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STUDY ON WORKABILITY AND MECHANICAL PROPERTIES OF GLASS FIBRE REINFORCED SELF COMPACTING CONCRETE USING GGBS AND METAKAOLIN

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ABSTRACT: Much research has been done on workability and mechanical properties of self compacting concrete. This research aim to find workability and mechanical properties of Glass fibre reinforced self compacting concrete on fresh and hardened state using mineral admixture ground granulated blast furnace slag and metakolin using varying in percentage of glass fibre from about 0% to 0.5% with about 6mm and 12mm length of glass fibre by weight of concrete with 0.8% of superplaticizer. In the following work slump flow, T50 slump flow, V-funnel and L-box test were conducted on fresh concrete and compression test, split tensile test, flexural strength with load-deflection characteristic and modulus of elasticity with stress- strain relationship on hardened concrete were tested. Slump flow, V-funnel and L-box were conducted to know the workability of FRSCC it's found that slump was 660 to 600mm from 0 to 0.5% of fiber by weight of concrete respectively, and V-funnel was around 7 to 11 seconds of flow for 0 to 0.5% by weight concrete respectively, and blocking ratio (H2/H1) values was 0.98 to 0.82 which is all good as per as codal provision for a good concrete mix for SCC. And mechanical properties such as compression test, split tensile test, flexural strength, flexural toughness (load-deflection characteristics) and young's modulus (stress –strain characteristics) of glass fiber reinforced self compacting concrete were determine, it's found that FRSCC has increase in compressive strength (67.22N/mm2) up to 125% for 0.2% of fiber added to concrete mix as compare to normal conventional concrete, and tensile strength was increase for 0.2% (4.26 N/MM2) of fiber added to SCC. And also significance increase about 165 % increase in flexural strength (8.4N/MM2) as compare to normal conventional concrete and good load-deflection characteristics for 0.2 % by weight of fibre added to SCC.
Keyword: Self compacting concrete, Glass fibre reinforced self compacting concrete, Supplementary cement material, Ground granulated blast furnace slag.

I. INTRODUCTION

Concrete is a composite material composed of coarse granular material (the aggregate or filler) embedded in a hard matrix of material (the cement or binder) that fills the space between the aggregate particles and bond them together. [13]

Current study of building business shows expanded development of expansive and complex structures, which frequently cause troublesome in concreting conditions. It is difficult to get the form work fully compacted without voids and honeycombs when much amount of heavy reinforcement is placed to it [13]. Concrete with vibration in congested areas may bring about danger to workers and they are always not sure about the quality, durability and strength of concrete set in that area. Self compacting concrete (SCC) is the solution for durability of strong concrete structures and free of quality of construction work. SCC is a concrete which has a capacity to flow in its particular weight which thoroughly fill the formwork with no isolation, even though of heavy reinforcement, it maintains homogeneity with no vibration[1]. SCC was created in Japan by Okamura in 1980's to basically utilized in highly congested reinforce concrete structures in seismic regions. Hence SCC has created huge enthusiasm among the engineers, research scholar and concrete technologists. Although concrete have high compressive strength, durability, rigidity, low thermal conductivity and electrical conductivity, low combustibility and toxicity, hence following features has constrained its utilization, i.e. it have less strength in tension and it is weak[5].

Though advancement of fiber-reinforced composites (FRC) has given a specialized theory to enhancing these inadequacies. Fibers are tiny pieces of reinforce material mixed to concrete blend which typically contains cement, water and fine and coarse aggregate. The most utilized fibers are steel, glass, asbestos and polypropylene. As the load is placed on concrete it results in collapse and cracks will propagate. Fibers in concrete helps to arrest the crack growth. If the modulus of elasticity of the fiber is soaring regarding to the modulus of elasticity of the concrete or mortar binder, the fibers support to take the load which lead to increase the tensile strength of material. Fibers improve the toughness, durability, and the flexural strength, reduces creep strain and shrinkage of concrete.

Glass Fiber Reinforced Concrete (GFRC) is made out of concrete reinforced with glass fiber to create slim, low weight, and strong material. In spite of the fact that concrete has been utilized all through the ages, GFRC is a moderately new development. High compressive and flexural strength, and has an capacity to reproduce fine surface point with less maintenance requirement, low coefficients of thermal expansion, highly fire resistive, also eco friendly. Hence GFRC is the better choice for engineers. The superiority of GFRC is known by length of fibre, distribution of fibre, orientation of fibre, amount of fibre, and aspect ratio of fibre.

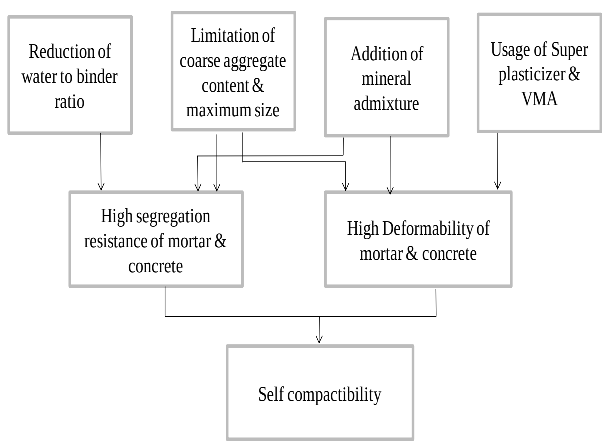
Consideration of fibers into SCC will produce Fiber Reinforced Self Compacting Concrete (FRSCC) with good properties in fresh and hardened state. The reinforced fiber in concrete may enhance the tensile strength, flexural strength, impact strength, toughness, drying shrinkage, and failure pattern of the concrete. Generally cement, coarse and fine aggregates, water, super plasticizer, fibers are raw materials used for the production of FRSCC [5].

