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Experimental Investigation on Strength and Durability Parameters of Concrete Replacing Cement by Glass Powder in Concrete

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Abstract: The construction industry has been one of the largest and most active zones. It is responsible for consuming natural resources. Solutions must be found to help reduce the environmental problems generated, because of both the adverse impact on the environment and more use of non-renewable natural resources. The shortage of sand there are emergency requirements. This research study reports the potential use of Glass Waste as a replacement for sand in concrete. Based on value of optimum percentage it will be decided to replace sand by Glass Waste in concrete and improvement in flexural behavior glass fiber will be added as percentage of weight of cement in M20, M25 and M30 grade. After achieving mechanical properties of replacement mix in M20, M25 and M30 grade than based on trial method to reduce cement content in replacement mix of M20 grade and evaluate its compressive, flexural, and tensile strength of concrete and sea water attack and acid attack will give weight loss and strength loss of concrete as durability properties. And finally cost analysis will be considered for M20, M25 and M30 grade concrete for control, only sand replacement, and sand replacement plus cement reduction mix.

Keywords: fiber, durability, compressive strength, glass powder.

1. Introduction

In construction industry sector concrete is most commonly used material. As it is made from nonrenewable natural resource conventional concrete has become very expensive creating more environmental pollution issues. Requirement of supplementary materials for concrete is must because of its constitute scarcity in day to day life. In order to maintain economic development there are urgent needs for optimal resource utilization and efficient quality construction for the shortage of sandstone. There is upmost necessity of using supplementary waste materials in concrete because of environmental pollution issue is also more due to waste material disposal. For replacement of fine aggregates for specific need researchers developed management strategies. In recent years some waste like as blast furnace slag ,tire waste, glass waste , construction & demolition waste ,agro-waste, industrial waste, are used. In order to compensate the lack of natural resources and to find alternative ways conserving the environment, the sustainable development for construction involves the use of nonconventional and innovative materials, and recycling of waste materials.

It is possible to utilize waste material in the production of normal concrete and high strength concrete when used as partial and/or full replacement of cement or/and aggregate as a review of the recent research showed that. Many of the produced concrete (either normal or High Strength Concrete (HSC)) made with wastes and industrial resources possesses superior properties compared with the conventional concrete in terms of strength, performance and durability that it has been demonstrated.

Today glass in the form of fibers has found wide and varied applications in all kinds of industry because it is the most versatile industrial materials known. Along with useful bulk properties such as Hardness, Transparency, Resistance to Chemical Attack, Stability, and Inertness, as well as Desirable Fiber Properties such as Strength, Flexibility, and Stiffness all glass fibers derived from compositions containing Silica, which are available in virtually unlimited supply. Divided into four basic categories:
(a) Reinforcements, (b) Optical Fibers, (c) Insulations, (d) Filtration Media. Glass fibers are used in a number of applications.

2. Experimental Programme

An extensive experimental Programme involving the various processes of material testing, mix proportioning, mixing, casting and curing of test specimens were done. The forthcoming sections elaborate the various physical and chemical properties of each material separately.

A. Materials Used

The material used in the preparation of concrete mixes includes cement, fine aggregates, coarse aggregates, basalt chopped fibres and admixtures. Each material was tested &its physical properties are described below.

1. Cement (Ppc –Hathi)

The word cement is commonly used to refer to pulverized materials which improve durable adhesive qualities when combined with water. These materials are additional properly known as hydraulic cements ,Cement is a fine greyish powder which, when mixed with water, forms a dense paste. When this paste is mixed with sand and gravel and permissible to dry it is called concrete.For this study we have used portlandpozzolona cement (PPC) factory-made by HATHI cement.

2. Fine Aggregate

Nearby available river sand was used as fine aggregate.

3. Coarse Aggregate

For casting of concrete sample locally available 10 mm and 20 mm aggregates have been used as coarse aggregates. Coarse aggregate used in the study were sieved to attain obligatory range. Two different sizes are listed below:

a.) 100% passing with 10mm sieve and 100% retained on 6mm sieve.
b.) 100% passing with 20mm sieve and 100% retained on 10mm sieve.

4. Water

Water is a central ingredient of concrete as it actually contributes in the chemical reaction with cement. The water, which is used for creating concrete and for curing, should be fresh and free from damaging impurities such as oil, alkali, acid, etc. in general, the water, which is appropriate for drinking should be used for creating concrete.

Glass Waste (GW)

Glass is made by silica, sodium carbonate, dolomite, and lime stone at very tall temperature at a 1600° c. Due to more quick development waste glass derived from container or packaging glass, flat glass, domestic or tableware glass and continuous filament glass fibers and it' s disposal is one of the major environmental challenges.In 1999/2000, the percentage of waste glass was roughly 2.1% of total MSWgeneration in India. United Nations predictable the volume of yearly disposed solid waste to be 200 million tones 7% of which is made up of glass the world over. In 2010, the percentage of waste glass was nearly 4.6% of total MSW generation in the United States. Therefore, we require use this waste in correct way which not create environmental pollution. The glass waste is white, green, brown, etc. Color's glassy particle and granular materials in nature and has a parallel particle size range like sand. Its specific gravity and bulk density is closely same as sand.

