International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 7 Issue 4, July-August 2023 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

A Study of Cement and Aggregate Replacement in Concrete using Glass Powder and Recycled Aggregate

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ABSTRACT

It has been estimated that several million tons of waste glasses are generated annually worldwide. The key sources of waste glasses are waste containers, window glasses, window screen, medicinal bottles, liquor bottles, tube lights, bulbs, electronic equipments etc. Only a part of this waste glass can be used in recycling. The remaining waste glass cannot be used for any purposes. But recently the research has shown that the waste glass can be effectively used in concrete either as glass aggregate (as fine aggregate or as coarse aggregate) or as a glass pozzolana. The waste glass when grounded to a very fine powder shows some pozzolanic properties. Therefore the glass powder to some extent can replace the cement and contribute to the strength development.

In a growing country like India a huge amount of industrial waste is polluting the environment. With a view of the above, this study aims at utilization of such industrial by product for value added application. In addition the waste can improve the properties of construction materials. The recycled glass has been used in the form of powder. The glass powder was tested with concrete and mortar. Cement was replaced by the glass powder in some proportion. The flexural strength was conducted for the above replacements. The result showed glass powder improves the mechanical properties. The advantages of this project are that the replacement of glass powder is economically cheap as well as a superior concrete can be made.

How to cite this paper: Manmohini Verma | Prof. Afzal Khan | Prof. Imran Ahmad Faizy "A Study of Cement and Aggregate Replacement in Concrete using Glass Powder and Recycled Aggregate" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-7 | Issue-4, August 2023, pp.700-719, URL: www.ijtsrd.com/papers/ijtsrd59788.pdf

IJTSRD59788

Concrete is the most widely used man made construction material in the world. The popularity of concrete is due to the fact that from the common ingredients the properties of concrete are tailored to meet the demand of any particular application and then most widely used in all types of civil engineering works including infrastructures, low and high rise buildings, defense developments. It is obtained by mixing cementing materials, water and aggregate. However, in recent years the wisdom of own continued wholesale extraction and use of aggregate from natural resources has been questioned at on an international level. This is mainly because of the depletion of quality primary aggregate and greater awareness of environmental protection. In light of this the availability of natural resource for future generations has also been realized. In fact, many governments throughout the world have now introduced various measures aimed at reducing the use of primary aggregates and increasing reuse and recycling where it is technically, economically or environmentally acceptable. The project explores a theme on the need for recycled aggregates and glass powder and highlights its potential use as aggregate and cement in new concrete construction. Research comprises of studies on offer of replacement of cement & aggregate by glass powder and recycled aggregate in concrete by some percentage for 28 days flexural strength of concrete. A result show that the flexural strength of recycled concrete gives higher results with(5% glass powder and 20% recycled aggregate)& slightly lower result with (10% glass powder and 20%recycled aggregate) & (20% glass powder and 10 % recycled aggregate).

KEYWORDS: *Glass powder, Recycled aggregate, Concrete Mix, Compressive Strength, flexural strength*

1. INTRODUCTION

This experimental study consists of a collection of different materials to be used for investigation, In this study an attempt is made to find out the hardened properties of concrete such as Flexural Strength of M40 grade concrete containing waste glass powder as porcelain and recycled aggregate as aggregate.

Recycled Aggregate sample collection from BY Pass Road Bangali Square Indore Road project M.P. And the glass powder is derived from post- consumer glass source from Indore, M.P. The OPC (43 grade) used in the present work is of Ultratech brand. This is used as the main binder in the mixes. Cement, sand and coarse aggregate are also collected from local consumer sources. 20mm maximum size of aggregate is used. Plasticizer does is optimized to make the mixes workable for paving application is about Fosrock brand. The water, which is available in the laboratory is used. The mixes were designated as a mix with the varying percentage of Glass Powder and Recycled Aggregate such as 5%, 10%, 15%, 20%, 25% respectively, and finding out its suitable combination at which concrete shows the highest flexural strength at 7-days and 28-days. Designing the mix as per IS 10262-2009, batching, mixing, compacting of concrete, casting the specimen for various test considered for the study, testing the specimen, tabulation and analysis of data andlastly conclusion based on test results.

1.1. PREPERATION OF SPECIMEN

1.1.1. Batching and mixing

The batching plant/concrete mixer shall be capable of proportioning the materials by weight, each type of material being weighted separately. The mixing of all concrete ingredients should be uniform to make homogeneous mix. This can be achieved during the mixing phase,preferably the dry quantity of cement, sand, glass powder, Recycled aggregate, aggregate are mixed and then water & admixture is added to the mixture.

1.1.2. Placing

After mixing of concrete, it is placed and filled in the concrete mold and care should be taken to see that no segregation of material is occurring.

1.1.3. Compaction

The controlled concrete, and modified concrete (concretes in which glass powder and Recycled Aggergate are added are called, modified concrete") compacted immediately just after the material is filled in the beams with a necessary surcharge (extra loose material).