FRESH PROPERTIES OF SCC

The concrete be named "High performance concrete." and was characterizing in 3 phases of concrete:

(1) Fresh: self-compactable
(2) Early age: evasion of initial defects
(3) Subsequent to hardening: assurance against external factors.

FLOW CHART TO ACHIEVE SELF COMPACTIBILITY



II. AIM AND OBJECTIVE OF STUDY

The study on new materials like SCC and GFRSCC over its mechanical properties and stress-strain behavior is necessary for initializing confidence in engineers. The literature indicates that some studies are available on plain SCC and steel FRSCC but sufficient literature is not available on the stress-strain behavior and mechanical properties of GFRSCC and SCC with different mineral admixtures. Consequently considering the discontinuity in present literature an attempt has been made to research on workability and mechanical properties and stress strain behavior and other imperative view point like young's modulus, and flexural strength of concrete with glass fiber of both SCC and GFRSCC.

By studying the nature and level of work done on SCC using GGBS and metakaolin as substitution of concrete, the projects aims at :

- Surveying an impact of cement supplementary material like GGBS and metakaolin on workability and mechanical properties of fiber reinforced SCC.

- Arriving at ideal mix ratio for the different supplementary cementing material being used while mixing.
- In addition, physical and durability on hardened concrete will also be evaluated.
- The rheological properties of the cement paste were evaluated.
- This projects comprise an investigation on workability perspectives by conducting j-ring, v- funnel, l-box, slum flow test.
- Strength perspectives like compressive strength, split tensile strength , flexural strength are evaluated and,
- Important test to be directed on young's modulus (stress-strain behavior of cylinder) and flexural strength (load-deflection characteristic of beam) containing and admixture like GGBS and metakolin with glass fiber to be included and high range water reducer and plasticizer to be added.

SCOPE OF STUDY

By adding supplementary cement materials the dependence on cement can reduce to greater extent.

- By using the industrial waste of GGBS and Metakaolin it decreases the ecological contamination.
- GGBS and Metakaolin less thick than bond, the dead weight of composite concrete could be decreased sensibly and also in the construction cost.
- Metakaolin being better than other admixture enhance compaction, workability, and reduces dissolution and leaching.
- The project can impact the SCC making in a positive way.
- For GFRSCC, the optimum fiber content will be determined from the test results and applied to the mix proportions of the reinforced concrete slabs.

SIGNIFICANES OF STUDY

FRSCC has great potential and wider applications in construction industry due to the combined benefits of both SCC and FRC. FRSCC with elimination of compaction and improved toughness of hardened concrete make it more suitable for use in construction of structures with dense reinforcements and subjected to impact and earthquake loads.

The results of this study will present the physical and mechanical properties of the plain SCC and GFRSCC. For GFRSCC, the optimum fiber content will be determined from the test results and applied to the mix proportions of the reinforced concrete slabs. The fiber conditions and failure patterns of the concrete specimens will also be observed.

III. LITERATURE REVIEW

EARLIER RESEARCH

G K VISHVANATH et,al.,have studied on flexural behavior of reinforced concrete beams using self compacting concrete for Mix30, Mix40, Mix50 and Mix 60 grade concrete in their research they carried experiment studied on flexural behavior of glass fibre reinforced self compacting concrete on above concrete mix with Glass fibre0-0.1% by weight of concrete And Load-deflection characteristic of glass fibre reinforced self compacting concrete for above concrete mix with varying glass fibre content from 0 to 0.1% by weight of concrete.

Conclusion from investigation

1) Glass fiber reinforced concrete gives good surface finish and homogeneity of concrete and has good crack resistance properties.
2) Its observed that load carrying capacity of glass fibre reinforced self compacting beam is increases for 0.03% of glass fibre added as compare to 0%, 0.06% and 0.1%.
3) The presence of glass fibre not only increases the flexural strength of concrete but also micro structure of concrete is improved with the reduction of crack and also micro crack prevention.

CANDRAMAULI K, SRINIVAS RAO P et.al have studied the strength properties of glass fibre concrete in his research he had experimental investigation on normal high strength glass fibre reinforced concrete. In his investigation the alkali resistance of glass fibre has been used to study effect on compression strength, split tensile strength, and flexural strength on Mix30, Mix40, and Mix50 Grade concrete with glass fibre 0.3% percentage by weight of concrete.
Following conclusion had drawn from study

1) Lessening in bleeding was noted by the adding glass fibre in the glass fibre concrete mix.
2) Glass fiber reinforced concrete gives good surface finish and homogeneity of concrete and has good crack resistance properties.
3) Increase in about 20-25% of compressive strength with the addition of glass fibre was observed as compare to normal conventional concrete.
4) Increase in about 10-15% of tensile and flexural strength with the addition of glass fibre was observed.