Material	LOI	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Na_2O
Glass							13.29%
Waste	1.84%	70.13%	2.32%	0.63%	12.61%	0.51%	

Table Chemical properties of Glass waste

Glass Fiber

Glass fiber is a material consisting of numerous extremely well fibers of glass. These are combined with thermoplastic or thermosetting resins for molding composites. These are fibers which have been chopped to lengths of 1.5 to 50 mm. Chopped strands are either soft or hard sized, dependent on the molding application. Its uses in several fields like as composite application, transportation, building construction, infrastructure, etc. due to its ductile properties is upright. Glass fibers used in concrete because of plastic shrinkage during the setting phase and this can often tip to cracking. Today's current in fibers market that is anti-crack fibers, which are alkali-resistant glass fibers

Cut length	12 mm
Melting point	> 800°C
Specific gravity	2.5-2.6
Aspect ratio	857:1
Tensile strength	2000 MPa
Odor	odorless
Appearance	white

Physical and Chemical properties of Glass Fiber

Compressive Strength Test

The concrete is made by hand mixture and machine mixing it will be taken first.

After taking concrete in oil mold with four equal layers with temped by 25 strokes by steel rod of each layer.

The air bubble and voids to remove from that use needle vibrator and table vibrator. In further process put the concrete in room 27°C and relative humidity for 24 hour.

After that 24 hour to going the cube in natural water curing and it's compressive strength will be measure by compressive testing machine.

Before place cube in the testing machine remove loose sand, dust and other ingredients from the cube. To set that cube like that the load is apply uniformly.

Load is given gradually in increase cause of avoid shock and when the cube is break down to note down the value of load and shape of cube.

And calculate the compressive strength with using following equation. Strength=P/A.

B. Flexural Strength: Concrete as we know is relatively strong in compression but weak in tension. In reinforced concrete structural member, little dependence is placed on the tensile strength of concrete so, steel reinforcing bars are provided to resist all tensile forces. However tensile stresses are likely to develop in concrete due to temperature gradients, rusting of steel reinforcement, drying shrinkage, and many other reasons. Therefore the knowledge of tensile strength of concrete is of importance. Beam tested by -

a) Single point load Method
b) Double point load Method

a.) Single Point load method

The beam breaking machine applies a load at the midpoint of a 500 mm beam in which continuous load is applied to on it as per the position of beam casted and measured the load which is carried by the beam

b.) Double point load Method

In Third point loading method, the beam will be tested on its opposite direction in which it was cast. The specimen should not be removed from the curing tank until just before testing. Even a small amount of drying can adversely affect the results. Two tests will be made on each beam. Therefore, for the first test, position the beam with one end about 30 mm from the support After the load test, the average depth and width of the specimen at the failure section must be measured to the nearest point method the load is distributed in 3 span of the beam.

The value of the modulus of rupture depends on the manner of loading and dimension of the beam. The system of loading used in finding out the flexural tension is central point loading third point loading and central point loading. Where the bending moment is maximum, in the central point loading, maximum fibre stresses will come below the point of loading.

C. Splitting Tensile Strength:

Split tensile strength measured on cylinder as per IS 5816:(1999), it is casted and after continuous curing of 28 days cylinder is tested, cylinder is placed horizontally, and continuous load is applied on it, as per the equation using tensile strength of cylinder is measured.

D. Durability Test Sea Water Attack

This test was carried out on the 150mm×150mm×150 mm Concrete cube.
Total 6 cubes are cast for each mix and de molded after 24 hours and at the ends of 28 days of the normal curing period tested.
The specimens were taken out from the curing and initial weight was taken.
Throughout this period the concentration of sea water solution was maintained by changing the solution periodically.
The specimens were taken out from the sea water after 28 days of continuous soaking.
The surface of the Cube were cleaned from dust, weighed & then tested in the compressive testing machine under the uniform rate of loading of 140 kg/cm2/min.
As per IS: 516-1959 The changes in strength of the concrete cube were calculated

E. Acid Attack

This test was carried out on the 150mm×150mm×150mm Concrete cube.
Total 6 cubes are cast and de molded after 24 hours and at the ends of 28 days of the normal curing period tested.
The specimens were taken out from the curing tank and initial weight was taken. H2So4 (5%) + HCl (5%) by weight of water was added to the water as per earlier investigators.
Throughout this period the concentration of the solution was maintained by changing the solution periodically.

