STRUCTURAL BEHAVIOUR OF GLASS FIBER IN REINFORCED CONCRETE

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ABSTRACT
Glass-fiber reinforced concrete (GFRC) is a material made of a cementatious matrix composedof cement, sand, water and admixtures, in which short length glass fibers are dispersed. It has been widely used in the construction industry for non-structural elements, like façade panels, piping and channels. GFRC offers many advantages, such as being lightweight, fire resistance, good appearance and strength. In this study trial tests for concrete with glass fiber and without glass fiber are conducted to indicate the differences in compressive strength and flexural strength by using cubes of varying sizes.
Various applications of GFRC shown in the study, the experimental test results, techno-economic comparison with other types, as well as the financial calculations presented, indicate the tremendous potential of GFRC as an alternative construction material. Many efforts have been made to use glass fiber in concrete industry as a replacement of coarse aggregate, fine aggregate and cement. Its performance as a coarse aggregate replacement has been found to be non-satisfactory because of strength regression and expansion due to alkali-silica reaction. The research shows that there is strength loss due to fine aggregate substitution also. The main goalis 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.

Key Words: Glass-fiber reinforced concrete (GFRC), Fibre reinforced concrete (FRC), Fiber glass, Reinforced
Sub Area : RCC
Broad Area: Civil Engineering

INTRODUCTION:

Fiber glass is widely acknowledged as a material that has major advantages over more conventional rivals, such as wood, steel and aluminum. 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 automotivewhere 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.

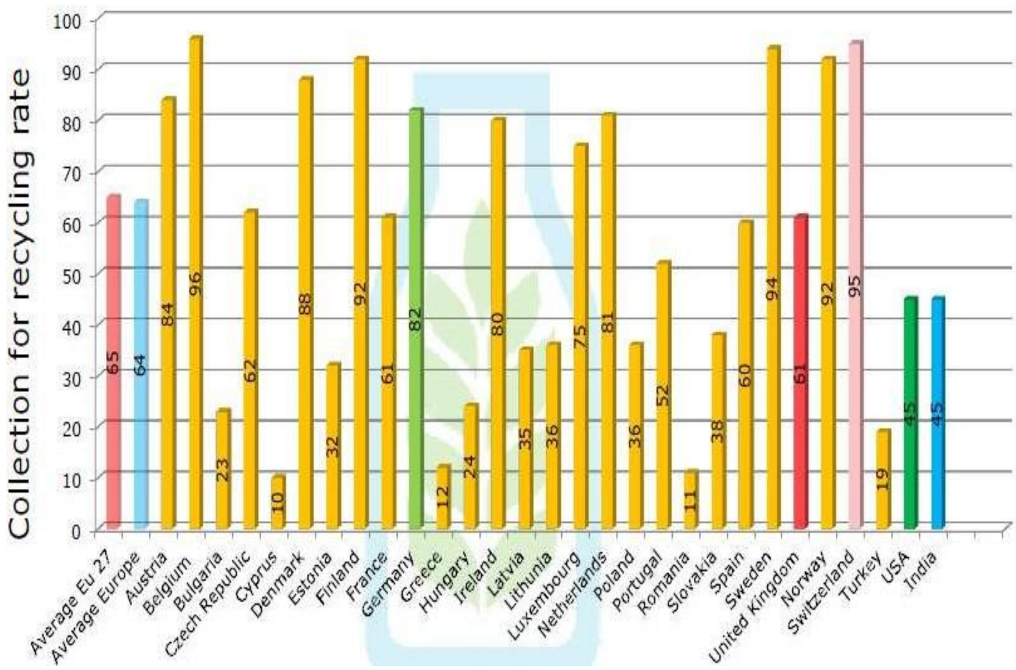


Fig No.:-1.2:- Countrywise Waste Collection Recycling rate

Incineration of GRP is not practical since about 50-70% of the material is mineral and would beleft as ash, which still needs to be land filled. GRP typically consist E-glass, which is usually alumino-borosilicate, along with an organic resin and often calcium carbonate filler. When fed into a cement kiln the organic resin burns providing energy (about 12 MJ\kg of waste) and the mineral constituents provide feedstock for the cement clinker. The clinker is ground to form cement. Any calcium carbonates calcines (releasing carbon dioxide) to calcium oxide, the primary component of Portland cement. Alumina and silica also have cementatious properties in an alkaline environment and are typically present in Portland cement at about 25%, and in much higher proportions in cement alternatives from fly-ash and slag. Boron, which is found in most E-glass, can cause a reduction in early strength during the setting of cement, but as long asproportions are kept low it is not considered a problem.

