MECHANICAL PROPERTIES OF GLASS FIBER REINFORCED CONCRETE

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Abstract : The research primarily focuses on the mixing of additional materials like glass fiber and fly ash in the concrete. The main purpose of glass fiber is to increase the tensile or flexural strength of the concrete. The amount of 24mm glass fiber to be added in the mix is 0.25%, 0.50%, 0.75% and 1% of the weight of the sample mix. The fly ash replaces the cement content in the mix. In this case, 20% of cement will be replaced by the fly ash. Fly ash helps in increasing the compressive strength and makes the mix more workable. The experiment will focus on the flexure and hence the specimens that will be focused will be the beams as the flexural strength test are performed on the beams. The research will give the information about the effect of glassfiber in concrete mix. The other parameters like workability and consistency will also be determined.

I. INTRODUCTION

The main advantage of glass fiber in concrete is to enhance the tensile strength ofconcrete. The structure can resist more flexural loads. Glass fiber provides ductility to the structure hence, making the structure a bit more flexible. Glass fiber helps in resisting thermal shocks. In other words, glass fiber provides the structure the ability to withstand the rapid changes in temperature. The cracks due tothermal shocks can be prevented. Concrete is one of most produced materials currently and a lot research has and is being done onconcrete in order to make it better and in this case, to study the behavior of concrete when glass fiber is added. As we know, concrete is not good at taking tensile forces. So to increase the tensile strength of concrete, glass fiber is added. Glass fiber is not traditionally used in concrete, so, to observe the effect of adding fiber in concrete has to be studied. Every material in the concrete mix has a specific role to play and is added in a specific quantity to get maximum benefit. Therefore, to estimate the optimal concentration of glass fiber to be added in the concrete mix, various tests and trial mixes have to be prepared.

Fly ash is another material that is to be added in the mix. Fly ash is an easily available material and is pretty significant in increasing the strength of the concrete. The fine particles of fly ash fillthe small voids in the concrete and help in increasing the strength. Moreover it helps in increasing the workability of the mix. In order see the effect of combination of fly ash and fiber glass in concrete, that is what this study will be focusing on.

II. AIM OF THE STUDY

The basic aim of this study is to check the behavior of concrete after glass fiber is addedto the mix. To check the tensile strength of concrete after adding glass fiber. To check the optimum percentage of glass fiber to be added on the concrete. The see the effect on the workability while mixing. To see the gain in the strength of concrete after curing. To check the effect of fly ash in the mix. To see the difference in normal mix and the fiber reinforced mix with the addition of flyash.

III. USES

In order to provide tensile strength of structures, we add fiber glass in concrete. It also helps to prevent the post cracking due to plastic shrinkage and drying shrinkage. Glass fiber is used in those construction works where the structural strength is not needed. Therefore, we do not useglass fiber reinforced concrete for the construction of those parts of a structure which give structural strength to the structure. But it is very effective in construction the following:

- Building renovation works
- Acoustic barriers
- Sewer lines
- Ducts and roofs
- Tunnel linings
- Ridge lining panels

3. Materials used

Fine aggregates: the locally available fine aggregates were used and the sieve analysis was done to separate the impurities and larger particles from the sand. The selection of sand is done according to IS 650:1991. The sieve analysis is done with thehelp of sieves confirming to IS 460 (part 1): 1985.

Coarse aggregates: the locally available coarse aggregates were used. The size of aggregates ranged from 10 to 20mm. Sieve analysis was done according to IS: 2386 (part 1) – 1963. The aggregates retained on 10mm sieve and passed from 20mmsieve were used for the mix. The aggregates of size not more than 1/4th of minimum thickness were used.

Cement: locally available cement of OPC 53 grade conforming to IS: 12269, is usedthroughout the test.

Water: the ordinary available water was used throughout the test in the mix.

Glass fiber: Glass Fiber manufactured specially for the construction industry was used. The chopped form of readymade glass fiber having 24mm size of strands was used in different proportions for various samples.

Fly ash: the fly ash of class f was used throughout the test. The main purpose of addingfly ash was to partially replace the cement content in the mix.

3.2 Material Properties

Fine aggregates: fine aggregates conforming to zone-1 of the table 4th in IS: 383 wereused in dry conditions with the water absorption percentage of 1.0%. The specific gravityof sand came out to be 2.70.

Coarse aggregates: the 10 to 20mm angular shaped coarse aggregates with the waterabsorption percentage of 0.4% and having the specific gravity of 2.80 was used.

Cement: Ordinary Portland cement of grade 53 confirming to the code IS: 12296 having a specific gravity of 3.15 was used throughout. Consistency 32%. Initial settingtime 91 minutes and final setting time 220 minutes with the soundness of 2.8.

Glass fiber: glass fiber in chopped from having strands of size 24mm and diameter 14micron having a specific gravity of 2.68 was used.

Fly ash: Class f fly Ash with the specific gravity of 2.2 was used throughout.

3.3 Theoretical framework

If we talk about the glass fiber, a glass fiber may be defined as the material that is made up of a number of fine fibers of glass. Glass fiber is mostly made up of silica with the presence of oxides of calcium, boron, iron, aluminum, sodium etc.

