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The Study of Split Tensile Behavior with Special Reference to Glass Fiber Reinforced Concrete

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***Abstract*— This paper focuses on studying the effect of glass fiber on the properties of concrete mixtures as a partial replacement of cement. The main goal is to investigate the possibility of using glass fiber as a partial replacement of cement in concrete. A series of tests were conducted to study the effect of 10% ,15% and 20% replacement of cement by glass fiber. The compressive strength, split tensile strength and the flexural strength test were determined for the mixes at the curing age of 7 days and 28 days. The results obtained for the above mixes were compared to investigate the effects of partial replacement of cement by glass fiber. Use of glass fiber in concrete can prove to be economical.**

Index Terms— Concrete mixtures, Glass fiber, Cement, Split Tensile Strength
Sub Area : Construction Technology & Management
BroadArea : Civil Engineering

I. INTRODUCTION

Fiber glass is widely acknowledged as a material that has major advantages over more conventional rivals, such as wood, steel and aluminium. It is less energy-intensive in development and is used extensively for products which decrease carbon emissions-product such as low-energy windows. But what do we do with do with the glass fiber when its usefull life is over. The world is going through a low carbon revolution and the potential for composites to reduce greenhouse gas emissions is clear. But the difficulity of recycling glass fiber reinforced plastic (GRP) is a stumbling block particularly in construction and automotive where the pressure to recycle is high. The European Composites Industry Association (EuCIA) states that GRP is "recyclable and compliant with EU legislation". But at present facilities exit only in Germany to recycle, which for companies in UK, for example, is prohibitively expensive and not environmentally friendly due to the effect of transport, leaving the option only to landfill.

II. LITERATURE REVIEW

The necessary literature studies were carried out through national/international journals, periodical conferences, books and recent data from the internet source.

Prof. Autade Pankaj B., Wakankar Anil B (2016): Studied the effect of GGBFS as pozzalanic Material with glass fiber on mechanical properties of concrete. Replacement of cement by a pozzalanic material named Ground Granulated Blast Furnace Slag, which is waste product of steel manufacturing industries. Glass fiber of 12mm size was also added to increase both compressive and tensile strength of concrete. In present paper focuses on using GGBFS as replacement material to cement in different percentage 0%, 20%, 30% and 40% by weight of cement and Glass Fiber is also added to concrete in different proportion 0%, 0.03% and 0.06% by total volume. Twelve mixes of concrete with GGBFS and Glass Fiber were studied with w/c ratio 0.39 and Super plasticizer named CONPAST SP-430. Combinable effect of GGBFS and Glass Fiber is best for 30% GGBFS and 0.06% Glass Fiber as we know that concrete starts bleeding above 30% replacement by GGBFS and Glass Fiber controls the bleeding of concrete.

Gesoglu Mehmet, Güneyisi Erhan, Öz Hatice Öznur, Taha Ihsan, Yasemin Mehmet Taner(2015): Studied the properties of self-compacting concretes (SCCs) produced with recycled coarse aggregates (RCAs) and/or recycled fine aggregates (RFAs) compared to SCCs with natural aggregates (NAs). The SCC mixtures were designed with a constant slump flow of 680 ± 30 mm and two water/binder (w/b) ratios of 0.3 and 0.43. Silica fume (SF) was also used at two replacement levels of 0% and 10%. Hardened properties of the SCCs were evaluated in terms of compressive strength, splitting tensile strength, static modulus of elasticity, and net flexural strength after 56 days of water curing. Failure mechanism of the concretes was also monitored via three-point bending test on the notched beams. The results indicated that failure occurred throughout the recycled aggregates (RAs) which in-turn decreased the mechanical properties of SCCs. However, SCCs with both fine and coarse RAs (RCAs + RFAs) had relatively worse performance than those with only RCAs or RFAs such that the reduction in strength was about 30% as compared to the corresponding reference mixes. Moreover, incorporating SF and decreasing w/b ratio improved the mechanical properties of SCCs.