M.MERGIN BENIZE, A DEEPAK RAJ et,al.,had carried experimental investigation glass fibre reinforced self compacting concrete on fresh and hardened state of concrete with varying in length (1.2mm, 1.8mm, 2.4mm) and percentage of glass fibre 0%, 0.25%, 0.5%, 0.75% and 1% by weight of concrete and mineral admixture were used was 30% fly ash as replacement of cement and super plasticizer were about 1% by weight of cement.
Following conclusion from investigation

1) The addition of glass fibre does not affect the passing ability, filling ability and segregation resistance to self compacting concrete
2) The test were conducted for different length of glass fibre with different percentage by weight of concrete its observed that from the test results flow ability of SCC is directly proportional to the length of fibre and quantity added i.e., the results come under the range of recommended values when quantity and length of glass fibre is maximum
3) It's observed that 1% of glass fibre added in all length is more flow able then that of 0.25% of glass fibre in all length.
4) 1% and 2.4mm length posses good workability property give good slump value than any other mixes.

SUMMARY OF LITERATURE

With the help of the available literatures, outcome of literature give that fly-ash, GGBS, Metakaolin, silica-fume and rice husk ash can be used as supplementary cementing materials (SCMs). These SCMs are the by-products from various industries, which are creating environmental hazards while disposing. These by-products be able to be utilized as a partial replacement to cement in producing concrete, which helps in reducing both environmental impact and the production cost of concrete. Workability properties of the concrete are also influence positively by the use of these SCMs.

EFNARC gives specification and guidelines in preparing SCC because there is no specific code book for mix design for SCC. Super plasticizer is the key material in preparing SCC, poly-carboxylic ether based super plasticizer gives better performance than any other super plasticizers. If segregation is observed in fresh concrete it can be avoided by using viscosity modifying agents. The using of coarse aggregate size should be limited to 12.5mm to get good workability results.

The use of GGBS in combination Metkaolin gives better mechanical properties, when compared to the concrete which is produced using individual SCMs. The use of GGBS when used as a replacement to cement is found to be effective for a maximum replacement of 40%,and Metakaolin can be replaced up to 15%. And mechanical properties are very much influence by adding glass fibre to SCC which give attractive mechanical properties (compression, tensile and flexural strength) of concrete. It is observed in the review the strength of concrete is depend upon amount and length of fibre in concrete i.e., percentage by weight of concrete and varies from 0% to 1% can be added to SCC mix. And with addition of fibre its having good results on fresh concrete and also crack and crack propagation can also be eliminated with the addition of fibre.

IV. MATERIAL AND ITS PROPERTIES

GFRSCC contains the following material for its composition they are cement, fine aggregate i.e., sand (manufacturing sand), coarse aggregate, mineral admixture (GGBS and Metakolin), super plasticizer and Glass fibre. SCC had gain popularity because it's designated and constructed using as like normal concrete.

The cement used in GFRSCC is normal 53 grades Portland cement and its most widely used in all form of conventional concrete. The typical fineness of cement ranges from 350 to 500m^2/kg for cements. In the GFRSCC the Portland cement conforms with IS 12269-1987 is use. One of the important constituent of concrete is Aggregate. And aggregate give body to the concrete and reduces shrinkage and it effect economy of concrete. In SCC the aggregate are used in range from 10-20mm of minimum and maximum size respectively.

The coarse aggregate which was used in the work was crushed granite of highest size 12.5mm and retain on IS 4.75 sieve where used. The physical properties of coarse aggregate are satisfying in accordance with IS: 2386-1963.

Due to high demand and high cost of construction of natural river sand we had employed manufacturing sand from stone query which give good physical properties as like Natural River sand and have best results in construction. In the study fine aggregate is contrived from sand quarry is used, are as per IS: 383-1997.

MINERAL ADMIXTURE

The admixture is that material in the concrete which added before or after mixing of concrete it's other than that of cement, coarse aggregate, fine aggregate and water. Admixture is added to concrete to improve the property of concrete or to have special properties in concrete.

GGBS

Ground granulated blast furnace slag is called as slag cement and it's obtained during the manufacturing of pig iron or during blasting of iron in furnace. The granular material which is obtained is ground to less than 45 microns and the surface area fineness is about 450 to 650 kg/m2 Blaine. The specific gravity (Relative density) of GGBS is same as that of cement that is around 2.85 to 2.95.

METAKOLIN

Metakaolin, special calcined clay, is produced by low temperature calcination of high purity kaolin clay. As an average of about 1 to 2 micrometer the product is grounded

From clay mineral kaolinite the metakolin is dehydroxylated. During the manufacturing of porcelain the rock which is rich in porcelain known as china clay are used.

SUPERPLASTICIZER

The important admixture for achieving good workability by reducing the water content in concrete and increase the strength of concrete is super plasticizer.

For achieving concrete to deform or achieving self compactable the superplasticizer is a key material. In the present study AURAMIX 300 superplasticizer with exceptional combination of latest generation in chemical industry in concrete technology it's based on polycarboxylic ether with extended lateral chain.

Properties of superplasticizer (Auramix 300)

SL.NO.	Property	Value
1	Color	Off white Liquid
2	Relative Density	1.08±0.01@25ºC
3	Ph	>6
4	Chloride ion content	<0.2%

GLASS FIBRE

Plain concrete posse's very low tensile strength, limited ductility and little resisting cracking and crack propagation. Due to micro crack and its propagation in conventional concrete there will be poor tensile strength and eventually lead to brittle fracture. Fibre is small piece of reinforcing material which is added to concrete To eliminate the gap i.e., to improve tensile, flexural strength and other important properties of concrete such as load-deflection characteristic and stress-strain characteristic of concrete fibre reinforced concrete.

Glass fibre is a new discovery or introduction in making fibre reinforced concrete its having high tensile strength varies from 1040 to 4060 N/mm2. Glass fibre was used in conjunction with cement was found to be alkaline condition of cement. The glass fibres are available in wide range in shape, size, stiff and flexibility. In the research glass fibre are used with different percentage and with different length (aspect ratio of fibre) in the research glass fibre of length 6mm and 12mm are used, following are the properties of glass fibre.

