REPLACEMENT OF FINE AGGREGATE BY USING GLASS POWDER IN HIGH STRENGTH CONCRETE

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ABSTRACT

Concrete is used as the major material in construction industries. As the population of world increase rapidly, worlds faces the problem for habitation and waste byproduct. As the waste is proportional to the population and there are restriction of natural resources used in concrete , this construction industry need some attention to use some other material so that they can be mix in concrete to get the new product which physical properties are same as the conventional one. Every year there is several tons of waste glasses created all over the world. Waste glass can be re-used as a raw material and it presents an option to save natural and non-renewable materials. The use of waste glass powder in concrete production can make the construction industry more ecological. In this research an attempt is taken to bring into play the waste glass in various proportions so that the final product property of concrete mixture is same as the control mix.

This Thesis presents the feasibility of the usage of Glass powder as 100% substitutes for Natural Sand in concrete. Mix design has been developed for M25 and M40 grades using design approach IS for both conventional concrete and quarry dust concrete. Tests were conducted on cubes and beams to study the strength of concrete made of Glass powder and the results were compared with the Natural Sand Concrete. It is found that the compressive and flexural strength of concrete made of Glass powder are nearly 10% more than the conventional concrete. The results show that at a dosage 1.3% of super plasticizer by weight of cement the concrete made of glass powder as fine aggregate attained low strengths when compared with other dosages (1% and 1.6%) in compression and flexure.

1.0 INTRODUCTION

A lot of facelift is being is given to roads, footpaths along with roadside. Concrete paving blocks are ideal materials on the footpaths for easy laying, better look and finish. Cement concrete paving blocks are precast solid products made out of cement concrete. The product is made in various sizes and shapes viz. rectangular, square, and round blocks of different dimensions with designs for interlocking of adjacent paving blocks. The raw materials require for manufactures of the product are Portland cement and aggregates which are available locally in every part of the country. Market potential cement concretes paving blocks find applications in pavements, footpaths, gardens, passengers waiting sheds, bus stops, industry and other public places. The product is commonly used in urban areas for the above applications. Hence, the unit may be set up in urban and semi urban areas, near the market.

Currently India has taken a major initiative on developing the infrastructures such as express highways, power projects and industrial structures etc., to meet the requirements of globalization, in the construction of buildings and other structures concrete plays the rightful role and a large quantum of concrete is being utilized. River sand, which is one of the constituents used in the production of conventional concrete, has become highly expensive and also scarce. In the backdrop of such a bleak atmosphere, there is large demand for alternative materials from industrial waste.

The largest quantity of all materials used in construction is concrete which is of the order of 2 tons per person per year [(Mehta and Montero, 1997)]. This is next to the total consumption of water. One of the ingredients of concrete is fine aggregate, which is usually taken from river beds. Such exploration led to fast depletion of this material. This has resulted in the lowering of ground water, erosion of river banks and in turn dying of rivers. Hence, the alternative material for this is of paramount importance. Many materials have been tried in the recent past such as marine sand, waste from stone crusher quarry and crushed stone grounded to the required grading. Among the above glass powder (QSD) is the most reasonable option due to the availability of innumerable rock hills in the country

The utilization of Glass powder has been accepted as a building material in the industrially advanced countries of the west for the past three decades. As a result of sustained research and developmental works undertaken with respect to increasing application of this industrial waste, the level of utilization of Glass powder in the industrialized nations like Australia, France, Germany and UK has been reached more than 60% of its total production. The use of manufactured sand in India has not been much, when compared to some advanced countries.

This paper presents the feasibility of the usage of Glass powder as hundred percent substitutes for Conventional Concrete. Tests were conducted on cubes and beams to study the compressive, flexural strengths of concrete made of Glass powder for two different grades of concrete M25 and M40. The investigation on the use of Glass powder in concrete as an alternative to sand as fine aggregate are presented in this report. Standard concrete cubes (150x150x150 mm), prisms (100x100x500 mm) were tested. The physical properties of stone dust and its influence on the strength of concrete in the fresh and hardened state, along with a comparative study with the concrete prepared using river sand are also included. The strength in direct compression at 7 days and 28 days, and those in flexure at 7days and 28 days were compared.

1.1CEMENT:

In modern cement plants cement is manufactured by semi-dry process, in which lime stone and shale are crushed to powder form and blended in correct proportions. This is then mixed in dry form by means of compressed air. This mixture then behaves like a fluid and is sieved and sent to the CALCINER who converts it into clinker which is ground to cement. The main constituents in cement that give cementing properties are C_2S, C_3S, C_3A, and C4AF.

