Impact of Glass Powder and Recycled Coarse Aggregate as a Partial Replacement of Fine and Coarse Aggregate

Mohammed Jasar NT, Varsha Shaji

Abstract: ***The Fine and coarse aggregates are the main ingredients of concrete as the filler materials. As coarse aggregates are non-renewable resources, scarcities of these materials have been increased in recent years. Therefore, it is essential to search for other materials, which can be used as an alternative to fine and coarse aggregate. Now days, waste of glasses are been increasing ,and the powder form of waste glass(GP) can be used as a partial replacement for the fine aggregates(FA), which can cause increase in the strength of concrete due to the proper alkali aggregate reaction up to 30% replacement. Recycled coarse aggregates (RCA) can be used as coarse aggregate (CA) partially in concrete, which reduces the strength of concrete with variation in various percentage of RCA. The combination of GP and RCA as a partial replacement of cement and coarse aggregates are used in concrete with 30% of GP and varying the percentage of RCA as 10%, 20%, 30%, 40% & 50%. Compressive strength & split tensile strength of newly prepared specimens are compared with conventional concrete. Workability test, acid test & water absorption tests are also conducted on the hardened concrete and compared with the conventional concrete. This new technology will provide new solution for the disposal glass sheet waste as well as the demolished waste of concrete.***

Keywords: Glass powder, Recycled coarse aggregate, Fine aggregate, coarse aggregate, Glass powder concrete, Modified concrete, Compressive strength, Split tensile strength

1. Introduction

Conservation of resource is always the prime need of human kind. In the starting of era/civilization, we have used the resources limitedly but soon after we have started over exploitation. This result causes the scarcity of resources. Later on we have known the fact that we need to conserve the resources. Thus human have decided to use resources efficiently and wisely. This phenomenon is discussed by using the principle of 3R i.e. reduce reuse and recycle. Our study primarily focuses on these “3R” concepts. The waste glass from in and around the small shops is being disposed in waste landfill. Glass is an inert material which could be recycled and used many times without changing its chemical properties. Concrete waste is also increasing due to reconstruction and demolition of different concrete structures. Since the demand in the concrete manufacturing is increasing day by day, the utilization of river sand as fine aggregate and natural rock as the coarse aggregate leads to exploitation of natural resources, lowering of water table and sinking of the bridge piers and also reduce the non-renewable resources. The most widely used fine aggregate for the preparation of concrete is the natural sand mined from the river beds. The present scenario demands identification of substitute materials for the river sand and coarse aggregate for making concrete because of the abundant scarcity it is facing. Attempts have been made in using crushed glass and recycled coarse aggregate as fine and coarse aggregate as replacement for river sand and natural-coarse aggregate.

In the current research, sand and natural coarse aggregate is partially replaced by glass powder and recycled coarse aggregates. The sheet glass powder is obtained from crushing the waste glass, which is disposed as landfill by the glass industries. Glass is a transparent material produced by melting a mixture of materials such as silica, soda ash, $CaCO_3$ at high temperature followed by cooling where solidification occurs without crystallization. Glass is widely used in our lives through manufactured products such as sheet glass, bottles, glassware, and vacuum tubing. Glass is an ideal material for recycling. The use of recycled glass saves lot of energy and the increasing awareness of glass recycling speeds up focus on the use of waste glass with different forms in various fields, in the same way we have used concrete waste from the reconstructed and demolished concrete site. This will reduce the effect of concrete on the society. Then concrete is broken into various sizes (This is done by crusher and the mechanism. After this it is recycled into new cube for the study. Using waste glass and concrete waste in the concrete construction sector is advantageous, as the production cost of concrete will go down. Most of the waste glasses and concrete waste have been dumped into landfill sites. The land filling of waste glasses and concrete waste are undesirable because they are not biodegradable, which makes them environmentally less friendly. There is huge potential for using waste glass in the concrete construction sector. When waste glasses are reused in making concrete products, the production cost of concrete will go down. Crushed glass or cullet, if properly sized and processed, can exhibit characteristics similar to that of gravel or sand and sometimes asphalt, to reclaim the aggregate.