SL.NO.	Property	Value
1	Colour Appearance	White monofilament
2	Density (kg/m3)	0.91
3	Tensile strength	>2500 Mpa
4	Elastic modulus	>4500
5	Melting point in degree	1200
6	Compression strength	1200 Mpa

WATER

This is the least pricey universally obtainable material, other than most important ingredient of concrete. The water, which is used for making concrete and for curing, be supposed to be clean and free from harmful impurity such as oil, alkali, acid, etc, in common, the water, which is fit for drinking should be used for making concrete.

V. MIX DESIGN AND METHODOLOGY

Mix design can be defined as the procedure of selecting appropriate ingredients of concrete and determining with the object of producing concrete of certain minimum strength and durability as economically as possible. EFNARC gives specification and guidelines for SCC because there is no specific code book for mix design of SCC.

SCC PRINCIPLE AS PER EFNARC

The key components by volume relatively than mass it's most effective for design mix in comparative proportions.

- Water / Powder ratio by means of volume of 0.80 to 1.10
- Total powder content – 400 – 600 Kg/per cubic meter.
- Coarse aggregate content usually 28 to 35 percent by means of volume of the mix.
- Based on EN 206 Water Cement ratio is selected. Water at ease be supposed to not exceed more than 200 liters/m3. Hence the sand content balances the volume of the other constituents.

MIX DESIGN PROCEDURE FOR GFRSCC

After many trails and satisfactory results on fresh properties of GFRSCC. With varying glass fibre content in a concrete mix design, the following Mix design was finalize and the superplasticizer dosage was determined by measuring the flow of concrete. From above literature I have selected mineral admixture as GGBS and metakolin with about 15% of GGBS and 6% of Metakolin of cementious materials with varying in percentage of glass fibre from about 0.1%-0.5% of 6mm and 12mm.with a superplasticizer dosage about 0.8% of cementious materials.

MIX-1: CEMENT-79%, GGBS-15%, METAKOLIN-6% WITH 0.1% GLASS FIBRE (6MM LENGTH)
Similarly Mix design is done for
MIX 2: Cement 79%, GGBS 15%, Metakaolin 6%, and Glass fibre 0.1% (12mm)
MIX 3: Cement 79%, GGBS 15%, Metakaolin 6% and Glass fibre 0.2 %(6mm)
MIX 4: Cement 79%, GGBS 15%, Metakaolin 6% and Glass fibre 0.2 %(12mm)
MIX 5: Cement 79%, GGBS 15%, Metakaolin 6% and Glass fibre 0.3% (6mm)
MIX 6: Cement 79%, GGBS 15%, Metakaolin 6% and Glass fibre 0.3% (12mm)
MIX 7: Cement 79%, GGBS 15%, Metakaolin 6% and Glass fibre 0.4% (12mm)
MIX 8: Cement 79%, GGBS 15%, Metakolin 6% and Glass fibre 0.5% (12mm)

The mix proportions of various mixes are given in below table

Table containing Mix proportion

Mix No	Cement Kg/m^3	GGBS Kg/m^3	MK Kg/m^3	FA Kg/m^3	CA Kg/m^3	W/C Ratio	SP Kg/m^3	Glass fibre grams
Mix 1	441.82	74.505	27.527	880.94	714.42	0.349	4.35	78.26
Mix 2	441.82	74.505	27.527	880.94	714.42	0.349	4.35	78.26
Mix 3	441.82	74.505	27.527	880.94	714.42	0.349	4.35	142.43
Mix 4	441.82	74.505	27.527	880.94	714.42	0.349	4.35	142.43
Mix 5	441.82	74.505	27.527	880.94	714.42	0.349	4.35	213.64
Mix 6	441.82	74.505	27.527	880.94	714.42	0.349	4.35	213.64
Mix 7	441.82	74.505	27.527	880.94	714.42	0.349	4.35	291.90
Mix 8	441.82	74.505	27.527	880.94	714.42	0.349	4.35	370.16

METHODOLOGY

Experimental investigation is carried out for studying fresh and hardened state properties of GFRSCC, by replacing cement with GGBS and Metakolin with about 15% and 6% respectively. And to get optimum mix of Glass fibre added, the fibre is varied from 0.1%-0.5% with 6mm and 12 mm fibre length. After much trial mix to check for a proper mix design for good slump value superplasticizer dosage is varied, then after many trail an optimum dosage of superplasticizer was fixed to about 0.8% of cementious material.

Research was performed in steps:

In step one every one mix tests were conducted to find out fresh workability properties (such as Slump flow, V-funnel test, and L-box test) of concrete. Fresh concrete were casted into cubes, cylinders and prisms. Specimens were water cured till testing (7and 28 days).

In the second step, at each age (7 and 28days) tests were conducted on cubes, cylinders and prisms to determine hardened properties of GFRSCC such as compressive, splitting tensile and flexural strengths and also load versus deflection behavior of GFRSCC for every mix magnitudes. Also Young's modulus (to known the stress-strain behavior of concrete) was conducted on specimens after 28 days of curing to know the stress- strain behavior of GFRSCC.

VI. EXPERIMENTAL PROGRAMME

TESTS ON FRESH CONCRETE OF GFRSCC

Test on workability were conducted i.e., slump flow test (diameter spread), V-funnel, and L-box test.