1.1.4. Finishing

Finishing of concrete specimen is done with the help of a trowel by doing leveled surface of beams. It should be ensured that, the surface should be plain to carry equal load at every pointon the surface.

1.1.5. Curing

After 24 hours of casting, the specimen is removed from the mold and immediately submerged in clean fresh water and kept there until taken out just prior to testing. The water in which the specimens are submerged, are renewed every seven days. The specimens are not to be allowed to become dry at any time until they have been tested.

One control mix named as controlled concrete and 25 experimental mixes named as modifiedconcrete were prepared incorporating the glass powder and Recycled Aggergate in concrete mix by partial replacement of cement and aggregate respectively. These 25 combinations of glass powder and recycled aggergate as listed in table 4.1 are prepared. For each combination three beams were casted for 7 days testing and three beams were casted for 28 days testing for flexural strength test. That means total 78 beams (75 modified beams + 3 normal concrete beams) are prepared for 7 days testing and similarly 78 beams are prepared for 28 days testing hence total 156 specimens were prepared.

Table 1.1- Concrete Mixes & Their Composition

Type ofmix	Binding material		Coarse aggregate	
	% Replacement ofcement by Glass Powder	% of cement is used in mixtures	% Replacement of Aggregate by RecycledAggregate	% of Aggregate is used in mixtures
CONTC	0%	100%	0%	100%
G05RA05	5%	95%	5%	95%
G05RA10	5%	95%	10%	90%
G05RA15	5%	95%	15%	85%
G05RA20	5%	95%	20%	80%
G05RA25	5%	95%	25%	75%
G10RA05	10%	90%	5%	95%
G10RA10	10%	90%	10%	90%
G10RA15	10%	90%	15%	85%
G10RA20	10%	90%	20%	80%
G10RA25	10%	90%	25%	75%
G15RA05	15%	85%	5%	95%

G15RA10	15%	85%	10%	90%
G15RA15	15%	85%	15%	85%
G15RA20	15%	85%	20%	80%
G15RA25	15%	85%	25%	75%
G20RA05	20%	80%	5%	95%
G20RA10	20%	80%	10%	90%
G20RA15	20%	80%	15%	85%
G20RA20	20%	80%	20%	80%
G20RA25	20%	80%	25%	75%
G25RA05	25%	75%	5%	95%
G25RA10	25%	75%	10%	90%
G25RA15	25%	75%	15%	85%
G25RA20	25%	75%	20%	80%
G25RA25	25%	75%	25%	75%

1.2. TESTING OF FRESH CONCRETE

1.2.1. Workability test

Workability is the property of freshly mixed concrete that determines the ease with which itcan be properly mixed, placed, consolidated and finished without segregation. The workability of fresh concrete was measured by means of the conventional slump test as per IS; 1199 (1989). Before the fresh concrete was cast into molds, the slump value of the freshconcrete was measured using the slump cone. In this project work, the slump value of fresh concrete was maintained in the range of 25mm to 50mm.

1.2.2. TESTING OF HARDENED CONCRETE

1.2.2.1. Flexural strength of concrete

Flexural strength is one measure of the tensile strength of concrete. It is a measure of a concrete beam or slab to resist failure in bending. The flexural strength is expressedas Modulus of Rupture (MR) in measured psi (MPa).

Flexural strength is checked after 7 and 28 days curing. Beams of size 700 x 150 X 150 mmare cast for both controlled concrete as well as for modified concrete from reference mixes. The specimens are tested in a universal testing machine with 2 ton load capacity cell as per IS: 516-1959 (2004).

$$Ff = \frac{wl}{bd2}$$

Where,
W= load
l= length of beam
b= breath of beam
d= depth of beam

Table 1.2- Concrete mix proportions for 1 m^3 of concrete

Concrete Mix Proportion=M40 (1: 1.004: 2.332) W/C=0.35									
Type of mix	Cement (kg)	Sand (kg)	Gravel (kg)	Water (kg)	Glass powder		Recycled aggregate		Plasticizer (kg) For slump maintains
					%	(Kg)	%	(Kg)	
CONT.C.	530	532	1236	185.40	0	0	0	0	0
G05RA05	503.50	532	1174.2	185.40	5	26.50	5	61.80	3.71
G05RA10	503.50	532	1112.4	185.40	5	26.50	10	123.60	3.71
G05RA15	503.50	532	1050.6	185.40	5	26.50	15	185.40	4.24
G05RA20	503.50	532	988.80	185.40	5	26.50	20	247.20	4.24
G05RA25	503.50	532	927.00	185.40	5	26.50	25	309.00	4.24
G10RA05	477.00	532	1174.2	185.40	10	53.00	5	61.80	4.24
G10RA10	477.00	532	1112.4	185.40	10	53.00	10	123.60	4.24
G10RA15	477.00	532	1050.6	185.40	10	53.00	15	185.40	4.24
G10RA20	477.00	532	988.80	185.40	10	53.00	20	247.20	4.24