2. Materials Used

Water:
The used ater for the project was colourless, fresh and testless. The water is portable free from organic materials and pH value is around the 7.

Cement:
Ordinary Portland cement of 53 grades available in local market is used for the research. The various tset has conducted on cement based on IS 4031 -1988 and confirmed the results.

Fine aggregate:
The use of fine aggregate is reduced by the partial replacement of glass powder. Loaclly available M-sand is used for the rearch and which comes under the zone II. Various test on

fine aggregate is conducted based on IS 2386-1963.

Coarse aggregate:
The use of coarse aggregate is redused by the partial replacement of recycled coarse aggregate. The coarse aggregate size between 20mm and 4.75mm is selected for the investigation. Various test on conducted based on the IS 2386 and results are confirmed.

Glass powder:
Glass powder is produced by crushing of waste glass sheet and it is used as the substituent material for fine aggregate due to similar properties with fine aggregate. The different test onducted on fine aggregate also conducted on glass powder.

Recycled coarse aggregate:
Recycled coarse aggregate is the waste material from the demolition of concrete building, which is a coarse aggregate with cement debris on it. Recycled coarse aggregate is used for the partial replacement of coarse aggregate due to related properties with coarse aggregate.

Objectives

The main objectives of the work are given below:

- To Study the effect of glass powder and RCA as a partial replacement of cement and coarse aggregate on the strength properties of concrete.
- To study the properties of RCA.
- To prepare mix design for M20 concrete using RCA.
- To Study the influence of glass powder and RCA on hardened properties such as compressive strength and split tensile strength.
- To compare the result of modified concrete with the cglass powder concrete.
- To find the economical profit using modified concrete.

3. Scope of the Work

According to results obtained from the test on materials, it is able to prepare mix design for the experiment by referring IS 10262. From this it is able to understand the influence of glass powder and RCA on hardened properties such as compressive strength and split tensile strength. Concrete design can be done with different proportions of RCA and glass powder. Recycling of RCA by converting it to aggregate components could save landfill space and also reduce the demand for extraction of natural raw material for construction material. And also this will help to reduce the environmental pollution. The reuse of waste glass and RCA in concrete has economical and technical advantages.

4. Experimental Procedures

It is an attempt to form a modified concrete by adding partially glass powder and recycled coarse aggregate for fine and coarse aggregate. It provides the similar properties of fresh and hardened concrete for modified concrete compare with the conventional concrete. The strength increasing of glass powder is used to overcome the reduction of strength parameters of recycled coarse aggregate. The modigied concrete is formed by the replacement of glass powder and recycled coarse aggregate for fine and coarse aggregate. The glass powder concrete has higher increment in strength and the modified concrete concrete has lesser compressive and split tensile strength compared with glass powder concrete and higher than the conventional concrete.
The experimental procedure including the following steps:

4.1Material properties
4.2 Design of concrete mix
4.3 Mixing of concrete
4.4 Workability test on conventional concrete.
4.5 Preperation of glass powder concrete specimens
4.6 Hardened properties of glass powder concrete
4.7 Workability test on glass powder concrete
4.8 Preperation of modified concre specimen
4.9 Hardened properties of modified concrete
4.10 Workability test on modified concrete
4.11 Durability test on conventional and modified concrete

4.1 Material properties

Table 1: Properties of cement

Fineness of cement	4%
Normal consistency	31%
Initial setting time	1 hour
Final setting time	12 hour
Secific gravity	3.13

Table 2: Properties of other materials

Material	Specific gravity	Fineness modulus	Water absorption
Fine aggregate	2.52	2.77 (zone II)	2.8%
Coarse aggregate	2.7	2.79	1.03%
Recycled coarse aggregate	2.72	2.91	5.67%
Glass powder	2.311	3.02 (zone III)	1.53%