SLUMP FLOW TEST

One of most important and usually test at current time for SCC is slump flow, this test involve the make use of slump cone used with conventional concrete as described in ASTM. T50 CM test can be determined during conducting slump flow test. It is simply the amount of time the concrete takes to flow to a diameter of 50 centimeters. In T50 cm test the concrete should flow about 50cm at a given time, usually time to flow for a concrete to 50cm take around 2-5sec.

Procedure:

Concrete needed to perform the test is 6 litres and it is sampled normally .Wet the base plate and also inside of slump cone. Lay base plate on level steady view and place slump cone in centre of base plate and clutch down resolutely. Fill up the cone with scope, as its self compacting concrete it will flow by own weight so, no need of tamping, just remove the excess concrete from cone by trowel. Clean the table i.e., needs to remove the concrete which is around the table (surplus concrete) such that concrete should flow freely on the table. Allow to flow concrete freely, by raising cone vertically .At the same time, the time is taken by stop clock for the concrete to reach to 500mm spread circle (and this will be T50 time). Spread the concrete on table in both the directions (perpendicularly),by measuring both diameter calculate average that is slump value in MM.

L-BOX TEST

L-box test is an option to the J-ring test often used in rising SCC mixtures. It is also used to determine a concrete mixture's pass ability, fluidity, as well as the tendency to segregation.

The vertical part is crammed with concrete and the gate is lift and concrete flows in parallel section. As the flow have congested, the depth of the concrete at the end of the parallel section is uttered as a amount of that residual in the perpendicular section (H2/H1in the diagram).This shows the slope of concrete when at rest. Its sign passing capability, or the amount to which the passage of concrete from side to side the bars is restricted. As the EFNARC guidelines suggest, the limit should be between 0.8 and 1.0, where above 0.8

Procedure

To perform L-box test 14 liters of concrete is needed, which is normally sampled. The apparatus is set in such a way, its firmly grounded such that the sliding gate can release freely and can shut it freely. Moisten the inside surfaces of the apparatus, remove extra water.

Fill the vertical section of the apparatus with the concrete sample. Depart it to stand for nearly 1 minute.

Raise the sliding gate and permit the concrete to flow out into the parallel section. At the same time, begin the stopwatch and record the times taken for the concrete to arrive at the 200 and 400 mm. When the concrete stops flowing, the distance “H1” and “H2” are calculated. Calculate H2/H1, the Blocking Ratio. The whole test has to be performed within 5 minutes.

V-FUNNEL TEST

V-funnel test is used to find out the filling ability (flow ability) of the concrete with a utmost aggregate size of 20 mm. The funnel is full with 12 liters of concrete; its instant time rummage-sale flow from side to side the apparatus is been intended. Then the funnel is refilled with concrete and it is left for 5 minutes to reconcile. If the concrete show separation then the flow time will enlarge drastically. The acceptance decisive factor for V-funnel flow time for T_0min is 6 to 12sec and for T5min is 15sec. The V-funnel apparatus is shown in fig.5.5 and how test have been performed is shows in figure fig.5.6

Procedure of flow time

For performing V-funnel test, 12 litres of concrete is needed which is sampled usually. Set the V-funnel on stiff position. Wet inner surface of the funnel. Let the ensnare door open such that it allow surplus water to drain. Close by the trap door and abode a bucket below.

Fill the apparatus totally with concrete lacking compacting or tamp; simply strike the rotten concrete plane with top covered by towel. Release inside 10 sec followed by filling the trap door and let the concrete to flow out underneath gravity. Begin the stop clock at what time the trap door is open, and note the time intended for the discharge to total time. This is taken to be at what time light is seen from above from side to side the funnel. The entire test is supposed to have to take 5miniutes to perform.

MECHANICAL PROPERTIES TESTS

To determine the hardened properties of concrete standard tests were carried out at standard ages (7 and of curing) i.e., compression test on cubes for compressive strength (150x150x150mm size), split tensile test on cylinders for tensile strength (150mm dia with 300mm height) and flexural test on prisms for flexural strength and also to find load vs deflection for prism (500x100x100mm) of concrete. And modulus of elasticity for cylinder and also for finding stress-strain relationship of concrete (150mm dia with 300mm height).

COMPRESSION TEST

The compression strength of concrete is mainly defined as the load which leads to failure of the specimen divided by the area of the cross section in uniaxial compression, under a specified rate of loading.

The cubes were tested in 2000KN capacity compression testing machine loaded at 140Kg/cm^2/min as per standard procedure explained in IS: 516-1956(1999) to get the compression strength of the concrete. The load at which cube fail or get crack or collapse is known as ultimate load, it is noted for each specimen. The values are tabulated and calculations are done.

Compression strength = Ultimate Load/Area (N/mm^2)

SPLIT TENSILE TEST

The tensile strength is one of the vital and important tests of the concrete. The concrete is not more often than not predictable to resist the direct tension because of its low tensile strength as well as harsh character.

The cracking is a type of tension collapse or a type of tensile failure. The test is conducted as per IS: 5816-1999. A concrete cylinder of size 150mm dia×300mm height is subjected to compressive force at a rate of 4tons/min along two opposite edges. The cylinder is under compression near the loaded region across the diameter and cylinder is under to uniform tensile stress all through length. The calculated is done using the equation given below,

Horizontal tensile stress = 2P/πDL

Where, P = Compressive load on the cylinder.
L = Length of the cylinder.
D = cylinder diameter.