G10RA25	477.00	532	927.00	185.40	10	53.00	25	309.00	4.24
G15RA05	450.50	532	1174.2	185.40	15	79.50	5	61.80	4.24
G15RA10	450.50	532	1112.4	185.40	15	79.50	10	123.60	4.24
G15RA15	450.50	532	1050.6	185.40	15	79.50	15	185.40	4.24
G15RA20	450.50	532	988.80	185.40	15	79.50	20	247.20	4.24
G15RA25	450.50	532	927.00	185.40	15	79.50	25	309.00	4.24
G20RA05	424.00	532	1174.2	185.40	20	106.0	5	61.80	4.24
G20RA10	424.00	532	1112.4	185.40	20	106.0	10	123.60	4.24
G20RA15	424.00	532	1050.6	185.40	20	106.0	15	185.40	4.24
G20RA20	424.00	532	988.80	185.40	20	106.0	20	247.20	4.24
G20RA25	424.00	532	927.00	185.40	20	106.0	25	309.00	4.24
G25RA05	397.50	532	1174.2	185.40	25	132.5	5	61.80	4.24
G25RA10	397.50	532	1112.4	185.40	25	132.5	10	123.60	4.24
G25RA15	397.50	532	1050.6	185.40	25	132.5	15	185.40	4.24
G25RA20	397.50	532	988.80	185.40	25	132.5	20	247.20	4.24
G25RA25	397.50	532	927.00	185.40	25	132.5	25	309.00	4.24

Figure no. 1.1: Beams specimen

Evaluation Parameters

1.3. Testing On Concrete Ingredients

1.3.1. Fineness of Cement and Glass Powder

The degree of fineness of cement/Glass Power is a measure of the mean size of the grains in the cement/Glass Powder. The rate of hydration and hydrolysis, and subsequent development of strength depends upon the fineness of cement. It can be calculated from the particle size distribution or determined from one of the air permeability methods. Forordinary Portland cement, the residue by mass in 90 micron sieve should not exceed 10 percent. The standard cement should comply with the following conditions of fineness as given by IS: 460-1978 & IS: 269-1976.

1.3.2. Specific Gravity of Cement & Glass Powder

Specific gravity defined as the ratio of the mass of a given volume of material to the mass of an equal volume of water. Specific gravity of cement & Glass powder is found by the use of Le-Chatelier flask in the laboratory.

1.3.3. Consistency of Cement

The amount of water added to cement to get a paste of normal consistency, i.e. the paste of certain standard solidity. It is used to fix the quantity of water to be mixed with cement before performing tests for setting time, soundness and compressive strength.

1.3.4. Setting Time of Cement
Setting of cement is resulted from hydration of cement. Hydration of cement is the chemical reaction occurred between cement compound and water. The setting and hardening ofcement are continuous processed, but two points are distinguished for test purposes. The initial setting time is the interval between the mixing of the cement with water and the time when the mix has lost plasticity, stiffening to a certain degree. It marks roughly the end of the period when the wet mix can be molded into shape. The final setting time is the point at which the set cement has acquired a sufficient firmness to resist a certain defined pressure.

1.3.5. Soundness of Cement
After it has set, cement must not undergo any appreciable expansion, which could disrupt a concrete. This property of soundness is tested by subjecting the set cement to boiling in water or to high-pressure steam. Unsoundness can arise from the presence in the cement of too much magnesia or hard-burned free lime.

1.3.6. Compressive Strength of Cement
This test is measured the rate at which a cement develops strength are usually made in a mortar commonly composed one part cement to three parts sand, by weight, mixed with a definite quantity of water and tested on the compressive strength machine. 3 days & 7 days compressive strength test were conducted for obtaining compressive strength of cement.

1.3.7. Specific Gravity of Fine Aggregate
Specific gravity defined as the ratio of the mass of a given volume of material to the mass of an equal volume of water. Specific gravity of sand is found by the use of Le-Chatelier flask in the laboratory.

1.3.8. Fineness Modulus of Fine Aggregate, Coarse Aggregate
It is the numerical index of fineness giving some idea of the mean size of particles in the entire body of aggregate. For finding out the fineness modulus of sand Indian Standardsieves (sieve size 4.75mm, 2.36mm, 1.18mm, 600µm, 300µm, 150µm) is used and finding out the Fineness modulus of coarse aggregate Indian Standard sieves of 80mm, 40mm, 20mm, 10mm, 4.75mm is used. The sieve analysis of sand and coarse aggregate is shown in table 5.6 & table 5.7 respectively.

1.3.9. Water Absorption of Sand
Water absorption shows the percentage of water present in the sand sample. IS: 2386 (Part- III) was used for determination of water absorption of sand.