4.2 Design of concrete mix

The concrete mix ratio is prepared by using IS 10262-2009

Target strength for mix proportion

f 'ck = fck + (1.65 x s)
where,
f'ck = target average compressive strength at 28 days
fck = characteristic compressive strength at 28 days
s = standard deviation
s = 4 N/mm2
fck = 20 N/mm2
There for,
Target strength = 20+ (4 x 1.65)
= 26.6 N/mm2
Selection of water content
Maximum w/c ratio = 0.55
Maximum water content = 186 litre
(for 25 to 50 mm slump range)
Estimated water content for 150 mm slump = 208.32 litre
Calculation of cement content

Water cement ratio = 0.55
Cement content = 208.32/0.55
= 378.77 kg/m3
Check,
From IS 456,
Minimum cement content for severe exposure condition =300kg/m3
There for, 378.77 kg/m3 < 300 kg/m3 (Hence ok)
Proportion of volume of ca & fa content
M20 grade, & 0.50 w/c ratio
Volume of CA = 0.62
But here w/c ratio is 0.55
Proportion of volume of CA change @ rate -/+ 0.01 for every +/- 0.05 change in w/c ratio
i.e.,
Volume of CA = 0.62-0.01
= 0.61
Volume of FA = 1.0-0.61
= 0.39
Mix calculation
The mix calculation per unit volume of concrete shall follow
i) Volume of concrete = 1 m3 (a)
ii) Volume of cement = (M/G) x (1/1000)
Where,
M = Mass of cement
G = Specific gravity of cement
Volume of cement = (378.77/3.15) x (1/1000)
=0.12m3(b)
iii) Volume of water = (M/G) x (1/1000)
= (208.32/1) x (1/1000)
= 0.208 m3 (c)
iv) Volume of all in aggregate = [a-(b + c)]
Where, a = 1, b = 0.12, c = 0.208
=[1-(0.12+0.208)]
= 0.672 m3 (d)
v) Mass of CA = d x Volume of CA x G x 1000
= 0.672 x 0.61 x 2.73 x 1000
=1119.08kg
vi) Mass of FA = Density x Volume of FA x G x 1000
= 0.672 x 0.39 x 2.56 x 1000
= 670.92 kg
Cement = 378.77 kg/m3
Water = 208.32 kg/m3
Fine aggregate = 670.92 kg/m3
Coarse aggregate = 1119.08 kg/m3
Water cement ratio =0.55

Then,
Mix proportion = 378.77: 670.92: 1119.08
= 1: 1.77: 2.95

Table 3: Concrete proportions of glass powder concrete (cube)

Mix	Cement (kg)	FA (kg)	Glass powder (kg)	CA (kg)	Water (litre)
Conventional concrete	1.56	2.76	0	4.6	0.85
10% Glass powder	1.56	2.484	0.276	4.6	0.85
20% Glass powder	1.56	2.208	0.552	4.6	0.85
30% Glass powder	1.56	1.93	0.828	4.6	0.85
40% Glass powder	1.56	1.656	1.104	4.6	0.85
50% Glass powder	1.56	1.380	1.380	4.6	0.85

Table 4: Concrete proportions of glass powder concrete (cylinder)

Mix	Cement (kg)	FA (kg)	Glass powder (kg)	CA (kg)	Water (litre)
Conventional concrete	2.45	4.33	0	7.230	1.35
10% Glass powder	2.45	3.897	0.433	7.230	1.35
20% Glass powder	2.45	3.464	0.866	6.507	1.35
30% Glass powder	2.45	3.031	1.299	5.780	1.35
40% Glass powder	2.45	2.598	1.732	5.061	1.35
50% Glass powder	2.45	2.165	2.165	4.338	1.35

4.3 Mixing of concrete

The mixer should be clean and wet the inside of the mixer. The fine aggregate, coarse aggregate and required proportion of glass powder is added in to the mixer and mixed it for 1 minute, then cement and water is added into the mixer and continue the mixing for addional 2 minutes. The total mixing time should not be greater than 15 minutes from the adding of first material. Then place out the well mixed mixture of concrete into smooth and cleaned surface.