During manufacturing, the molten glass is made out of the molten glass passed through machines to form thin strand and fine hair like structures. Glass fibers have following properties:

- High tensile strength
- Low electrical conductivity
- High chemical resistance
- Heat resistant
- Light weight

With these properties, the glass fibers seem to be ideal to be used in concrete inorder to increasethe tensile strength of concrete. If we talk about the history of glass fiber, the first commercial glass fiber was produced in the year between 1932-1933. Owen-Illinois Glass company and Corning Glass Works combined to form Owens-Corning Fiberglass Corporation and then introduced the glass fiber. If we talk about the inventor, Games Slayter is known as the inventor of Glass Fiber.

Fly ash is a very fine substance that is obtained after the combustion of certain material like coal. The difference between normal ash and fly ash is that the fly ash is lighter than normal ash. The fly ash is majorly obtained from thermal power plants. It is composed of aluminium silicate, silicone dioxide, calcium oxide. Some toxic heavy metals like lead, arsenic, cobalt and copper are also present in fly ash. But it has a significant use in construction industry. It is used in manufacturing of Portland cement, bricks, blocks, roads, tiles etc. presently, 63% of the fly ash isbeing utilized. If we talk about cement, almost 35% to 55% of cement is made up of cement. Fly ash bricks are lighter than the traditional bricks.

In concrete mix, fly ash provides reactive silica and alumina which gives secondary CHS gel, reduces the porosity, stops chlorides and corrosion of steel, prevents sulphate attack, prevents alkali silica reaction, prevents carbonation and increases lifespan of concrete. Not onlythis but it helps in increasing the pumpabilty and retention. The bulk density of fly ash may varyfrom 540 to 860 kg/m3 if the compaction is not done and in case of compacted state, the bulk density may range from 1120 to 1500 kg/m3.

Equations

The grade of concrete selected for the mix is M30 with the addition of fly ash. Here, from theTable 5 of IS: 456, the water-cement ratio taken is 0.50.As for the water content, according to table 2 if IS: 10262-2009, the maximum water content in case of 20mm aggregates 186kg per cubic meter of concrete. As per clause 8.2.4.2 of IS: 456, the maximum cement content is 456 kg/m3. The volume of coarse aggregates according to table 3 ofIS: 10262-2009 will be 0.60. The fly ash will replace 20% of the cement from the mix. Now, based on the above selections, the ratio for mix came out as 1:2.32:3.61:0.24:0.5, where 1 is for cement, 2.32 for fine aggregates, 3.61 for coarse aggregates, 0.24 for fly ash and 0.5 for water.

Now, to cast a single beam for testing in lab:
Vol. of beam= 100×100×500mm = 5000000mm3 = 0.005m3

Quantity required for each beam,

Cement required = 1/7.17×0.005×1440×1.54= 1.44kg

Fine aggregates= 2.32/7.17×0.005×1450×1.54= 3.5kg

Coarse aggregates= 3.61/7.17×0.005×1500×1.54= 5.7kg

Fly ash= 0.24/7.17×0.005×1300×1.54= 0.33kg

The water content shall be adjusted according to the desired slump results. Trial mixes should beprepared in order to achieve the desired water content with the initial water cement ratio of 0.50.

I. RESEARCH METHODOLOGY

3.1 Casting Procedure

Beam specimens were prepared in accordance to IS: 516-1959. Before the casting was done, it was made sure that the moulds are well lubricated. The mix was prepared by mixing all the ingredients thoroughly and the glass fiber was added to the mix at the time of mixing. Then the mix was poured into the moulds in layers with tampering done 25 times after each layer was poured. Before the casting was done a slump cone test was also done on the mix. After placing the mix in the moulds, the moulds were vibrated to ensure that there were no spaces and voids left. After the casting part is done, the moulds are kept for 24 hours to dry up. After 24 hours, thespecimens are taken out of the moulds and placed in curing for 7 and 28 days. And after 7 days some samples are tested and some are tested after 28 days. Following specimens are prepared:

Cubes of size 150×150×150mm

Beams of size 100×100×500mm

Cylinders of length 300mm and of diameter 150mm

Quantity of materials in the mix per beam (in kg)						
GF%	Cement	C.A	F.A	FLY ASH	WATER(IN LTRS)	GLASS FIBER
0.00%	1.44	5.7	3.5	0.33	0.72	0.00
0.25%	1.44	5.7	3.5	0.33	0.72	0.02925
0.5%	1.44	5.7	3.5	0.33	0.72	0.0585
0.75%	1.44	5.7	3.5	0.33	0.72	0.08775
1%	1.44	5.7	3.5	0.33	0.72	0.117

3.2 TESTS

Slump cone test

On fresh concrete, the slump cone test needs to be performed according to IS: 1199-1959 in order to get the consistency of the concrete. The test gives the information about workability, consistency and uniformity of different batches of the concrete. It is shape of the slump that gives the information about the workability o the concrete mix. In this case at initial water content, the slump obtained was a true slump without any deformation and the workability was considerably low. But on increasing the water content by 10%, the slump showed the deformation as it collapsed. Due to the addition of fiber in the mix, the workability was affected and to increase the workability, a slight increase in the water content was done in order to get the desired workability.