2. RESULTS AND DISCUSSION
2.1. Physical Properties

Table 2.1- Physical Properties of cement

Fineness of Cement	**96.80%**
Specific Gravity of Cement	**3.15**
Consistency of cement	**33%**
Initial setting time	**68 minutes**
Final setting time	**184 minutes**
3-days compressive strength	**23.5N/mm2**
7-days compressive strength	**34 N/mm2**

Table 2.2- Physical Properties of Fine Aggregate

Specific Gravity of Fine aggregate	**2.65**
Fineness Modulus of Fine Aggregate	**2.94**
Water absorption of sand	**1.00%**

Table 2.3- Physical Properties of Coarse Aggregate

Specific Gravity of Coarse aggregate	**2.90**
Fineness modulus of coarse aggregate	**6.988**
Water absorption of coarse aggregate	**0.72%**

Table 2.4- Physical Properties of Glass powder

Fineness of Glass Powder	**97%**
Specific Gravity of Glass Powder	**2.65**

Table 2.5- Fineness modulus of sand

SIEVE SIZE	WEIGHT RETAINED	% WEIGHTRETAINED	CUMMULATIVE % WEIGHT RETAINED
10 mm	0	0	0
4.75 mm	0.306	6.120	6.120
2.36 mm	0.389	7.780	13.900
1.18 mm	0.452	9.040	22.940
600 microns	1.684	33.680	56.620
300 microns	1.906	38.120	94.740
150 microns	0.236	4.720	99.460
Pan	0.027	∑ =	**293.780**

$$\text{Fineness Modulus of Fine Aggregate} = \frac{293.780}{100} = \underline{\mathbf{2.94}}$$

Table 2.6- Fineness modulus of coarse aggregate

SIEVE SIZE	WEIGHT RETAINED	% WEIGHT RETAINED	CUMMULATIVE % WEIGHT RETAINED
80 mm	0	0	0
40 mm	0	0	0
20 mm	.670	13.40	13.40
10 mm	3.600	72.00	85.40
4.75	0.700	14.60	100
Total	5.0	∑ =	**198.8**

$$\text{Fineness Modulus of Coarse Aggregate} = \frac{198.8+500}{100} = \mathbf{6.988}$$

Table 2.7- Fineness modulus of Recycled Aggregate

SIEVE SIZE	WEIGHT RETAINED	% WEIGHT RETAINED	CUMMULATIVE % WEIGHT RETAINED
80 mm	0	0	0
40 mm	0	0	0
20 mm	1.374	27.48	27.48
10 mm	3.604	72.08	99.56
4.75	0.022	0.44	100
Total	5.0	∑ =	**127.04**

$$\text{Fineness Modulus of Recycled Aggregate} = \frac{127.04+500}{100} = \mathbf{6.27}$$

2.2. Chemical Properties

Table 2.8.- Chemical properties of cement

Constituents (% mass)	Percent Content
CaO	60-67
SiO_2	17-25
Al_2O_3	3-8
Fe_2O_3	0.5-6
MgO	0.1-4
So_3	1.3-3
Alkalis(K_2O, Na_2O)	0.4-1.3

(Source- Ultra Tech manual)

Table 2.9.- Chemical properties of glass powder

Constituents (% mass)	Percent Content
CaO	9.79
SiO_2	73.1
Al_2O_3	1.36
Fe_2O_3	0.67
MgO	3.45
So_3	-
Alkalis (K_2O, Na_2O)	11.1

2.3. WORKABILITY OF VARIOUS CONCRETE MIX

Table 2.10- Workability of various concrete mixes

Type ofmix	% addition of admixture (by weight ofcement)	Slump value (mm)
CONT.C.	0%	23 mm
	0.7%	33mm
G05RA05	0.7%	29mm
G05RA10	0.7%	27mm
G05RA15	0.7%	24mm
	0.8%	40mm
G05RA20	0.8%	38mm
G05RA25	0.8%	36mm
G10RA05	0.8%	39mm
G10RA10	0.8%	37mm
G10RA15	0.8%	32mm
G10RA20	0.8%	35mm
G10RA25	0.8%	34mm
G15RA05	0.8%	38mm
G15RA10	0.8%	35mm
G15RA15	0.8%	33mm
G15RA20	0.8%	32mm
G15RA25	0.8%	30mm
G20RA05	0.8%	37mm
G20RA10	0.8%	35mm
G20RA15	0.8%	32mm
G20RA20	0.80%	30mm
G20RA25	0.80%	28mm
G25RA05	0.80%	32mm
G25RA10	0.80%	30mm
G25RA15	0.80%	29mm
G25RA20	0.80%	28mm
G25RA25	0.80%	26mm

Figure No. 2.1: - MIXING OF MATERIAL M-40

Figure No. 2.2: - BEAM CASTING SIZE 700X150X150

Figure No. 2.3: - CURING OF BEAM

2.4. FLEXURAL STRENGTH OF CONCRETE

The Flexural strength of beams are shown in below table.