4.4 Workability test on conventional concrete.

Variouse workability test was conducted to satisfy on the properties of fresh concrete. Slump test and compaction factor tests are conducted to determine the workability of concrete.

4.4.1 Slump test

The apparatus required foer the test is trowel, gauged tamping rod and slump test apparatus includes base plate with cone. The internal surface of the mould shall be twenty five strokes of rounded end of the tamping rod. The strokes shall be distributed in a uniform manner over the cross section of the mould and for the second and subsequent layer shall be penetrate in to the underlying layer. The bottom layer shall be tamped throughout its depth. After top layer has been compacted the concrete shall be struck off level with a trowel or a tamping rod, so that the mould is exactly filled. Any mortar which may be having leaked out between the mould and base plate shall be cleaned away. The mould shall be removed from the concrete immediately raising it slowly and carefully in a vertical direction. This allows the concrete to subside and the slump shall be measured immediately by determining the difference between the height of the mould and that of highest point of the specimen being tested. The above operation shall be carried out at a place free from vibration or shock and within a period of two minutes after sampling. Prepare a concrete mix of 1:1.77:2.95 with 0.5 w/c ratio and measure the slump. Change the w/c ratio and note the corresponding slump.

Table 5: Slump test results

Sl No	W/C Ratio	Slump (cm)	Remarks
1	0.45	0	True slump
2	0.50	3	Shear slump
3	0.55	6	Shear slump

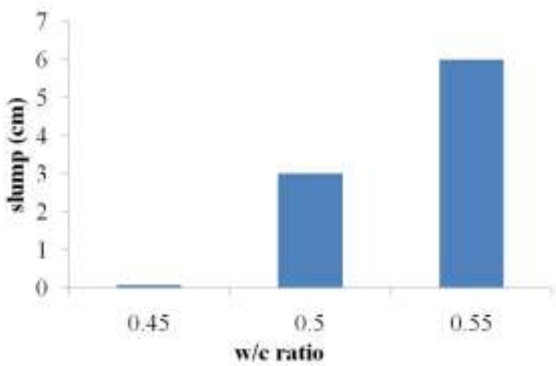

Figure 1: Water cement ratio v/s slump

4.4.2 Compaction factor test

The sample of the concrete to be tested shall be placed in an upper hopper. The hopper shall be filled with its brim and the trap door shall be opened so that concrete in to the lower hopper. Certain mixes have a tendency to stick in or both the hoppers. If this occurs the concrete may helped thorough by pushing the rod gently in to the concrete from the top. During this process the cylinder shall be covered by the trowels. After the concrete has come to rest the cylinder shall uncovered and the trap door of the lower hopper opened and the concrete allowed to flow in to the cylinder, the excess concrete remaining above the level of top of cylinder shall then cut off by holding the trowel in each hand with the plane of blade horizontal and them simultaneously one from each side across the top of the cylinder at the same time keeping them pressed on the edge of the cylinder. The outside of the cylinder shall then determine to the heaped clear. The above operation shall be carried out in a place free from vibration and shock. The weight of the concrete in the cylinder shall then determine to the nearest 0.01N. This weight shall be known as the weight of the partially compacted concrete. The cylinder shall be refilled with the concrete from the same sample to layers approximately 50mm deep. The layers shall be heavily compacted cylinder is noted to 0.01N. The compacting factor is defined as the ratio of partially compacted concrete to fully compacted concrete.

Table 6: Compaction factor test results

SI NO	1	2
w/c Ratio	0.5	0.55
Wt of the empty cylinder	7.4	7.4
Wt of the partially compacted concrete (w1)	9.4	10.4
Wt of the fully compacted concrete (w2)	12.1	11.8
Compaction factor = w1 / w2	0.776	0.881
Type of workability	Low	Medium

4.5 Prepartion of glass powder concrete.

Cube and cylinders are used for the task. The moulds are cleaned thoroughly and oiled inside and required portion of mould before filling the fresh concrete in to the mould. Fill the fresh concrete in to the mould with threelayer and 25 strokes are provided in each layer. Keep the concrete in mould for 24 hours and then remove from the mould. Place specimens in curing tank for certain curing period. After the curing period the specimens taken out from the curing tank and tested. The glass powder is partially replaced for fine aggregate ie, the replacement of glass powder is 10%, 20%, 30%, 40% and 50% for fine aggregate (FA).