- ***Is specification for ordinary Portland cement:***

(a) Grade 33-IS 269-1989 designated as C-33
(b) Grade 43-IS 8112-1989 designated as C-43
(c) Grade 53-IS 12269-1987 designated as C-53

The above grades of cement are available in India. Along with these Sleeper cements as per IRS-T40-85 (which is supplied only to railways) is also available. Sand belonging to Zone The strength of this will lie between C43 and C53. The chemical reactions responsible for strength attaining of cement are:

- **$2\ Ca_3SiO_5 + 7\ H_2O \dashrightarrow 3\ CaO{\cdot}2SiO_2{\cdot}4H_2O + 3\ Ca(OH)_2 + 173.6kJ$**
- **$2\ Ca_2SiO_4 + 5\ H_2O \dashrightarrow 3\ CaO{\cdot}2SiO_2{\cdot}4H_2O + Ca(OH)_2 + 58.6\ kJ$**

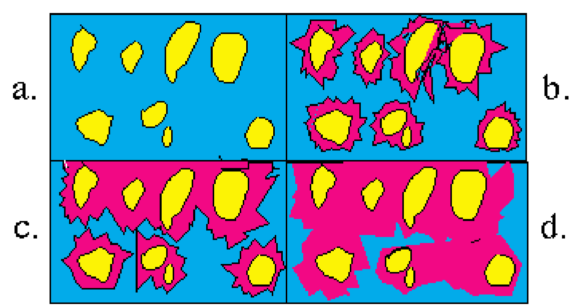

Fig1: Different stages of hydration.

1.2 GLASS POWDER:

It is obtained from the screenings left from the crushed stone. It is a byproduct in Quarry stone crusher plants. Nowadays, this is being used as fine aggregate because of the difficulty in getting natural sand. Special crushers are introduced in India for making fine aggregate from rocks. In the present work QSD from existing crushers which is a byproduct was used.

1.2.1 PROPERTIES

Stone dust is a by-product of crushing, with a typical grain size of 0 – 3..4mm or 0 – 6..8mm. Because stone dust contains very fine mineral aggregates (grain size 0mm), it forms a hard, load-bearing surface.

1.2.2 AVAILABLE GRADING

Grain sizes

0 – 3.4mm For the sub-base in laying block paving & passage way

0 – 6.8mm For driveway and yard surfacing

1.3 SAND:

II and III are recommended for structural works. Very Coarse sand shows more difficulties in surface finishing. In most of the cases, concrete mix can be designed to fit the available sand and coarse aggregates.

1.4 SUPERPLASTICIZER:

These are chemicals which decrease the water requirement for a given workability more than plasticizers, by more than 15%. They can reduce water requirement even up to 30%. In all high strength concrete production, super plasticizer have to be used water-cement ratio. These are generally used in ready-mixed concrete plants. Reduction in W/C ratio enables increase in density and impermeability thus enhancing durability of concrete.

1.5 WATER

Water is the most essential material for construction. IS456-2000 specified the requirements of water to be used for construction. The pH of water should not be less than 6. Chlorides content exceeding 400mg/lit in water cannot be used for R.C works. Sea water or brackish should not be allowed for making or curing of R.C. works.

1.6 COURSE AGGREGATE:

Coarse aggregate is obtained by crushing quarry rock to required size. The pieces of crushed stone varying from 5mm to 80mm size can be called coarse aggregates. The size of the aggregate that is to be used depends on the type of work. Most of the times 20mm to 40mm size aggregates are used in R.C works.

1.7 OBJECTIVES:

The main objectives of the present work are:

1. To compare the properties of made of natural river sand and concrete made of glass powder as fine aggregate.
2. To study the effect of super plasticizer on water-cement ratio.
3. To study the behavior of concretes M25 and M40 grades when exposed to temperature.

2. LITERATURE REVIEW

Investigation on the strength characteristics of mortars and concrete with crusher dust as partial and full replacement of the aggregate are reported by several researchers. The test results indicate that stone crusher dust can be used in mortar and concrete without significant difference in strength and workability compared to mortar and concrete with conventional river sand.

[1] SAHU ET AL investigated the use of crusher dust only as a partial replacement of fine aggregates, and not as complete replacement, while ***JAFFAR ET AL*** investigated the performance of high strength concrete with silica stone dust as a partial replacement of cement. Further, comprehensive tests on beam models are not reported so far.

