5.18

3. RESULTS AND DISCUSSIONS

Workability of Fresh Concrete:

Effect of raw GFRP and re-engineered GFRP on slump of fresh concrete: To arrive a relation between percentages GFRP with slump values, the curves are plotted between percentage of raw and re-engineered GFRP with slump as shown in fig. 1. It is inferred that the slump of the fresh concrete increases with the addition of both raw as well as re-engineered GFRP. The slump is more in the case of raw GFRP when compared to re-engineered GFRP and the slump is same for both raw and re-engineered GFRP at 0.3 percent.

Effect of raw and re- engineered GFRP on compacting factor of fresh concrete: From the table 4 the curves are plotted between percentage of raw and re-engineered GFRP with compacting factor as shown in fig. 2. It is observed that the compacting factor of the fresh concrete increases with the addition of both raw as well as re-engineered GFRP. The compacting factor is same for both raw and re-engineered GFRP up to 0.3 percent and the compacting factor is more in the case of re-engineered GFRP compared to raw GFRP.

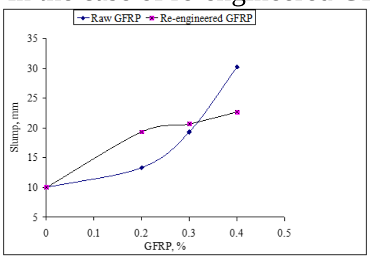

Figure.1. Relation between percentage GFRP and Slump

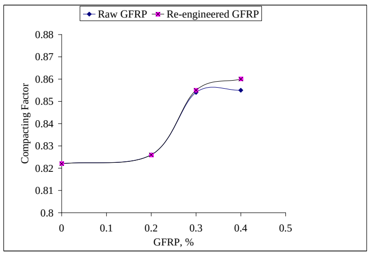

Figure.2. Relation between percentage GFRP and Compacting factor

Effect of raw and re- engineered GFRP on Vee-Bee time of fresh concrete: A relationship between percentage GFRP and Vee – Bee time is arrived by plotting the curves for raw and re-engineered GFRP concrete as displayed in fig. 3. It is inferred that the Vee – Bee time of the fresh concrete decreases with the addition of both raw as well as re-engineered GFRP. The Vee-Bee time is lesser in the case of re-engineered GFRP compared to raw GFRP and the Vee-Bee time same for both raw and re-engineered GFRP up to 0.2 percent and varies thereafter.

Properties of Hardened Concrete Compressive Strength: From the table.6 and 7 the curves are plotted between percentage of raw and re-engineered GFRP with compressive strength as shown in fig.4. It is observed that the 7 days compressive strength of raw GFRP concrete and re-engineered GFRP concrete increases to the maximum value for an optimum dosage of 0.2% and 0.25% respectively. Further dosage of GFRP decreases the compressive strength, but in any case the value is greater than the compressive strength of conventional concrete.

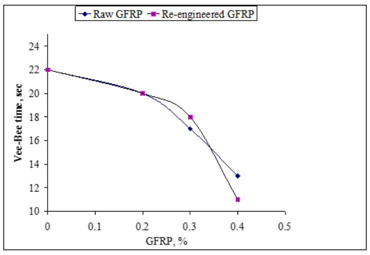

Figure.3. Relation between percentage GFRP and Vee-Bee time

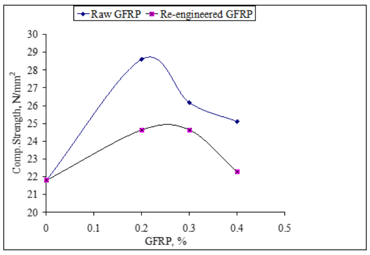

Figure.4. Relation between percentage GFRP and Compressive Strength (7 days)

From the table 6 and 7 the curves are plotted between percentage of raw and re-engineered GFRP with compressive strength for 28 days as shown in fig. 5. It is observed that the compressive strength of raw GFRP concrete and re-engineered GFRP concrete increases to the maximum value for an optimum dosage of 0.2% and 0.3% respectively. Further dosage of GFRP decreases the compressive strength.

Flexural Strength: From the table 8 and 9 the curves are plotted between percentage of raw and re-engineered GFRP with flexural strength as shown in fig. 6. It is observed that the 7 days flexural strength of raw GFRP concrete increases to the maximum value for a dosage of 0.4%. In case of re-engineered GFRP concrete, the flexural strength decreases initially and then increases to the maximum value for a dosage of 0.4%.

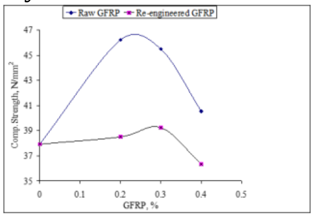

Figure.5. Relation between percentage GFRP and Compressive Strength (28 days)

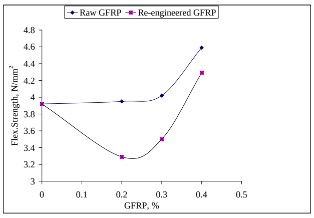

Figure.6. Relation between percentage GFRP and Flexural Strength (7days)

From the table 8 and 9 the curves are plotted between percentage of raw and re-engineered GFRP with flexural strength (28 days) as shown in fig. 7. It is observed that the flexural strength of re-engineered GFRP concrete increases to the maximum value for a dosage of 0.2% and flexural strength of raw GFRP concrete increases to a maximum value for a dosage of 0.3%.

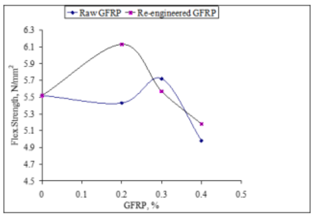

Figure.7. Relation between percentage GFRP and Flexural Strength (28 days)

4. CONCLUSIONS

The following conclusions are drawn from the test results.

- The workability of the fresh concrete increases with addition of raw GFRP as well as re-engineered GFRP.
- The compressive strength of raw GFRP concrete is increased by 22% for an optimum dosage of 0.2%.
- The compressive strength of re-engineered GFRP concrete is increased by 4% for an optimum dosage of 0.3%.
- The flexural strength of raw GFRP concrete is increased by 4% for an optimum dosage of 0.3%.
- The flexural strength of re-engineered GFRP concrete is increased by 11% for an optimum dosage of 0.2%.
- Hence the addition of both raw GFRP waste and re-engineered GFRP waste can be used as an effective admixture to the concrete to enhance the properties of concrete both in fresh and hardened state to suit special applications.

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