4.6 Hardened properties of glass powder concrete
4.6.1 Compressive strength

IS 516- 1959 is used to test compressive strength (CS) of cube. The cubes are taken out from the mould and allow little time to dry the specimen. Place the cube on compression testing machine (CTM). The specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom. The measured compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen during the test by the cross-sectional area and shall be expressed to the nearest N/mm2.Average of three alues shall be taken.

Figure 2: Cube placed in CTM

Table 7: Compressive strength

Mix	CS 7 days (N/mm2)	CS 14 days (N/mm2)	CS 28 days (N/mm2)
0% GP (Conventional)	14.82	19.37	21.47
10% GP	14.87	20.17	23.76
20% GP	15.11	20.68	23.91
30% GP	15.99	21.12	25.92
40% GP	14.49	19.73	22.90
50% GP	14.31	19.58	22.31

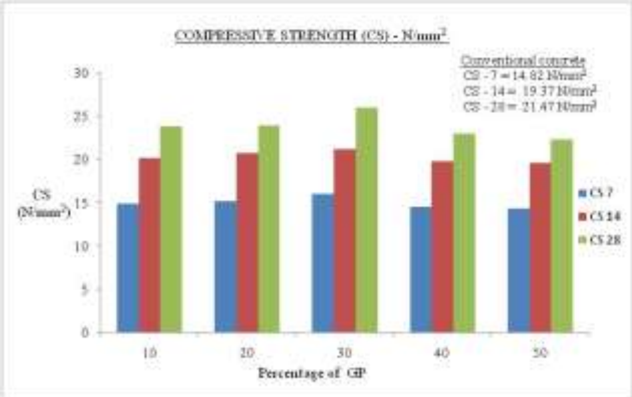

Figure 3: Compressive strength at 7, 14 and 28 days

4.6.2 Split tensile strength

IS 516- 1959 is used to test split tensile strength (STS) of cylinder. The cylinders are taken out from the mould and allow little time to dry the specimen. Place the cylinder on compression testing machine (CTM). The specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cylinder as cast, that is, not to the top and bottom. The measured split tensile strength of the specimen shall be calculated by using the equation (2 P /ΠDL). Wehre, P is the maximum load and D and L is diameter and length of the specimen respectively. Split tensile strength shall be expressed to the nearest N/mm2. Average of three alues shall be taken.

Figure 4: Cylinder placed in CTM

Table 8: Split tensile strength

Mix	STS 7 days (N/mm2)	STS 14 days (N/mm2)	STS 28 days (N/mm2)
0% GP (Conventional)	1.65	2.21	2.49
10% GP	1.60	2.320	2.75
20% GP	1.69	2.47	2.98
30% GP	1.86	2.64	3.17
40% GP	1.68	2.31	2.55
50% GP	1.43	2.122	2.44

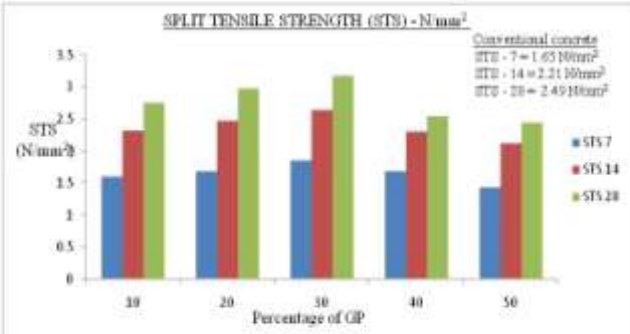

Figure 5: Split tensile strength at 7, 14 and 28 days

4.7 Workability test on optimum replacement of glass powder concrete.

The maximum compressive and split tensile strength is obtained for replacement of 30% glass for fine aggregate. The workability test on optimum replacement of glass powder concrete is conducted.