[2] SIVA KUMAR. A ET AL investigated the influence of 100% replacement of sand with quarry dust. The experimental results showed that the addition of quarry dust for a fine to coarse aggregate ratio of 0.6 was found to enhance the compressive properties as well as elastic modulus.

[3] DEVI. M ET AL dealt with the strength and corrosion resistance behavior of various integral type corrosion inhibitors namely *TRIETHANOLAMINE*, *DIETHANOLAMINE*, diethyl amine, calcium nitrite and sodium nitrate at the dosage of 1%, 2%, 3% and 4% by weight of cement in concrete containing quarry dust as fine aggregate is carried out. Results herein revealed that replacement of sand by quarry dust increases the strength of the concrete; with addition of inhibitor it offers lower permeability and greater density which enable it to provide better resistance to corrosion and durability in adverse environment.

[4] RADHIKESH.P.NANDAET AL presented study for producing paving blocks using crusher dust. The test results showed that the replacement fine aggregate by crusher dust up to 50% by weight has a negligible effect on the reduction of any physical and mechanical properties while there is a saving of 56% of money. The percentage of saving was less but highly beneficial for mass production of paving blocks. The saving would be more if the sand availability is at a greater distance.

[5] MAHENDRANA ET AL studied on feasibility of the usage of Glass powder as hundred percent substitutes for Natural Sand in concrete. It is found that the compressive, flexural strength and Durability Studies of concrete made of Glass powder are nearly 10% more than the conventional concrete.

[6] KATHIRVEL. PET AL studied the Durability of SCC with Partial replacement of cement by Quarry and limestone (dust) Powder by (10%, 20%, and 30%) and comparing the properties like Density Variation, Compressive Strength, Water *SORPTIVITY* for 28, 60, 90 and 120 Days age with respect to control SCC.

[7] SANTHOSH KUMAR.P.TET AL made an attempt to study the effect of type of fine aggregate on the 28 day compressive strength of concrete. The result of the investigation indicate that the ratio of the 28 day compressive strength of concrete with crushed stone sand to that of river sand is 1.06 with a coefficient of variation of 11 %.

[8] MAHENDRA. R.CHITLANGE ET AL studied properties of steel fiber reinforced concrete with artificial sand as fine aggregate. Three matrices with compressive strength 20, 30 and 40 M Pa were designed and reinforced with crimpled steel fibers at dosage rate of volume fraction 0, 0.5, 1.0, 1.5 and 2.0 percent

[9] APPUKUTTY.PET AL substituted crusher dust for sand in cement mortar for brick masonry is experimented with brick masonry prisms cast in different ratios of 1:8, 1:6, 1:5 and 1:4. The results of 12 prisms tested in each fine aggregate with different mortar ratios are compared with allowable compressive strength requirements of brick masonry specified by IS 1905-1989. The investigation indicates that the crusher dust can replace natural sand completely in masonry construction with higher strength and cheaper cost.

[10] NAIDU ET AL (2003A) have investigated the influence of partial replacement of sand with 20% of quarry dust and mineral admixtures in the compressive and pull-out force of concrete. Test results indicate that concrete incorporating quarry dust and without the inclusion of mineral admixtures exhibited a lower compressive strength but a higher pull-out force then the controlled concrete at all the ages. Inclusion of fly ash as 30% binder into the quarry dust concrete resulted in an increase in the compressive strength and pull-out force at almost all the conditions.

3. MATERIALS

3.1CEMENT

Ordinary Portland Cement (53 Grade) with 32% normal consistency Conforming to IS: 8112-1989 was used. The properties of cement were given below:

- **Initial setting time 118 min.**
- **Final setting time 242min.**
- **Specific gravity 3.13**
- **Fineness (IS sieve) 90 microns**

3.2GLASS POWDER

The Glass powder obtained from local resource *SRI KANAKADURGAFAL-G BRICK PRODUCTS; VISAKHAPATNAM* was used in concrete to cast test cubes and beams. The physical and chemical properties of Glass powder obtained by testing the samples as per Indian Standards are listed in Tables 1 and 2, respectively.

Property	**Glass powder**	**Natural sand**
Specific gravity	2.54-2.60	2.50
Relative density (kg/m^3)	1720-1810	1813.33
Sieve analysis	Zone II	Zone III

Table-1: Physical properties of glass powder and natural sand.