Table 2.11- Flexural Strength of Concrete Mixes

Type of mix	Flexural strength(N/mm^2)	
	7 days	28 days
CONTC	4.89	6.67
G05RA05	3.82	5.06
G05RA10	4.53	5.15
G05RA15	4.84	6.67
G05RA20	5.15	7.11
G05RA25	5.08	6.20
G10RA05	4.00	5.15
G10RA10	4.36	5.86
G10RA15	4.62	6.42
G10RA20	5.06	6.50
G10RA25	4.84	6.04
G15RA05	4.35	5.26
G15RA10	4.42	6.24
G15RA15	4.62	6.30
G15RA20	4.51	5.79
G15RA25	4.30	4.77
G20RA05	4.44	5.33
G20RA10	4.62	6.67
G20RA15	4.53	6.22
G20RA20	4.35	5.33
G20RA25	3.50	3.58
G25RA05	4.33	5.18
G25RA10	4.20	5.10
G25RA15	3.90	4.80
G25RA20	3.20	4.40
G25RA25	3.05	3.20

Figure No. 2.4: - BEAM TESTING

Figure No. 2.5:- BEAM CRACK PATTERN

Figure No. 2.6: - BEAM CRACK PATTERN

Figure No. 2.7:- FLEXURAL STRENGTH TEST

2.5. PERCENTAGE CHANGES OF FLEXURAL STRENGTH

Table 2.12- Flexural strength of concrete of 5% cement replaced by the Glass powder withvarying percentage of Recycled Aggregate

Type of mix	7-Days (N/mm^2)	28-Days (N/mm^2)
CONC	4.89	6.67
G05RA05	3.82	5.06
G05RA10	4.53	5.15
G05RA15	4.84	6.67
G05RA20	5.15	7.11
G05RA25	5.08	6.20

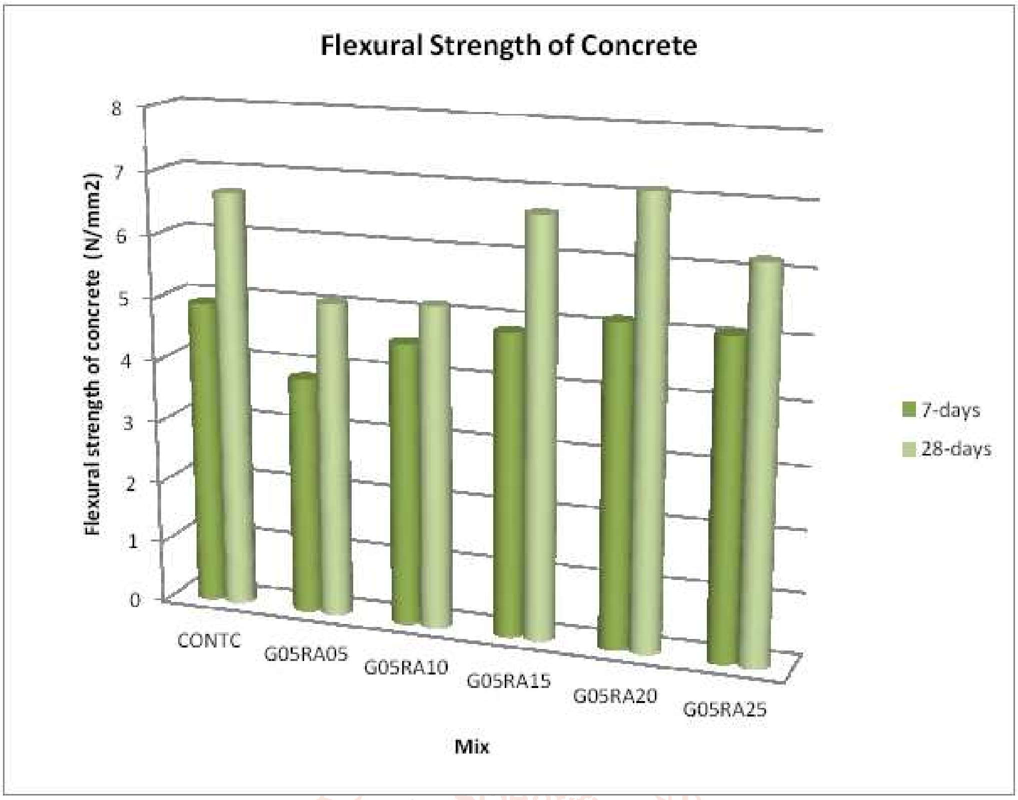

Figure No.2.8: - 7 days & 28 days Flexural Strength at 5% constant percentage of GlassPowder

Table 2.13 - Flexural strength of concrete of 10% cement replaced by the Glass powder withvarying percentage of Recycled Aggregate

Type of mix	7-Days (N/mm^2)	28-Days (N/mm^2)
CONC	4.89	6.67
G10RA05	4.00	5.15
G10RA10	4.36	5.86
G10RA15	4.62	6.42
G10RA20	5.06	6.50
G10RA25	4.84	6.04