(True slump formed in on of the mixes)

Tests performed on hardened concrete:

Compressive strength test: Compressive strength is the most important property of the concrete. The test is performed according to IS: 516-1959. Concrete performs extremely well in compressive loadings. To determine the compressive strength of the concrete, the tests are performed on the concrete cubes having the dimension 15×15×15. The specimens are kept in curing for 7 days and 28 days and compressive tests are performed to get the compressive strength of the mix. The specimen to be testedshould be in the surface dry condition. In case of cubes, the specimens are placed in the loading unit of the machine and the load shall be applied to opposite sides are casted.

Concrete as we know, performs well in compression and bears a good amount of compressive loads. The load is applied gradually on the cube till it breaks. The maximum load at which the cube breaks is taken as the compressive load. Now for calculating the compressive strength it is given by dividing the maximum compressive load taken by thespecimen by its cross-sectional area.

Flexural strength test: the flexural test on concrete is done to measure the tensile strength of concrete. The specimens are prepared for the test by marking the point of support on the specimen and for point of support, the mark is placed 50mm from the end of beam to the point of support. The test can be done by two methods. One is central point loading or two points loading. The testing machine is placed with steel rollers on which the specimens are placed. The rollers are set 400 mm apart. A similar roller in caseof one point loading is placed in the center of the machine from which the loading will beapplied and in case of two-point loading, the rollers are placed 200 or 133 cm apart from each other. The specimens are placed in the machine and load is applied on the specimensat a rate of 180 kg/min for 100 mm specimens. And the load at which the failure occurs isnoted and the distance between the point of fracture and the nearest support is noted and the values are placed in the

formula for flexural strength or modulus of rupture. If the distance between fracture point and nearest support is greater than 130mm, then the formula used will be ($f_b=P\times L/bd^2$). And if the distance is less than 133mm and greater than 110mm, then the formula applicable is ($f_b=3Pa/bd^2$). Where 'b' is the width of the beam in mm and'd' is the depth of failure point in mm, 'L' is the supported length in mm,'a' is the distance between the line of fracture and nearest support and 'P' is the maximum load applied to the beam in kilograms.

Split tensile test: in this test, the tensile strength of the concrete is determined by applying a compressive load along the length of the concrete cylinder. The specimen usedis cylindrical in shape and the length of specimen is 300mm and diameter is 150mm. A line is marked along the center of the cross sectional part and weight and dimensions are noted. The specimen is placed longitudinally in the machine and load is applied at the rate of 1.2 to 2.4 MPa/min. The load at which the cracks occur or the specimen fails is recorded and the resultant split tensile strength is given by $2P/\pi DL$, where P is the load atwhich the failure occurs.

IV. RESULTS AND DISCUSSION

4.1 Results of Descriptive Statics of Study Variables

In this experiment, different proportions of glass fiber were added to the concrete mix with 20%replacement of cement with fly ash. At every proportion of glass fiber i.e. ,0%, 0.25%, 0.5%, 0.75% and 1% of glass fiber added to the mix, 3 samples were made. And based on the performed experiment, following observations were made:

1. The workability of the mix got affected. On adding the glass fiber to the mix, theworkability got decreased.
2. Fly ash has a capability of replacing the cement content in concrete and about 20 to 35%of cement can be replaced by fly ash.
3. The main motive of adding glass fiber to mix was to increase the tensile strength and it was expected that the glass fiber would increase the tensile strength of concrete by up to33% based on the existing researches.
4. The tensile or flexural strength is the most affected mechanical property that getinfluenced by the addition of glass fiber.
5. Fly ash has a significant effect on the concrete as it increased the pumpability and helpedin retaining the slump for longer time.

The performed experiment gave the information about the addition of glass fiber to the concrete mix. Concrete as we know does not perform well in tensile forces, to counter this problem, the addition of glass fiber was done. Glass fiber has a good tensile strength and when added to the concrete, it increases the tensile or flexural strength of the concrete significantly. Based on the research done on the glass fiber reinforced concrete, the glass fiber can increase the strength. The glass fiber not only helps in increasing the tensile strength but also helps in controlling the cracks due to plastic shrinkage and drying shrinkage. But on the contrary, the usage of fibers with longer length reduces the workability.Thus, using micro fibers can help in getting a better workability comparatively to using the long fibers. Glass fibers not only increase the flexural strength but help in increasing ductilityand give concrete a good resistance to thermal shocks. The other additional material added inthe mix was fly ash. As we know that fly ash is a fine powered substance having properties similar to cement. Fly ash is finer than Portland cement and is used to replace the cement content in the mix. In this case, 20% of cement was replaced with fly ash. Fly ash increased the hydration time and reduced the heat of hydration which resulted in the delayed initial setting time of the mix. Fly ash helps in increasing the final compressive strength but decreases the short term strength. Fly ash has a good effect on workability as it increases the workability of fresh concrete.

I. ACKNOWLEDGMENT

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