3.3 FINE AGGREGATE (NATURAL RIVER SAND)

River sand having density of 1813.33kg/m^3 and fineness Modulus (FM) of 2.015 was used. The specific gravity was found to be 2.5.

ISSIEVE SIZE (mm)	WEIGHT RETAINED (KGS)	CUMMULTIVE WEIGHT RETAINED (KGS)	CUMMULATIVE % RETAINED	CUMMULATIVE % PASSING
10	0.005	0.005	0.5	99.5
4.75	0.005	0.010	1	99
2.36	0.01	0.02	2	98
1.18	0.075	0.095	9.5	90.5
0.6	0.16	0.255	25.5	74.5
0.3	0.43	0.685	68.5	31.5
0.15	0.260	0.945	94.5	5.5

Table-2 Sieve analysis for sand

3.4 FINE AGGREGATE (GLASS POWDER)

Glass powder used in the laboratory investigations was procured from a local crushing plant. The specific gravity of stone dust was 2.63 and
Fineness modulus was 2.67

IS SIEVE SIZE (mm)	WEIGHT RETAINED (Kgs)	CUMMULATIVE WEIGHT RETAINED (Kgs)	CUMMULATIVE % RETAINED	CUMMULATIVE % PASSING
10	0	0	0	100
4.75	0	0	0	100
2.36	0.25	0.25	25	75
1.18	0.215	0.465	46.5	53.5
0.6	0.095	0.56	56	44
0.3	0.175	0.735	73.5	26.5
0.15	0.235	0.97	97	3

Table-3 Sieve analysis for glass powder

3.5 COARSE AGGREGATE

Natural granite aggregate having density of 2700kg/m^3 and fineness modules (FM) of 7.26 was used. The specific gravity was found to be 2.60. (Conforming to IS 2386-1963)

IS SIEVE SIZE (mm)	WEIGHT RETAINED (Kgs)	CUMMULATIVE WEIGHT RETAINED (Kgs)	CUMMULATIVE % RETAINED	CUMMULATIVE % PASSING
80	0	0	0	100
40	0	0	0	100
20	1.37	1.37	27.4	72.6
10	3.545	4.915	98.3	1.7
4.75	0.085	5.0	100	0
2.36	-	-	100	0
1.18	-	-	100	0
0.6	-	-	100	0
0.3	-	-	100	0
0.15	-	-	100	0

Table-4 Sieve analysis for coarse aggregate

4.1 MATERIAL TESTS

4.1.1 Specific gravity (IS: 2386)

4.1.1 A). Specific gravity of Cement

1. Density bottle is cleaned with distilled water and dried.
2. The weight W_1 of the clean, dry density bottle with cap is noted.
3. About one-third of the density bottle is filled with cement. The weight W_2 of the density bottle and cement solids is determined.
4. Remaining quantity will be filled with kerosene and weight will be noted as w_3 .
5. The contents of the density bottle are removed. It is filled completely with water up to the top of the cap. The density bottle is dried from outside and its weight W_4 is noted.
6. The specific gravity of the sample is determined by

$$G = \frac{w2-w1}{(w2-w1)-(w3-w4)0.79}$$

7. The procedure is repeated twice, from steps 3 to 6 with other specimens from the same material. The specific gravity is reported as the average of three readings.
8. Average Specific Gravity of Cement = 3.07

S.NO	WEIGHTS (GM)	TRAIL 1	TRAIL 2	TRAIL 3
1	W_1	35	35	35
2	W_2	70.5	73	75.5
3	W_3	137	138.5	140.5
4	W_4	113	113	113
5	G	3.08	3.04	3.11

Table-5 specific gravity of cement

4.1.2 b). Specific gravity of Coarse aggregate

1. *PYCNOMETER* is cleaned with distilled water and dried.
2. The weight W_1 of the clean, dry *PYCNOMETER* with cap is noted.
3. About one-third of the *PYCNOMETER* is filled with coarse aggregates. The weight W_2 of the *PYCNOMETER* and soil solids is determined.
4. Small quantity of water is poured into the soil and left until all pores are completely filled with water.
5. Additional water is poured into the *PYCNOMETER* to fill it completely up to the top of the cap. The *PYCNOMETER* is dried from outside. The weight W_3 of *PYCNOMETER* and its contents is determined.
6. The contents of the *PYCNOMETER* are removed. It is filled completely with distilled water up to the top of the cap. The *PYCNOMETER* is dried from outside and its weight W_4 is noted.
7. The specific gravity of the sample is determined by
$$G = \frac{w2-w1}{(w2-w1)-(w3-w4)}$$
8. The procedure is repeated twice, from steps 3 to 6 with other specimens from the same material. The specific gravity is reported as the average of three readings.
9. Average Specific Gravity of C.A = 2.8