FLEXURAL STRENGTH TEST

Flexural strength or modulus of rupture or break or fracture strength, a motorized restraint for frail or hard material, is known as a material's capability to prevent deformation underneath load.

The test has conducted on universal testing machine which has a capacity of 400KN, in our investigation two point loading test is subjected to a beam with dimension of about 500x100x100, figure 5.15 show the set up of flexural strength on UTM, and in the search dial gauge has fixed to measure the deflection of beam under two point load by which load vs deflection characteristic of beam or concrete can be know.

Flexural strength of concrete is calculated using below formula.

$$f_b = pl/bd^2$$

Where, p = ultimate load,
b = width of specimen in MM
d = depth of specimen at failure point in MM
l =length of specimen supported on span in MM

YOUNG'S MODULUS OF ELASTICITY TEST AND STRESS-STRAIN RELATIONSHIP

The Modulus of Elasticity (E-value, the ratio between stress and strain), is used in the elastic calculation of deflection, often the calculating parameter in slab design, and of pre or post tensioned essentials. As the mass of the volume of concrete is aggregate, the type and amount of aggregate as well as its E-value have the most influence. Choosing an aggregate with a mounting E-value will upsurge the modulus of elasticity of concrete. Although increase in mortar or cement paste will decrease in modulus of elasticity, since SCC often has privileged paste content than conventional vibrated concrete.

After curing the specimens for 28 days, Three standard size specimens of 150x300mm cylinders are used for finding stress-strain behaviour under uniaxial compression. Test is conducted in stress controlled CTM of 3000KN capacity at 950 N/sec stress rate. At specified load interval corresponding strain is noted down. Then graph of normalised strain versus normalised stress is plotted.

VII. RESULTS AND DISCUSSION

The results of slump flow (spread), V-funnel flow time, and L-box test are summarized in Table Results were evaluated as per as "The European Guidelines for Self Compacting Concrete ". The following table presents the test results based on the various fresh properties tests conducted.

COMPRESSION TEST RESULT

The compressive test is conducted on the cubes for all mix proportions at 7 and 28 days. The Cubes specimen of size 150x150x150 mm is used to determine the compressive strength. Test results are given in the TABLE

Table shows workability results of SCC for different mix proportion

Table Cube Compressive Test Result of Different Mix Proportion's

Mix	**Compressive Strength(N/mm^2)**	
	7 days	**28 days**
Mix1	37.78	55.57
Mix2	41.49	61.02
Mix3	45.7	67.22
Mix4	42.45	62.44
Mix5	37.15	54.64
Mix6	38.37	56.72
Mix7	35.78	52.62
Mix8	34.69	51.02

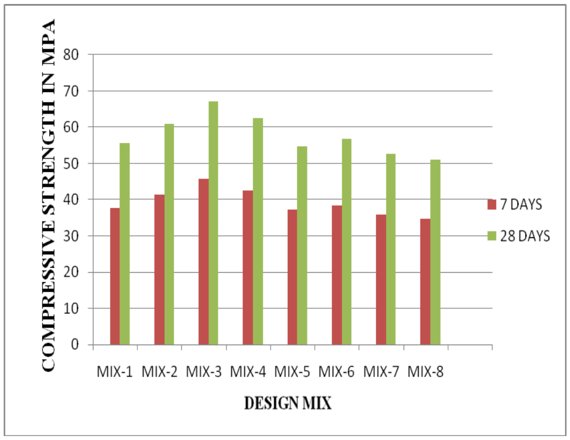
Mix	**Slump flow Dia(mm)**	**T_{50} Slump flow (Sec)**	**V-funnel test (Sec)**	**L-box Ratio (H_2/H_1)**	**Temp. (^{0}c)**	**Density (Kg/m^3)**	**Ph**
Mix1	660	2.9	7	0.82	24	2472	11.48
Mix 2	625	3.3	9.2	0.89	25	2526	11.50
Mix 3	640	2.9	8.1	0.84	24	2550	11.63
Mix 4	610	3.2	9.5	0.9	23	2470	11.8
Mix 5	635	3	8	0.86	26	2480	11.94
Mix 6	615	3.4	9	0.92	25	2510	11.70
Mix 7	610	3.1	10.5	0.95	24	2480	11.4
Mix 8	600	3.5	11	0.98	26	2546	11.35

SPLIT TENSILE STRENGTH RESULT

The split tensile test is conducted on cylinder specimens of size 150mmΦ and 300mm height. The results are tabulated below.

FLEXURAL TEST RESULT

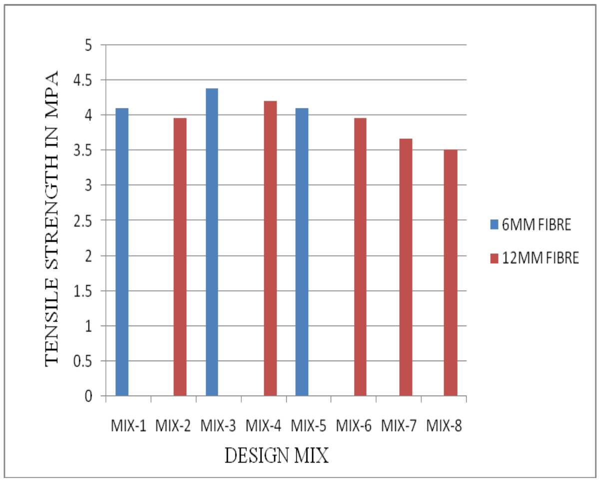
Test is conducted on the prism specimens of size 100x100x500 mm at 28 and 56 days of curing. Test results are tabulated below



Graph show design mix vs compressive strength in MPA.