III. PROPOSED METHODOLOGY

The materials procured for obtaining this composition were OPC, aggregates (fine and coarse), glass fiber, and the water. After procurement, testing of materials was done to achieve the desired properties of all the materials in order to obtain the desired strength at the end. Once testing of materials was done, mix trials were practiced in order to choose a optimal w/c ratio. After selection of w/c ratio, mix design was prepared and all the materials are proportioned in accordance to the mix design. A nominal mix of concrete of proportion 1:1.5:3 (M-20) was adopted for the present study. The first mix Mx-0 was control mix having only cement as binder. The Mx-1, Mx-2, Mx-3 mix represent the replacement of cement by glass fiber by 10%, 15%, 20% respectively. Materials once proportioned and mixed together to obtain a concrete paste,

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specimens were casted and cured for performing various tests to analyze the properties of the concrete containing glass fiber. Tests performed were as follows:-

Fresh concrete tests
- Slump Cone test
- Compaction Factor Test

Hardened Concrete Tests:-
- Compressive Strength Test
- Flexural Strength Test
- Split Tensile Strength Test

Durability Tests:-
- Water Absorption Test
- Sorptivity Test

Glass fiber Based Concrete Composition

The technology of GFRC concrete was based on adding or partially replacing Portland cement with amounts of fine material such as glass fiber without modifying the water content compared to common concrete. The materials procured for obtaining this composition were OPC, aggregates (fine and coarse), glass fiber, and the water. After procurement, testing of materials was done to achieve the desired properties of all the materials in order to obtain the desired strength at the end. Once testing of materials was done, mix trials were practiced in order to choose a optimal w/c ratio. After selection of w/c ratio, mix design was prepared and all the materials are proportioned in accordance to the mix design. However, hardened concrete becomes a strong, durable, and practically impermeable building material that requires no maintenance after completion of proper proportioning, mixing, placing, curing, and consolidation.

Glass Fiber Reinforced Concrete (GFRC)

Glass fiber-reinforced concrete consists of high-strength embedded in a cementitious. In this form, both fibers and matrix retain their physical and chemical identities, while offering a combination of properties that cannot be achieved with either of the components acting alone. In general, fibers are the principal load-carrying members, while the surrounding matrix keeps them in the desired locations and orientation, acting as a load transfer medium between the fibers and protecting them from damage. In fact, the fibers provide reinforcement for the matrix and other useful functions in fiber-reinforced composite materials. Glass fibers can be incorporated into a matrix either in continuous or discontinuous (chopped) lengths.

Table 3.7: Physical Properties of Glass fiber

Properties Of Glass Fiber	
Fiber	AR Glass
specific gravity	2.68
elastic modulus (Gpa)	72
tensile strength (Mpa)	1700
diameter(micron)	14
length(mm)	12
number of fiber	235
(million/Kg)	

Water: - The water used in the mix design was potable water from the water-supply network system installed in our concrete lab; so, it was free from suspended solids and organic materials, which might have affected the properties of the fresh and hardened concrete.

Target Strength for Mix Proportioning

$f'ck = fck + 1.65 \times s$

fck= 20 MPa

From Table 1, Standard deviation, s = 4.0 N/mm2

Therefore, Target Strength =20+1.6x4.0

= 26.4 N/mm2

Selection of Water-Cement Ratio:

From Table 5 of IS 456,

Maximum water cement Ratio = 0.55

Based on experience, adopt water-cement ratio as 0.43

0.43 < 0.550

Hence OK.

Selection of Water Content:

From Table 2, maximum water content = 186 litre (for 25 to 50 mm Slump range) for 20mm aggregate

Estimate water content for 50 mm slump =186 litre

Calculation of Cement Content

Water-cement ratio = 0.43

Cement content = 186/ 0.43

=432.56 kg/m3

From Table 5 of IS 456, minimum cement content for normal condition = **300 kg/m^3 432.56kg/m^3>300 kg/m^3. Hence, OK**

IV. CASTING OF SPECIMENS

The test moulds required for casting the specimens were kept ready before the mix was prepared. Tighten the bolts of the moulds carefully because if bolts of the moulds are not kept tight the concrete slurry coming out of the mould when vibration takes place. Then moulds were cleaned and oiled on all contact surfaces of the moulds and place the moulds on vibrating table. The concrete was filled into moulds in layers and then vibrated. The top surface of concrete was struck off level with a trowel. The number and date of casting were put on the top surface of the specimens casted.