S. No	Weights (gm)	Trail 1	Trail 2	Trail 3
1	W_1	638	638	638
2	W_2	1209	1185	1214
3	W_3	1897.5	1880	1903.5
4	W_4	1530	1530	1530
5	G	2.805	2.776	2.844

Table-6 specific gravity of C.A

4.1.3C. Specific gravity of fine aggregate

1. P*YCNOMETER* is cleaned with distilled water and dried.
2. The weight W_1 of the clean, dry P*YCNOMETER* with cap is noted.
3. About one-third of the P*YCNOMETER* is filled with fine aggregates. The weight W_2 of the P*YCNOMETER* and soil solids is determined.
4. Small quantity of water is poured into the soil and left until all pores are completely filled with water.
5. Additional water is poured into the P*YCNOMETER* to fill it completely up to the top of the cap. The P*YCNOMETER* is dried from outside. The weight W_3 of P*YCNOMETER* and its contents is determined.
6. The contents of the P*YCNOMETER* are removed. It is filled completely with distilled water up to the top of the cap. The P*YCNOMETER* is dried from outside and its weight W_4 is noted.
7. The specific gravity of the sample is determined by
$$G = \frac{w2-w1}{(w2-w1)-(w3-w4)}$$
8. The procedure is repeated twice, from steps 3 to 6 with other specimens from the same material. The specific gravity is reported as the average of three readings.
9. Average Specific Gravity of F.A = 2.66

This specific gravity is for Sand used in normal mix.

S.NO	WEIGHTS (GM)	TRAIL 1	TRAIL 2	TRAIL 3
1	W_1	638	638	638
2	W_2	1129	1120	1194.9
3	W_3	1838	1832	1877.5
4	W_4	1530	1530	1530
5	G	2.68	2.67	2.65

Table-7 specific gravity of F.A

4.2.1 Bulk density (IS: 2386)

4.2.1 A). Coarse aggregate

- Height of mould = 300mm
- Diameter of mould = 150mm
- Weight of empty mould = W_1
- Weight of mould + C.A = W_2
- Weight of mould + compacted C.A= W_3
- Volume of mould = V= $\pi/_4 \times 0.25^2 \times 0.3$ = 0.0147m^3

Weights(kg)	Trial 1	Trial 2	Trial 3
W_1	9.690	9.690	9.690
W_2	33.080	33.080	33.080
W_3	33.6	34	34.3
W_3-W_1	23.91	24.31	24.61

Table-8 bulk density of C.A

$$\text{Average Bulk Density} = \frac{\text{Net weight of aggregate in kg}}{\text{volume of container}}$$

$$= \frac{\epsilon\,(W3-W1)}{v} = 1650 \text{ kg/m}^3$$

4.2.2 B). Fine aggregate

1. Weigh the empty cylinder.
2. Calculate the volume of the empty cylinder.
3. Take the weight of cylinder with aggregate.
4. Repeat the procedure for twice. The bulk density is taken as the average of three readings.

Height of mould = 170mm
Diameter of mould = 150mm
Weight of empty mould = W_1
Weight of mould + F.A = W_2
Weight of mould + compacted F.A = W_3
Volume of mould = V = $\pi/4 \times 0.15^2 \times 0.17 = 0.0035\text{m}^3$

Weights(kg)	Trial 1	Trial 2	Trial 3
W_1	3.670	3.670	3.670
W_2	8.9	8.3	8.22
W_3	9.6	9.5	9.62
W_3-W_1	5.93	5.83	5.95

Table-9 bulk density of F.A

$$\text{Average Bulk Density} = \frac{\text{Net weight of aggregate in kg}}{\text{volume of container}}$$

$$= \frac{\epsilon\,(W3-W1)}{v} = 1687 \text{ kg/m}^3$$

4.2.3 Sieve analysis

4.2.3 A). Coarse aggregate

Sieve sizes (mm)	Weight retained (gm)	% weight retained	Cumulative % weight retained	% passing
80	0	0	0	100
40	0	0	0	100
20	490	9.8	9.8	90.2
10	4411	88.22	98.02	1.98
4.75	99	1.98	100	0