Split Tensile Strength of Different Mix Proportion's

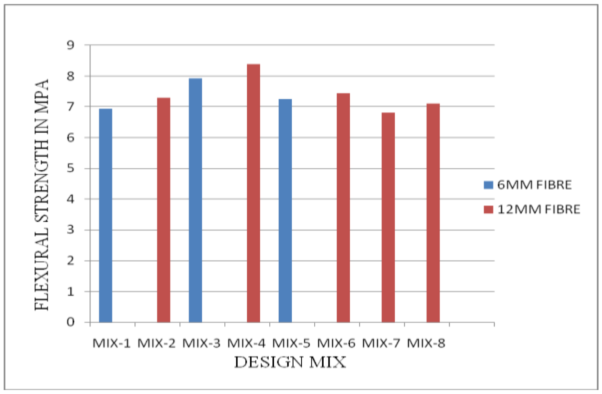
Mix	Split Tensile Strength(N/mm^2)
	28 days`
Mix 1	4.1
Mix 2	3.96
Mix 3	4.38
Mix 4	4.21
Mix 5	4.1
Mix 6	3.96
Mix 7	3.67
Mix 8	3.52



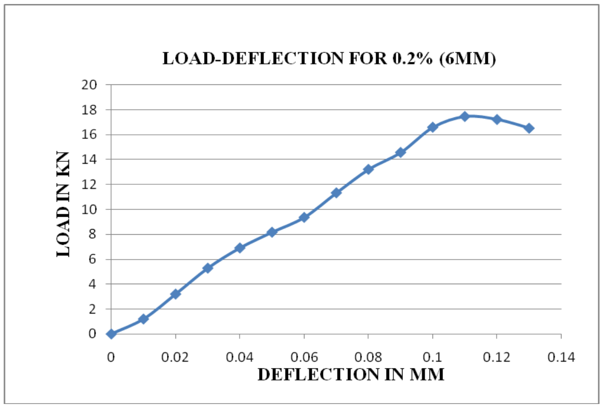
Graph show design mix vs tensile strength in mpa

Table Flexural Strength of Different Mix Proportion's

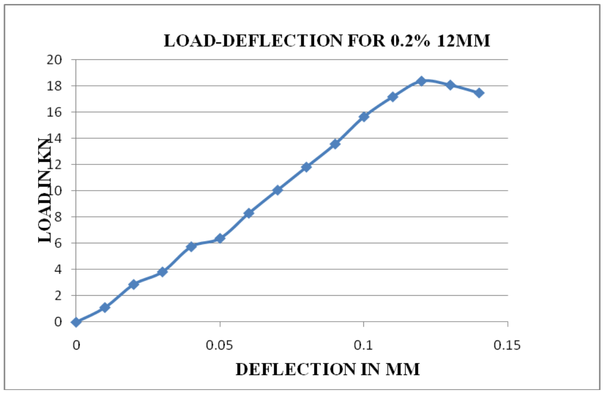
Mix	Flexural Strength(N/mm^2) 28 days
Mix 1	6.93
Mix 2	7.30
Mix 3	7.92
Mix 4	8.4
Mix 5	7.25
Mix 6	7.44
Mix 7	6.82
Mix 8	7.10



Graph showing design mix vs flexural strength



Graph load-deflection for mix-3 (6mm length fibre)



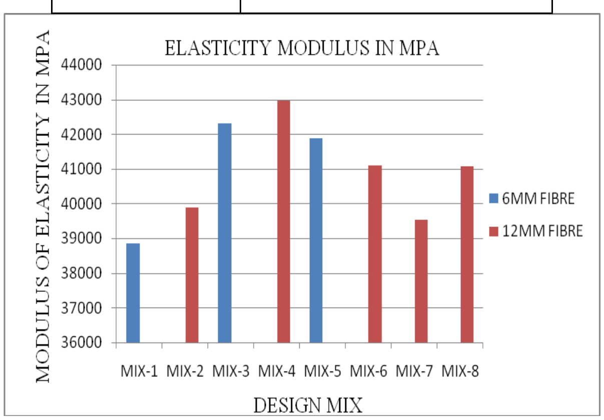
Load-deflection for mix-4 (0.2% 12mm glass fibre)

YOUNG'S MODULUS OF ELASTICITY

The test was conducted on cylinder specimen of 150mm dia and 300mm length.

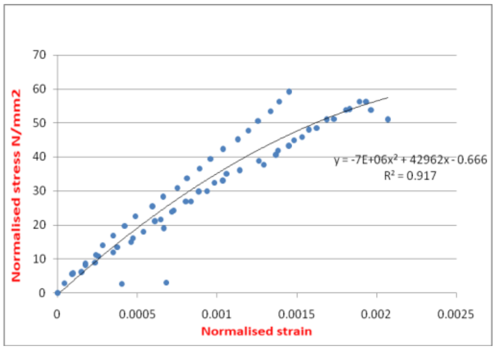
Table Young's Modulus of Elasticity

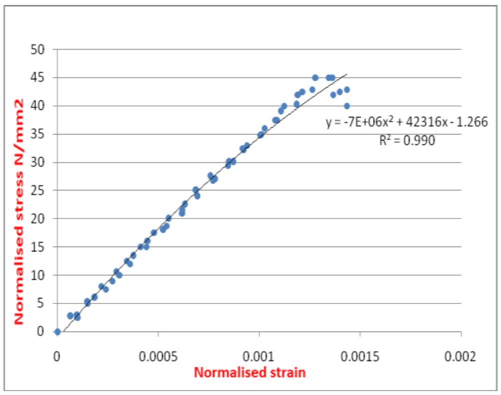
Mix	Young's Modulus of Elasticity (N/mm^2)
Mix 1	38850
Mix 2	39883
Mix 3	42316
Mix 4	42962
Mix 5	41888
Mix 6	41086
Mix 7	39537
Mix 8	41068