The specimens were taken out from the H2So4 (5%) + HCl (5%) solution after28 days of continuous soaking.

The surface of the Cube were cleaned from dust, weighed & then tested in the compressive testing machine under the uniform rate of loading of 140 kg/cm2/min.

As per IS: 516-1959 the changes in the strength of the concrete cube were calculated.

Results and Discussion

Optimum Percentage of Glass Waste

Sand replacement with 0%, 20%, 40%, 60%, 80% and 100% by glass waste inconcrete as shown below.

	0%	20%	40%	60%	80%	100%
Compressive strength	24.86	29.84	25.34	27.16	25.99	27.5
Flexural strength	4.86	4.81	4.8	4.7	4.62	4.79
Split tensile strength	2.53	2.4	2.37	2.36	2.35	2.39

results shows, the compressive strength is higher at 20% replacement sand compare to other replacement and control concrete also But it have flexural and tensile strength is lower than control concrete

Optimum Percentage of Glass Fiber

Glass fibers add in concrete with 0.10%, 0.20%, and 0.30% of cement content

	control	0.10%	0.20%	0.30%
Compressive strength	24.86	22.88	23.96	23.06
Flexural strength	4.86	5.01	6.16	5.98
Split tensile strength	2.53	2	3.96	5

Above results shows, the flexural and tensile strength is higher at 0.20% adding of glass fiber compare to other addition and control concrete also.But it have compressive strength is lower than control concrete

Compresive Strength Test Result

Test results for the Compressive test for the M20, M25, and M30 grade with and without replacement by glass waste and comparison each other at 3, 28, 56 and 90 days are as shown below

Volume by %	Compressive strength (Mpa)						Split tensile strength(Mpa)		Flexural strength(MPA)	
	3 days		28days		56 days		28 days		28 days	
	Normal	GW+GF	Normal	GW+GF	Normal	GW+GF	Normal	GW+GF	Normal	GW+GF
M20	12.31	15.56	24.86	29.99	28.22	34.96	2.53	.3.5	4.86	6.92
M25	15.37	19.02	29.98	35.18	32.1	37.29	2.63	4.18	4.9	7.16
M30	18.35	21.86	34.64	38.86	37.02	39.98	2.92	4.61	4.96	7.29

Table: Compressive, split tensile and flexural strength of M20 M25 M30 Grade of concrete

Acid Attack (Weight Loss) Results

Test results of acid attack - H_2SO_4 + HCl (weight loss) in M20 cement reduction mix (withsand replacement by glass waste plus glass fiber addition) and control mix. Compare each other at 28, 56 and 90 days as shown below.

results shows lower weight loss of acid attack in M20 cement reduction mix (with sand replacement by glass waste plus glass fiber addition) compares to the control mix.

Acid Attack (Strength Loss) Results

Test results of acid attack - H_2SO_4 + HCl (strength loss) in M20 cement reduction mix (with sand replacement by glass waste plus glass fiber addition) and control mix. Compare each other at 28, 56 and 90 days as shown below.

Results shows lower strength loss of acid attack in M20 cement reduction mix (with sand replacement by glass waste plus glass fiber addition) compares to the control mix.Above results shows lower strength loss of acid attack in M20 cement reduction mix (with sand replacement by glass waste plus glass fiber addition) compares to the control mix.

Conclusion

The physical properties of glass waste is nearly same as sand.

The optimum percentage of glass waste is 20% which have compressive strength 29.84 N/mm^2 in M20 grade at 28 days.

The maximum workability obtained (55mm) in M20 control concrete.

In mechanical properties have higher results in replacement of sand by glass waste and addition of glass fiber as percentage of weight of cement in M20, M25 and M30 grade.

Cement reduction mix have compressive strength at 3, 28, 56, and 90 days is 12.91N/mm^2 , 24.92N/mm^2 , 28.67N/mm^2 , and 30.14N/mm^2 , respectively which is nearly same of control concrete in M20.

Cement reduction mix have flexural strength at 28, 56 and 90 days is 4.97N/mm^2,5.07N/mm^2,and 5.21 N/mm^2, respectively which is higher than control concrete in M20 grade.

Cement reduction mix have tensile strength at 28, 56 and 90 days is 2.57N/mm^2, 2.90 N/mm^2,and 3.10 N/mm^2, respectively which is higher than control concrete in M20 grade.

Sea water attack has minimum weight loss and strength loss 2.70 % and 3.19 % respectively are lower than control concrete in M20 grade cement reduction mix at 28 days.

Acid attack has minimum weight loss and strength loss 4.61 % and 5.64 % respectively are lower than control concrete in M20 grade cement reduction mix at 28 days

After reducing cement upto 4.13% in M20 grade (sand replacement by glass waste plus glass fiber addition) got nearly same strength by reducing cost 0.20% in control concrete.

By this replacement, achieved eco-friendly concrete.

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