4.7.1 Slump test

The obtained slump test value is 70 mm, which is a true slump and also comes under medium workability.

4.7.2 Compaction factor test

The obtained compaction factor value is 0.921, which is comes under medium workability.

4.8 Preperation of modified concrete.

The preparation of modified concrete is similar to the conventional method. The variation occurs in the mix of the modified concrete. After the determination of maximum amount of glass powder which provides maximum compressive and split tensile strength, we formed a new combination of mixture of concrete. Various percentage of a new additional material known as recycled aggregate (RCA) is replaced for coarse aggregate (CA) with 30% glass powder for fine aggregate, but the mix ratio will not change.

Table 9: Concrete proportions of modified concrete (cube)

Mix	Cement (kg)	FA (kg)	GP (kg)	CA (kg)	RCA (kg)	Water (litre)
0% RCA with 30% GP	1.56	1.930	0.828	4.6	0	0.85
10% RCA with 30% GP	1.56	1.930	0.828	4.14	0.46	0.85
20% RCA with 30% GP	1.56	1.930	0.828	3.68	0.92	0.85
30% RCA with 30% GP	1.56	1.930	0.828	3.22	1.38	0.85
40% RCA with 30% GP	1.56	1.930	0.828	2.76	1.84	0.85
50% RCA with 30% GP	1.56	1.930	0.828	2.3	2.3	0.85

Table 10: Concrete proportions of modified concrete (cylinder)

Mix	Cement (kg)	FA (kg)	GP (kg)	CA (kg)	RCA (kg)	Water (litre)
0% RCA with 30% GP	2.45	3.031	1.299	7.230	0	1.35
10% RCA with 30% GP	2.45	3.031	1.299	6.507	0.723	1.35
20% RCA with 30% GP	2.45	3.031	1.299	5.780	1.45	1.35
30% RCA with 30% GP	2.45	3.031	1.299	5.061	2.169	1.35
40% RCA with 30% GP	2.45	3.031	1.299	4.338	2.892	1.35
50% RCA with 30% GP	2.45	3.031	1.299	3.615	3.615	1.35

4.9 Hardened properties of glass powder concrete

4.9.1 Compressive strength

IS 516- 1959 is used to test compressive strength (CS) of cube. The cubes are taken out from the mould and allow little time to dry the specimen. Place the cube on compression testing machine (CTM). The specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom. The measured compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen during the test by the cross-sectional area and shall be expressed to the nearest N/mm2.Average of three alues shall be taken. The compressive strength of modified concrete is compared with the compressive strength of glass powder concrete.

Table 11: Compressive strength of modified concrete

Mix	CS 7 days (N/mm2)	CS 14 days (N/mm2)	CS 28 days (N/mm2)
0% RCA with 30% GP	15.99	21.12	25.92
10% RCA with 30% GP	15.11	18.99	23.76
20% RCA with 30% GP	14.44	18.25	20.14
30% RCA with 30% GP	14.42	17.21	19.22
40% RCA with 30% GP	13.96	16.77	18.01
50% RCA with 30% GP	13.48	16.148	17.36