Graph showing design mix vs elastic modulus in MPA

BELOW Graph showing normalised stress vs normalised strain for 0.2% 6mm glass fibre





Graph showing normalised stress vs normalised strain for 0.2% for 12mm glass fibre

VIII. CONCLUSION

The research work was successfully carried out by placing GGBS and Metakaolin in place of Ordinary Portland cement and series of test were carried out on the specimens on GFRSCC for knowing mechanical properties and fresh concrete with the use of glass fibre. The following are the conclusions drawn.

- AAll the eight mix are observed to be good workable mix.
- TThe results of the workability tests are all well within the prescribed limits
- Developed glass fibre reinforced self compacting concrete mix passed all key requirements by satisfying all recommended values mentioned in EFNARC guidelines
- The results of the workability tests are all well within the typical range as explained in EFNARC guide lines.
- With the increase in glass fibre length and content its observed that the concrete workability decreases.

COMPRESSIVE STRENGTH

- 1It is observed that Metakaolin content higher than 10% is not feasible.
- 2The rate of strength gain for 7 and 28 days is maximum for mix-3
- 3The concrete which is having 12mm and maximum fibre content strengthen less that 6mm and Maximum Compressive strength like 67.22 N/mm^2 has been observed for Mix-3 (15% GGBS and 6% Metakaolin with 0.2% 6mm glass fibre)
- 4The compressive strength for GFRSCC has been observed to increase more than 155%.

SPLIT TENSILE STRENGTH

- Form all mixes it's found that, the tensile strength of GFRSCC is greater than normal conventional concrete.
- In all mixes, the tensile strength of GFRSCC is greater for mix-3 that is 0.2% 12mm fibre length of GFRSCC.
- The maximum split tensile of GFRSCC is greater for mix-3 and lower for 0.5% of 12mm fibre length, we can say with the increase in fibre content split tensile strength is decreases.

- It's found that 0.2% of 12mm glass fibre has greater strength of all mixes that is optimum mixes

FLEXURAL STRENGTH

- Flexural strength of GFRSCC is greater about 166% than that of normal conventional concrete.
- Flexural strength is observed to be least for Mix-1when compared to other mix. but strength of GFRSCC is greater for mix-4 that is 0.2% 12mm fibre length.
- We have observed that flexural strength is about 8.4 N/mm2 for Mix-4 which is highest among all the mix.
- Flexural strength is increase with the increase in length of glass fibre and optimum dosage found as 0.2% with 12mm fibre length.

MODULUS OF ELASTICITY

- The Young's modulus of elasticity (MOE) values calculated for ternary blends of GGBS and Metakaolin specimens after 28 days curing.
- It can be seen that the MOE increased with increasing percentage of SCM's of GGBS 15% and Metakaolin 6%.
- It is evident that the MOE increases linearly with compressive strength of combination of GGBS and Metakaolin.
- It is found that from all mixes, the elastic modulus is more for mix-3 and mix-4 that is 0.2% 6mm fibre and 12 mm fibre length and elastic modulus is less for 0.5% fibre (12mm length) it's found that the optimum mix for addition for glass fibre is 0.2% 12mm glass fibre.

STRESS-STRAIN RELATIONSHIP

- From the stress-strain graphs it can be observed that as the percentage of GGBS increased, the peak stress and strain at peak stress also increased.
- Maximum young's modulus value obtained for the mix which is having maximum normalized stress value.

FINAL CONCLUSION

- Developed GFRSCC mix passed all key requirements by satisfying all recommended values mentioned in EFNARC guidelines
- The results of the workability tests are all well within the typical range as explained in EFNARC guide lines
- GGGBS and Metakaolin as a combination is observed to provide reasonably higher strength for all the mechanical properties like compression split tensile and flexural strength and modulus of elasticity.
- IIn combination of 15% GGBS and 6% Metakaolin as a replacement to cement and with 0.2% glass fibre length has shown higher compression, split tensile and flexural strength than other mix.
- From the stress-strain graphs it can be observed that as the percentage of GGBS increased, the peak stress and strain at peak stress also increased.

FUTURE SCOPE OF GFRSCC

- FFurther experimental study can be carried out for the durability characteristics like Permeability, Sulphate attack of GFRSCC.
- RReplacement of cement by the mineral admixture like Glass powder, Red mud, Rice husk ash etc can be tried, to evaluate their suitability in GFRSCC
- FFlexural and split tensile strength capability of GFRSCC with these cements replacing materials has to be checked out.
- EExperiments can be conducted by considering different filler materials like Quarry dust, marble powder, granite powder etc. for different percentage replacements
- TThe resistance capacity of GFRSCC blended with minerals admixture against heat, temperature rise can also be checked.
- Evaluate shrinkage, freezing and thawing characteristics, chloride/sulphate resistance, fire durability and wear resistance of these GFRSCC mixes.
- Development of standard specifications for GFRSCC mixes by focusing on wide range of construction applications covering mix design, pump-ability, method of production and quality control.

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