Table-10 Proportions of different size fractions to obtain 20mm aggregate

Sieve sizes (mm)	Weight retained (gm)	%weight retained	Cumulative % weight retained	% passing
16	0	0	0	100
12.5	875	17.5	17.5	82.5
9.5	2080	41.6	59.1	40.9
4.75	1980	39.6	98.7	1.3
2.36	65	1.3	100	0

Table-11 Proportions of different size fractions to obtain 12.5mm aggregate

4.2.3 B). Fine aggregate

Sieve sizes	Weight retained (gm)	%weight retained	Cumulative % weight retained	% passing
4.75mm	25	2.5	2.5	97.5
2.36mm	52	5.2	7.7	92.3
1.18mm	161	16.1	23.8	76.2
600µ	355	35.5	59.3	40.7
300µ	364	36.4	95.7	4.3
150µ	36	3.6	99.3	0.7
75µ	5	0.5	99.8	0.2
Pan	2	0.2	100	0

Table-12 Proportions of different size fractions to obtain zone-II sand

4.3 Moulds and Equipment

4.3.1 Cubes

Standard cube moulds of size 150X150X150mm are made of cast iron were used for obtaining strength and durability properties.

4.3.2 Mixing

i) First mix all dry materials in the pan mixer.
ii) Add the liquid component of the mixture at the end of dry mixing, and continue the wet mixing for another four minutes.

Fig 2: Mixing of materials in 90 kg mixer

4.3.3 Casting

The standard moulds were fitted such that there are no gaps between the plates of the moulds. If there are small gaps they were filled with plaster of pairs.

4.4 MIX PROPRTIONS:

Cement = 375kg/m^3

Water = 180kg/m^3

Coarse aggregate = 1204.466kg/m^3

Fine aggregate = 616.503kg/m^3

Chemical admixture = 3.75kg/m^3

Water-cement ratio = 0.48.

4.4.1 Mix Design for M40-Grade Concrete

Grade Designation: M40

Type of cement: OPC 53 grade KCP

Maximum size of Aggregate: 20mm

Minimum cement content: 250Kg/m^3

Maximum Water-Cement ratio: 0.5

Workability: Slump

Type of Exposure: Severe

Degree of Quality Control: Good

Type of Aggregate: ANGULAR aggregate

Max. Cement content: 450Kg/m^3

Chemical Admixture type: SP 430 CONPLAST

4.4.2 TEST DATA FOR MATERIALS

Cement used: OPC 53 grade KCP

Specific Gravity of Cement: 3.03

Chemical Admixture type: SP 430 CONPLAST

Specific Gravity of Coarse Aggregate: 2.7

Specific Gravity of Fine Aggregate: 2.5

4.4.3 SIEVE ANALYSIS

1) Coarse aggregate: 20mm passed 10mm retained

2) Fine aggregate: Confirming to Zone III of Table 4 of IS: 383.

4.4.4 MIX PROPORTIONS:

Cement = 430kg/m^3

Water = 180kg/m^3

Coarse aggregate = 1181.320kg/m^3

Fine aggregate = 578.685kg/m^3

Chemical admixture = 3.75kg/m^3

Water-cement ratio = 0.43

The above mix designs are used for casting concrete specimens. The water-cement ratio changes for different dosages of super plasticizer. Usage of super plasticizer reduces the water requirement and new w/c ratios are obtained. The following tables show the details of w/c ratios obtained at various dosages of super plasticizer for M25 and M40 concrete.

GRADE	SUPERPLASTICIZER DOSAGE (%)	ACTUAL W/C RATIO	W/C RATIO
M25	1	0.48	0.456
	1.3	0.48	0.4557
	1.6	0.48	0.384

Table 12 w/c ratios for m25 grade

GRADE	SUPERPLASTICIZER DOSAGE (%)	ACTUAL W/C RATIO	W/C RATIO
M40	1	0.43	0.408
	1.3	0.43	0.387
	1.6	0.43	0.366

Table 13 w/c ratios for m40 grade

4.5 PREPARATION OF TESTING SPECIMEN:

The specimens are casted for the following:

1. ***M25 grade concrete with OPC+NATURAL SAND***
2. ***M25 grade concrete with OPC + GLASS POWDER***
3. ***M40 grade concrete with OPC+NATURAL SAND***
4. ***M40 grade concrete with OPC + GLASS POWDER***

Fig 3: Casting Concrete into Moulds

4.6 TESTING APPARATUS

A.COMPRESSION TESTING MACHINE

Compression testing machine (3000kN). The concrete cube that is to be tested is placed and loaded. The standard size of cube specimen used is 150X150X150mm for concrete made with coarse aggregate less than 20mm. The rate of loading should be approximately 14MPa/min till the failure of the cube.