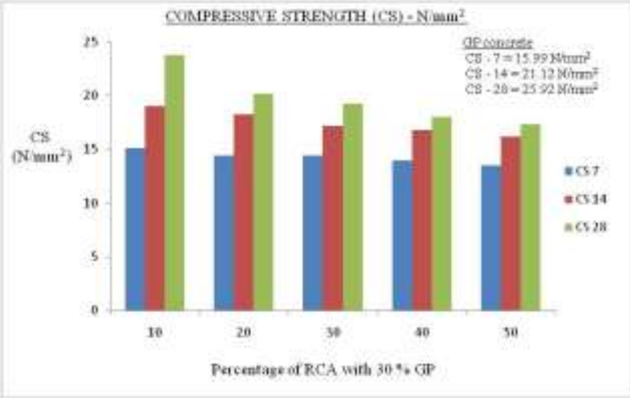

Figure 6: Compressive strength at 7, 14 and 28 days

4.9.2 Split tensile strength

IS 516- 1959 is used to test split tensile strength (STS) of cylinder. The cylinders are taken out from the mould and allow little time to dry the specimen. Place the cylinder on compression testing machine (CTM). The specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cylinder as cast, that is, not to the top and bottom. The measured split tensile strength of the specimen shall be calculated by using the equation (2 P /ΠDL). Wehre, P is the maximum load and D and L is diameter and length of the specimen respectively. Split tensile strength shall be expressed to the nearest N/mm2. Average of three alues shall be taken. The compressive strength of modified concrete is compared with the compressive strength of glass powder concrete.

Table 12: Compressive strength of modified concrete

Mix	STS 7 days (N/mm2)	STS 14 days (N/mm2)	STS 28 days (N/mm2)
0% RCA with 30% GP	1.86	2.64	3.17
10% RCA with 30% GP	1.82	2.55	2.82
20% RCA with 30% GP	1.63	2.093	2.51
30% RCA with 30% GP	1.52	1.94	2.33
40% RCA with 30% GP	1.43	1.839	2.22
50% RCA with 30% GP	1.30	1.744	2.07

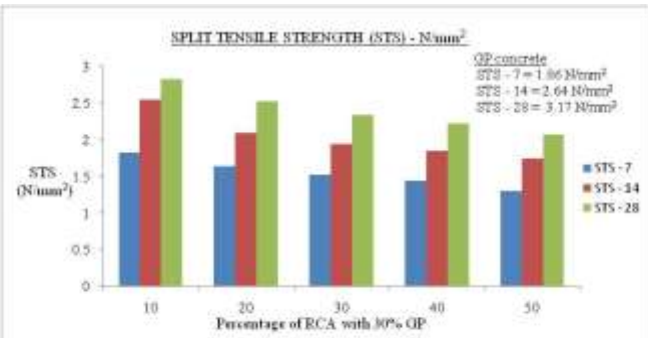

Figure 7: Split tensile strength at 7, 14 and 28 days

4.10 Workability test on optimum replacement of glass powder concrete.

The maximum compressive and split tensile strength is obtained for replacement of 30% glass for fine aggregate. The workability test on optimum replacement of glass powder concrete is conducted.

4.10.1 Slump test

The obtained slump test value is 55 mm, which is a true slump and also comes under medium workability.

4.10.2 Compaction factor test

The obtained compaction factor value is 0.89, which is comes under medium workability.

4.11 Durability test on modified and conventional concrete.

4.11.1 Water absorption test

One of the most important properties of a good quality concrete is low permeability, especially one resistant to freezing and thawing. A concrete with low permeability resists ingress of water and is not as susceptible to freezing and thawing. Water enters pores in the cement paste and even in the aggregate. According to this method, there is no shape limitation for testing concrete specimens other than each sample volume is not less than 350 cm3 (approximately equal to 800 g). In the first step, the oven-dry mass of each specimen should be obtained by placing them in an oven at a temperature of 100 to 110 ˚C not less than 24 h. Later, the saturated mass (using immersion) of samples will be determined by immersing them in water at approximately 21 ˚C for not less than 48 hours and until two successive measurements of mass of the surface-dried samples at intervals of 24 hours indicate constant mass. The increase in weight as a percentage of the original weight is expressed as its absorption (in percent). The average absorption of the test samples shall not be greater than 5%. The water absorption of concrete specimen can be found by using the equation

Percentage of water absorption = ((B – A)/A) x 100

Where, A = Mass of oven-dried sample B = Mass of surface-dry sample in air after immersion.