To cast concrete samples, 150mm×150mm×150mm standard dimension cube moulds were casted for carrying out compressive strength test and total no. of samples casted are 24 for all the mixes, 3 samples each for testing at the age of 7and28 days respectively. Similarly for flexural strength test, beams specimens of dimensions 500mm×100mm×100mm moulds were casted in 24 no. Cylindrical specimens of dimensions 150mm diameter and 300mm length were casted for performing split tensile strength,. For investigating durability properties, i.e. for performing water absorption test and cube specimens of dimensions 100mm×100mm×100mm and 70.7mm×70.7mm×70.7mm were casted, 12 each for all the mixes which are to be tested at the age of 28 days respectively.

V. SPLIT TENSILE STRENGTH

As concrete is weak in tension, it has become one of the basic and important properties of the concrete. Due to its brittle nature and low tensile strength, the concrete is not usually expected to resist the direct tension. While determining the tensile strength of concrete, the load is applied to the member till it cracks & the cracks developed are in the form of tension failure. For assessing the tensile strength of concrete in the laboratory, the usefulness of the splitting cube test is widely accepted and the usefulness of the above test for control purposes in the field is under investigation. With a view to unify the testing procedure for this type of test for tensile strength of concrete the standard has been prepared. The load at which splitting of specimen takes place shall then be recorded. The compression testing machine (CTM) having capacity of 200tonne was used for the splitting tensile strength of the concrete cylinders.

VI. CALCULATIONS:

The split tensile strength of the specimen calculated from the following formula

Tsp = (2P/ (πdL))

Where

P= maximum load in tonne

L= length of the specimen

d= diameter of width of the specimen

Final values are adopted from using standard deviation.

VII. SPLIT TENSILE STRENGTH TEST

The Split Tensile strength results for concrete containing different percentages of Glass fiber (GFRC) are presented in Table 4.6, 4.7and Figure 4.9, 4.10 and 4.11. Likewise the compressive strength it can be seen that in general, concrete containing 10% glass fiber shows higher or maximum strength as compared to the conventional concrete. There is an increase of approximately 12% and 10% in the split tensile strength of concrete containing 10% glass fiber when replaced by cement as compared to that of plain concrete at the age of 7 and 28 days respectively. The strength at 15% and 20% replacement is reduced to 5% and 12% at the age of 7 days and 7% and 19% approximately at the age of 28 days respectively

VIII. WATER ABSORPTION TEST

The reference mix absorbs more water as compared to other mixes. 10% replacement level of cement by glass fiber was found to be optimal from the water absorption point of view as at this % of replacement, water absorption is minimum as compared to all other mixes and after this replacement level, % water absorption increases but is less than reference mix and shows that the durability of concrete is enhanced by addition of glass fiber. Glass fiber can be safely used even upto 20% replacement of cement as the water absorption for all the mixes containing GFRC was found to be less than reference mix without GFRC.

Table No.:-4.8:- Water Absorption Test

Mix Description	Dry Wt. In grams (W1)	Wet Wt. In grams (W2)	% Water Absorption	Average % Water Absorption
Mx-0 (100% Cement)	2240 2240 2230	2470 2470 2450	5.58 5.58 5.63	5.60
Mx-1 (10% GFRC + 90% Cement)	2270 2250 2230	2470 2450 2450	4.14 4.17 5.07	4.46
Mx-2 (15% GFRC + 85% Cement)	2270 2270 2190	2470 2490 2410	4.25 5.18 5.36	4.91
Mx-3 (20% GFRC +80% Cement)	2230 2230 2190	2450 2450 2410	5.27 5.19 5.36	5.28

CONCLUSIONS

On the basis of experiments performed, following conclusions can be drawn:-

1. Use of glass fiber in concrete can prove to be economical .
2. Use of glass fiber in concrete prove to be environment friendly thus paving way for greener concrete.
3. Use of glass fiber in concrete will preserve natural resources particularly river sand and thus make concrete construction industry sustainable
4. The performance test results conducted in this research confirm that the properties of those special mixed concretes are satisfactory.

The present investigation was undertaken to study the effect of GFRC on characteristic strength of concrete. To achieve the objectives of the present study, cement was replaced by GFRC in different percentages i.e. 10%, 15%, and 20% respectively. The compressive strength, split tensile strength and the flexural strength test were determined for the mixes at the curing age of 7 days and 28 days. The results obtained for the above mixes were compared to investigate the effects of partial replacement of cement by GFRC on the above strength parameters of concrete.

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