Fig.4 Compression Testing Machine

B. UNIVERSAL TESTING MACHINE

Universal testing machine (10T) with test specimen. The flexural strength of concrete beam can be obtained by subjecting it to two –point loading as shown in fig.4.3. The standard size of beam specimen used is 100X100X500mm for concrete made of coarse aggregate less than 20mm.

Fig.5 Universal Testing Machine (10t)

5. RESULTS

In order to study the strength behavior and fire resistance of the concrete made with full replacement of sand with Glass powder the tests are conducted. Results so obtained for the tests conducted on cubes and prisms for M25 and M40 grades of concrete with various dosages of super plasticizer at 7days and 28 days were tabulated. The results were compared for concretes with natural sand to that of glass powder as fine aggregate.

5.1 COMPRESSIVE STRENGHTS (M25 GRADE):

The compressive strength of M25 grade concrete cubes made with natural sand and those made with glass powder as fine aggregate are tested under compression testing machine and results are tabulated in table-2 shown below

S. No.	Sp %	OPC + SAND		OPC + GLASS POWDER	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	1.00	14.54	28.33	17.22	28.67
2	1.30	17.74	28.67	18.89	29.89
3	1.60	18.13	29.67	18.77	28.55

Table 14 Strength comparison for M25 Grade cubes

From the table it is observed that both the concretes are achieving the target strengths at the age of 28 days. But the compressive strengths of normal concrete are slightly higher when compared with Glass powder concrete. There is no significant difference in the strengths with variation in dosage of super plasticizer. The following figures give an idea regarding compressive strengths.

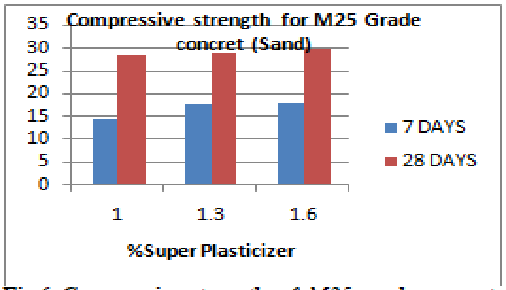

Fig.6 Compressive strength of M25 grade concrete

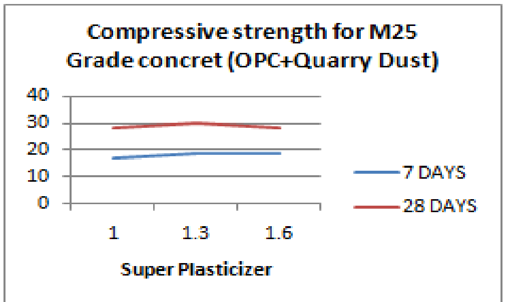

Fig. 7 Compressive strength of M25 grade concrete (OPC+ Glass powder)

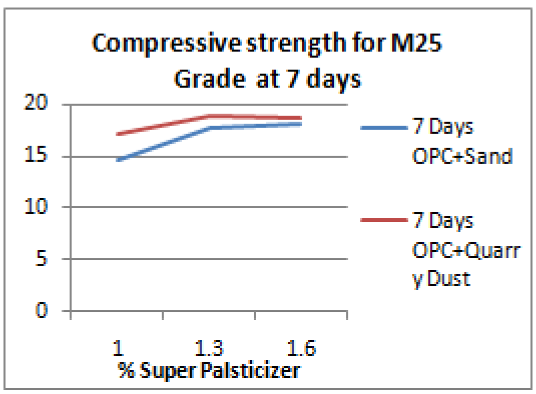

Fig.8 Compressive strength of M25 grade concrete at 7 days

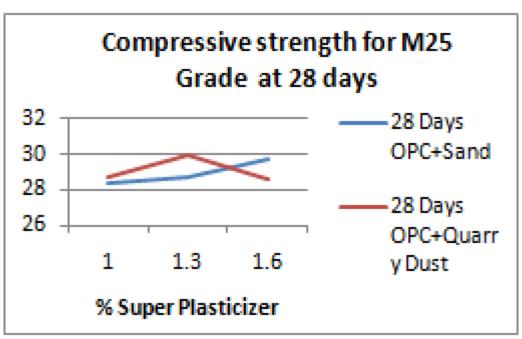

Fig.9 Compressive strength of M25 grade concrete at 28 days

5.2 COMPRESSIVE STRENGTH (M40):

The compressive strength of M40 grade concrete cubes made with natural sand and those made with glass powder as fine aggregate are tested under compression testing machine and results are tabulated in table-4 shown below.