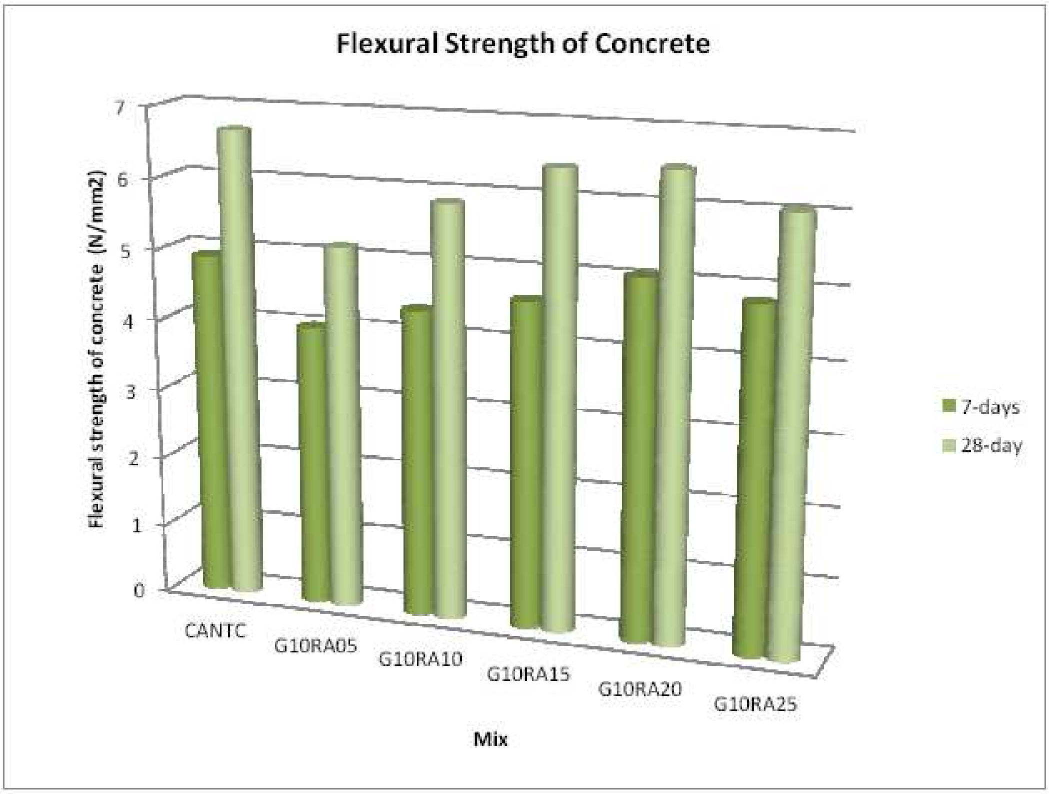

Figure No. 2.9: - 7 days & 28 days Flexural Strength at 10% constant percentage of GlassPowder

Table 2.14- Flexural strength of concrete of 15% cement replaced by the Glass powder withvarying percentage of Recycled Aggregate

Type of mix	7-Days (N/mm^2)	28-Days (N/mm^2)
CONC	4.89	6.67
G15RA05	4.35	5.26
G15RA10	4.42	6.24
G15RA15	4.62	6.30
G15RA20	4.51	5.79
G15RA25	4.30	4.77

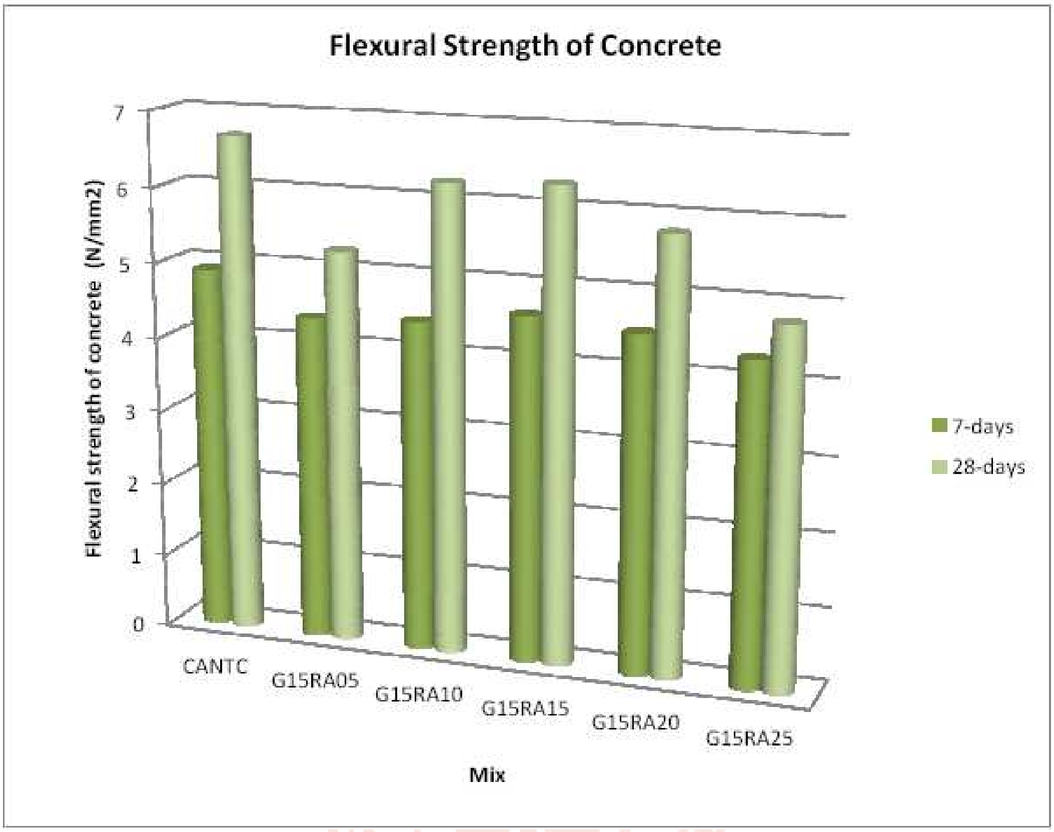

Figure No. 2.10: - 7 days & 28 days Flexural Strength at 15% constant percentage of GlassPowder