Fiber is a small piece of reinforcing material produced from various materials like steel, plastic,glass, carbon and natural materials in various shapes and size possessing certain characteristics

properties. They can be circular or flat. Fiber reinforced concrete (FRC) is concrete containingfibrous material which increases its structural integrity. It contains short discrete fibers that areuniformly distributed and randomly oriented. Fibers include steel fibers, glass fiber, syntheticfibers and natural fibers. Within these different fibers that character of fiber reinforced concretechanges with varying concrete, fiber materials, geometries, distribution, orientation and densities.Glass fiber is made by the combination of following chemicals. But this composition could bechanged depending on the requirements of the user. The chemical composition of glass fiber is: Silicon Dioxide: 55%
Calcium Oxide: 16-25%
Alumina Oxide: 12-16%
Baron Oxide: 8-13%
Sodium and Potassium Oxide: 0-1%Magnesium Oxide: 0-6%
This composition is calculated based on 100%. By blending and mixing all of the above chemicalsglass fiber is formed.

RESEARCH OBJECTIVES

This project 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. Furthermore objectives of this study are as follows:-
To partially replace cement content in concrete as it directly influences economy in construction.

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.

G.Jyothi Kumari (2013): studied behavior of concrete beams reinforced with glass fiber reinforced polymer flats and observed that beams with silica coated glass fiber reinforced polymer (GFRP) flats shear reinforcement have shown failure at higher loads.

EXPERIMENNTAL PROGRAM

Tests on cement Cement is the most important constituent of concrete which is also responsible for heat generation at early ages of concrete hardening. The 43 grade ordinary Portland cement (OPC) was used in all the experiments performed in the laboratory as this type of cement was typically used to achieve high strength in concrete. Some common properties of 43 grade cement, given in various IS codes, are listed below:

1. lime in cement. Unaerated cement should not have an expansion of more than 10 mm and .8 percent, when tested by the Le-Chatelier method and Autoclave test respectively as described in WAS 4031-Part 3 [1988].
2. Compressive strength: The average strength of at least three mortar cubes should be as follows.

- 72± 1 hr not less than 23 Mpa
- 168± 2 hr not less than 33 Mpa
- 672±4 hr not less than 43 Mpa

Table-2: Sieve Analysis for 20mm Coarse Aggregate (as per IS: 383-1970)

IS Sieve Designation	Wt. Retainedon sieve (gm)	Cumulativewt. retained(gm)	Cumulative %age retained	%age passing	S:383-1970
80mm	Nil	Nil	Nil	100	100
40mm	Nil	Nil	Nil	100	100
20mm	00	00	00	100	85-100
10mm	3175	3175	63.5	33.5	25-55
4.75mm	1655	4920	97.0	1.0	0-10
Pan	50	5000	100	0.0	----
			∑F = 2.65		
Fineness Modulus of Coarse Aggregate (20mm) = 2.64					

METHODOLOGY

Materials once proportioned and mixed together to obtain a concrete paste, 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 TestHardened Concrete Tests:-
- Compressive Strength Test
- Flexural Strength Test
- Split Tensile Strength TestDurability Tests:-
- Water Absorption Test
- Sorptivity Test

Mix Calculations:

- The mix calculation per unit volume of concrete shall be as follows:
- a) Volume of concrete = **$1m^3$**
- b) Volume of cement = (mass of cement /sp. Gravity of cement) x1000 = **$0.138\ m^3$**
- c) Volume of water = (mass of water/ sp. Gravity of water) x (1/1000 = 161.79/1000
- = **$0.176m^3$**
- **Calculations:**
- **F_b= PL/ bd^2** when a was greater than 13.1 cm or
- **F_b=3 Pa/2 bd^2** when a was in between 10.0 cm and 13.1 cm**,**

Where

a = the distance between the line of fracture and the nearest support.b= width in cm of specimen