S. No.	Sp %	OPC + SAND		OPC + GLASS POWDER	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	1.00	26.67	44.775	26.75	44.11
2	1.30	27.28	45.333	27.33	45.88
3	1.60	28.55	45.6	29.555	45.67

Table 15 Strength comparison for M40 grade cubes

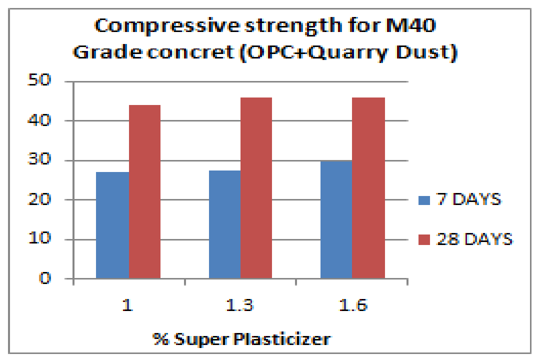

Fig 10 Compressive strength of M 40 grade concrete (OPC+SAND)

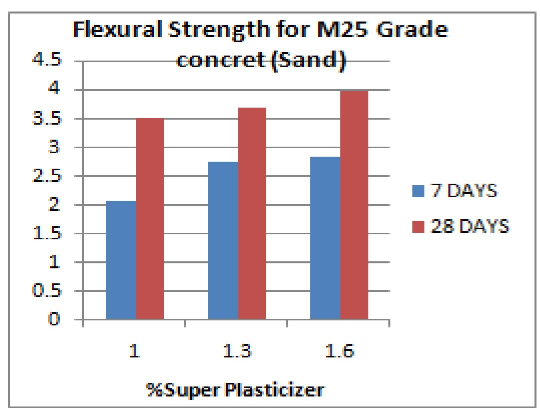

Fig 11 Flexural strength of M25 grade concrete (OPC+ sand)

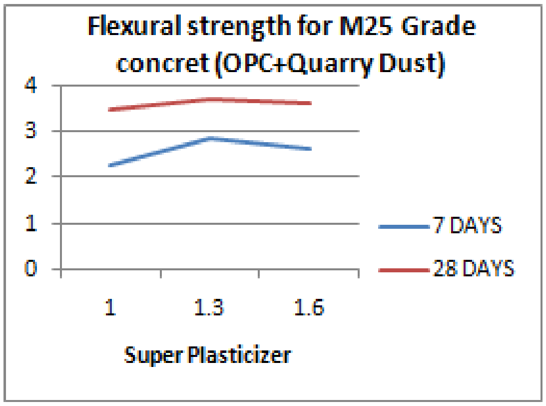

Fig 12 Flexural strength of M25 grade concrete (OPC+ Glass powder)

6. CONCLUSIONS

From the results tabulated in earlier chapter the following statements can be derived:

1. For the designed mix proportions of M25 and M40 grades of concrete the desired characteristic strengths for cubes are achieved in both conventional concrete and Glass powder concrete.
2. The strength achieved in concrete made with sand as fine aggregate achieved high strengths when compared with Glass powder concrete. However, in both the cases strengths were increasing at a super plasticizer dosage of 1.3% by weight of cement. Similar behavior was also observed in cubes of M40 grade cubes.
3. In M40 grade cubes it was observed that at 1.3% dosage of super plasticizer the compressive strength is increased.
4. Flexural strength of M25 prisms when subjected to two-point loading were approximately nearer at various dosages of super plasticizer at 7 days and 28 days for conventional concrete but whereas in QSD concrete at 1.3% dosage of super plasticizer the strength achieved more at 28 days.
5. At 28 days QSD concrete with a super plasticizer dosage of 1.3% by weight of cement exhibits has high strength compared to other dosages.
6. For M40 grade concrete the strength gradually increases for 1% to 1.3% super plasticizer whereas in glass powder the strength decreases from 1.6 % to 1.3% super plasticizer.

7. SCOPE FOR FUTURE WORK

1. The same work can be carried out by blending glass powder from one or more sources.
2. Alternative materials other than glass powder such as artificial sand, robots and, waste copper slag, marble sludge powder can be used for replacement.
3. Super plasticizer of different type can be used and water reduction can be determined.

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