Table 2.15- Flexural strength of concrete of 20% cement replaced by the Glass powder withvarying percentage of Recycled Aggregate

Type of mix	7-Days (N/mm^2)	28-Days (N/mm^2)
CONC	4.89	6.67
G20RA05	4.44	5.33
G20RA10	4.62	6.67
G20RA15	4.53	6.22
G20RA20	4.35	5.33
G20RA25	3.50	3.58

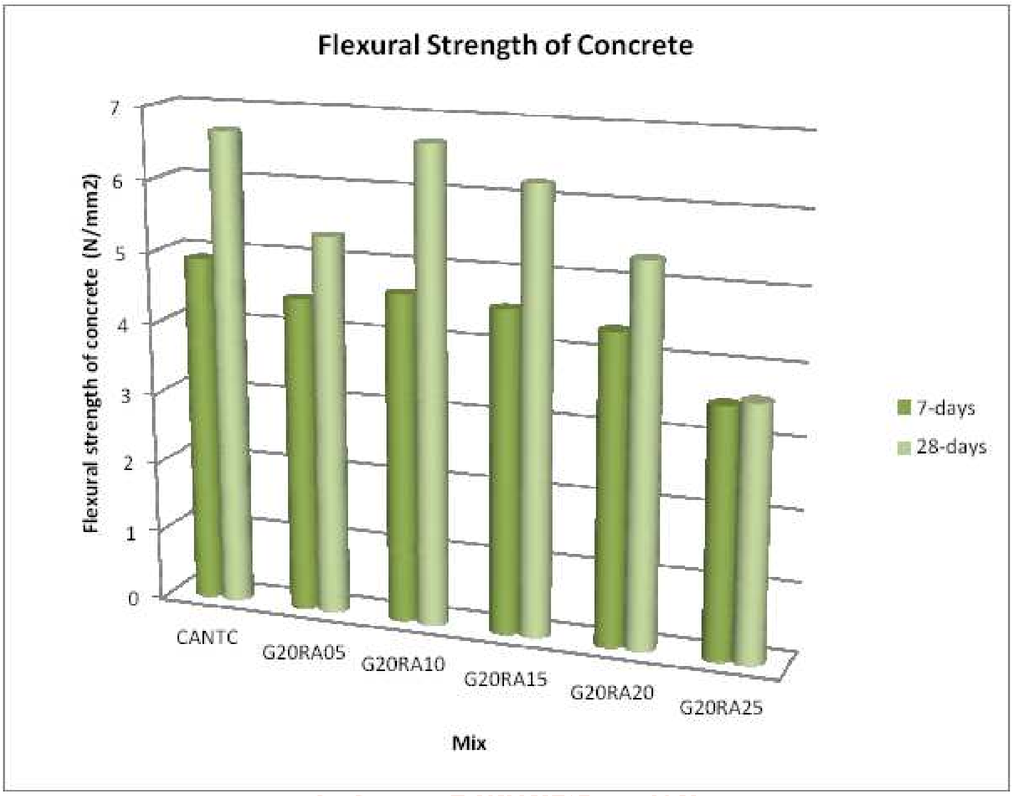

Figure No. 2.11:- 7 days & 28 days Flexural Strength at 20% constant percentage of GlassPowder

Table 2.16- Flexural strength of concrete of 25% cement replaced by the Glass powder withvarying percentage of Recycled Aggregate

Type of mix	7-Days (N/mm^2)	28-Days (N/mm^2)
CONC	4.89	6.67
G25RA05	4.33	5.18
G25RA10	4.20	5.10
G25RA15	3.90	4.80
G25RA20	3.20	3.44
G25RA25	3.05	3.20