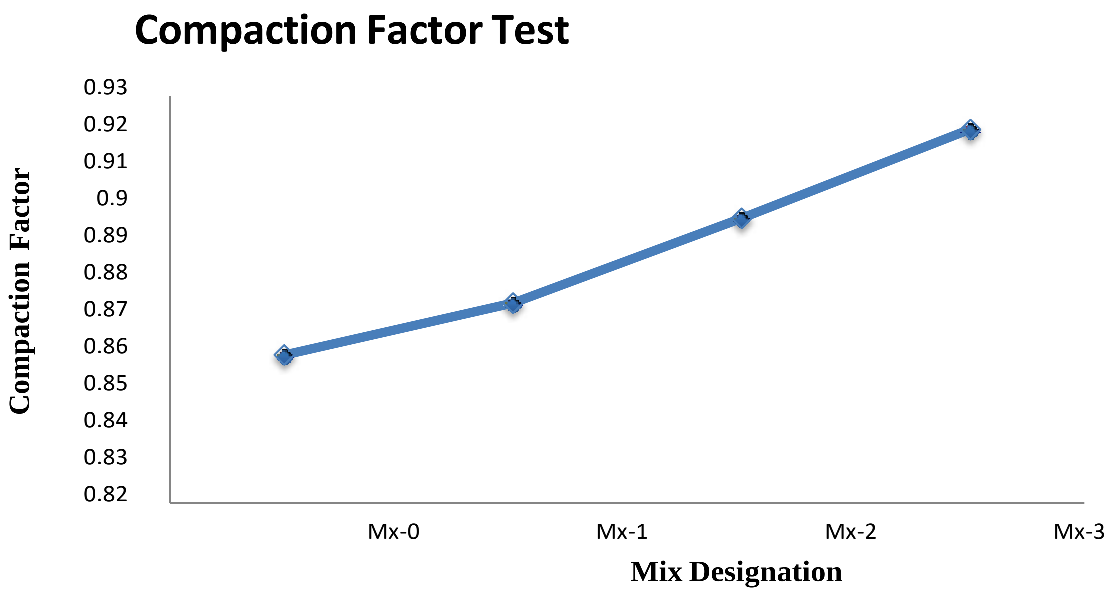
d= depth in cm of specimen at point of failure

L= length in cm of specimen on which specimen was supportedP= maximum load in kg applied to specimen
If a is less than 11.0 cm the test result was discarded.

- **Calculations:**
- The split tensile strength of the specimen calculated from the following formula
- **Tsp = (2P/ (πdL))**

Where
P= maximum load in tonneL= length of the specimen
d= diameter of width of the specimen
Final values are adopted from using standard deviation. On the basis of experiments performed,following conclusions can be drawn:-

Slump Test Curve



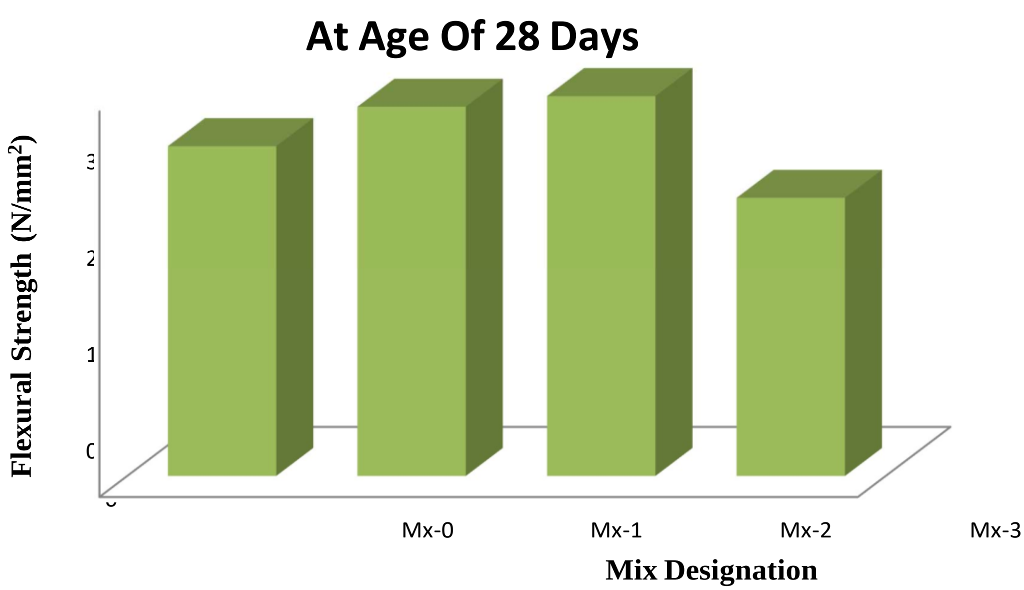


Fig.: Flexural Strength at 28 Days

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 forgreener concrete.
3. Use of glass fiber in concrete will preserve natural resources particularly river sand andthus make concrete construction industry sustainable

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