Figure 8: Specimen placed in water

Figure 9: Specimen placed in oven

Table 13: Water absorption test on dry concrete

Type of specimen	Oven dry wt of sample Kg	Saturated wt of sample Kg	% Water absorption	Compressive strength (N/mm^2)
Cube	8.06	8.40	4.71 %	20.52
	8.04	8.44		
	8.08	8.48		
Cylinder	12.80	13.36	4.48 %	2.50
	12.90	13.47		
	12.70	13.27		

4.11.2 Acid test (H_2SO_4 test)

The concrete specimens were immersed into sulfuric acid solutions with particular concentrations after 28 days of moist curing in 98% relative humidity. The initial weight of all the specimens was measured in accordance to ASTM C267 prior to the immersion. The average compressive strength and split tensile of three concrete samples was also measured before the procedure. Sulfuric acid prepared with a concentration of 7% that is used 7% sulfuric acid of total volume of the solution. The total length of the testing was 8 weeks. The solution was stirred once a week to provide a uniform distribution of sulfuric acid around the submerged specimens. The pH of the solutions was monitored biweekly after the 2 weeks period to see if the concrete sample had any significant effects on the acidity of the solutions. It was observed that after a certain period of exposure to a sulfuric acid solution, the concrete cylinders would start to lose particles from their outside surface which would accumulate around the bottom of the samples. After the immersion period weigh the samples and also find out loses in weight of samples as well as compressive and split tensile strength. The percentage loses in samples can be determine by using the equation.

Percentage of lose in weight = ((A – B)/A) x 100

Where, A = Mass of specimen after curing period.

B = Mass of specimen after period of immersed in acid

Figure 10: Specimen immersed in H_2SO_4 solutions

Figure 11: Specimen after acid test

Table 14: Water absorption test on dry concrete

Type of specimen	wt of sample after curing Kg	wt of sample immersed in H_2SO_4 (Kg)	%Lose in wt (Kg)	Compressive strength (N/mm^2)
Cube	8.06	8.40	4.71 %	20.52
	8.04	8.44		
	8.08	8.48		
Cylinder	12.80	13.36	4.48 %	2.50
	12.90	13.47		
	12.70	13.27		

5. Conclusions

- The replacement of cement and coarse aggregate by glass powder and RCA respectively found was formed as remarkable method for reducing the material quantity of concrete giving sufficient strength.
- The results obtained from the experiments shows that there is a great potential for utilization of best GP in concrete as partial replacement of fine aggregate. Partial replacement of fine aggregate in concrete by 30% of glass powder will give maximum result, glass powder concrete increased compressive strength 7.89%, 9.03% and 20.72% and the split tensile strength increased 12.72%, 19.45% and 27.30% compared to conventional concrete respectively for 7, 14 and days curing.
- The test result shows that strength of RCA specimens were gradually increased up to 10% replacement of recycled aggregate and then it gradually decreases up to 50% replacement of recycled aggregate. The test results showed that the concrete specimen with 10% replacement of recycled aggregate get highest compressive and split tensile strength when compared to glass powder concrete specimen with different percentage of recycled aggregate and it deceased 5.50%, 7.67% and 8.33% compressive strength and 2.15%, 3.40% and 11.04% split tensile strength respectively for 7, 14 and 28 days curing.
- Workability test on 10 % RCA concrete was found same as that of natural coarse aggregate. The economical comparison study resulted that considerable profit can be achieved by using modified RCA concrete over conventional concrete.
- Natural aggregates which are using for concrete is non-renewable resources, so we can reduce the uses of natural aggregates by the replacement of GP and RCA.
- Durability study on modified concrete shows poor result in acid test and better result on water absorption test. The percentage reduction in compressive and split tensile strength is 13.49% and 11.34% respectively after the water absorption test.
- The obtained value in percentage lose in weight of cube and cylinder is 5.81% and 6% respectively after the sulfuric acid test and the percentage lose in compressive and split tensile strength of cube and cylinder specimen is 20% and 26% respectively.
- The results indicate further prevention should be provided to protect this modified concrete from sulfuric acid attack. This modified concrete with sufficient strength will also be a best solution for the disposal problem of C&D waste and glass waste materials, but it can't be used sulfuric acid attack places.

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