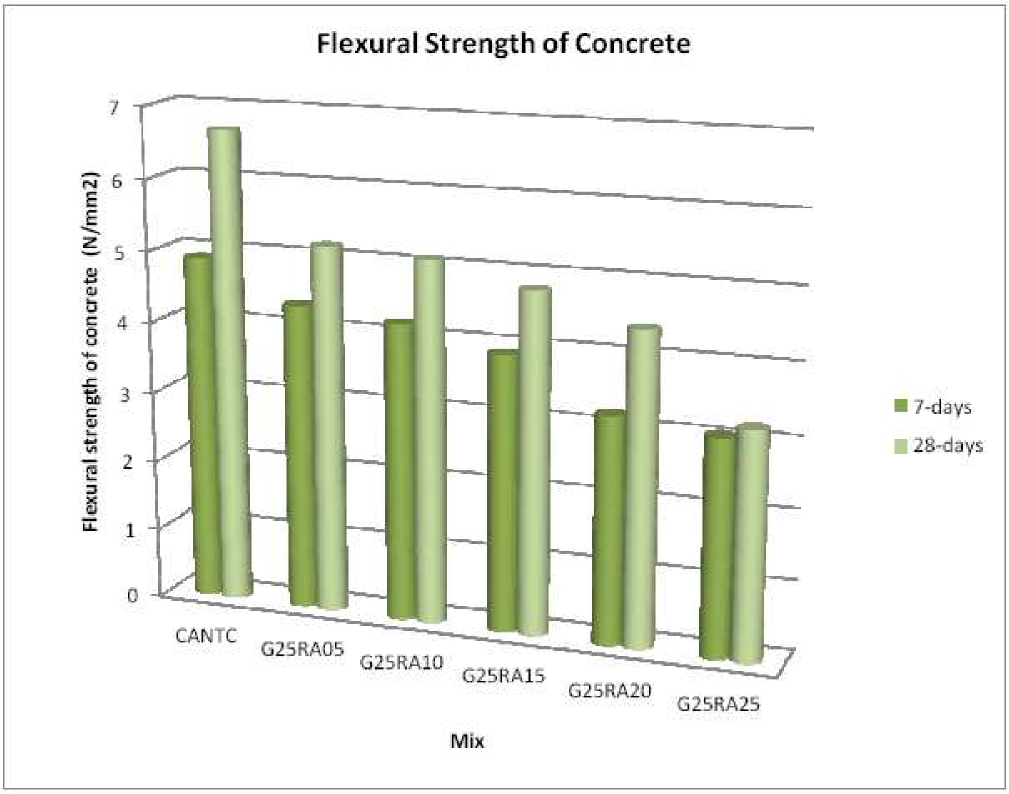

Figure No. 2.12:- 7 days & 28 days Flexural Strength at 25% constant percentage of GlassPowder

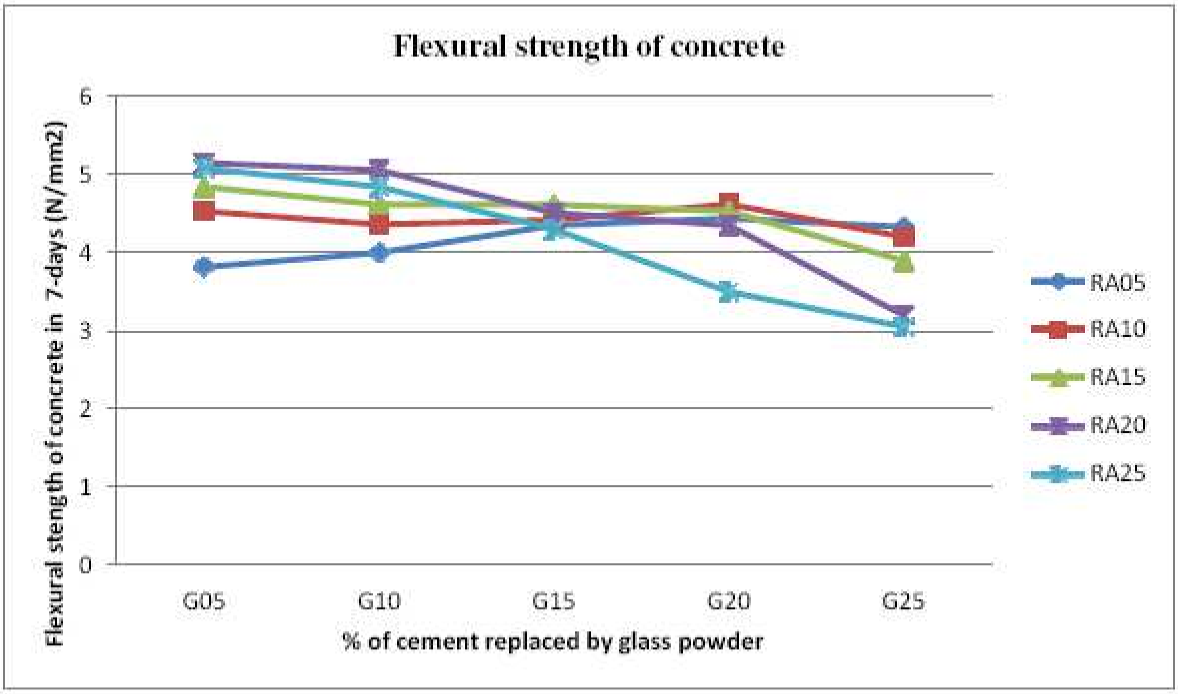

Figure No. 2.13: - Flexural strength of concrete in 7-days at 5%, 10%, 15%, and 20% 25%constant of glass powder

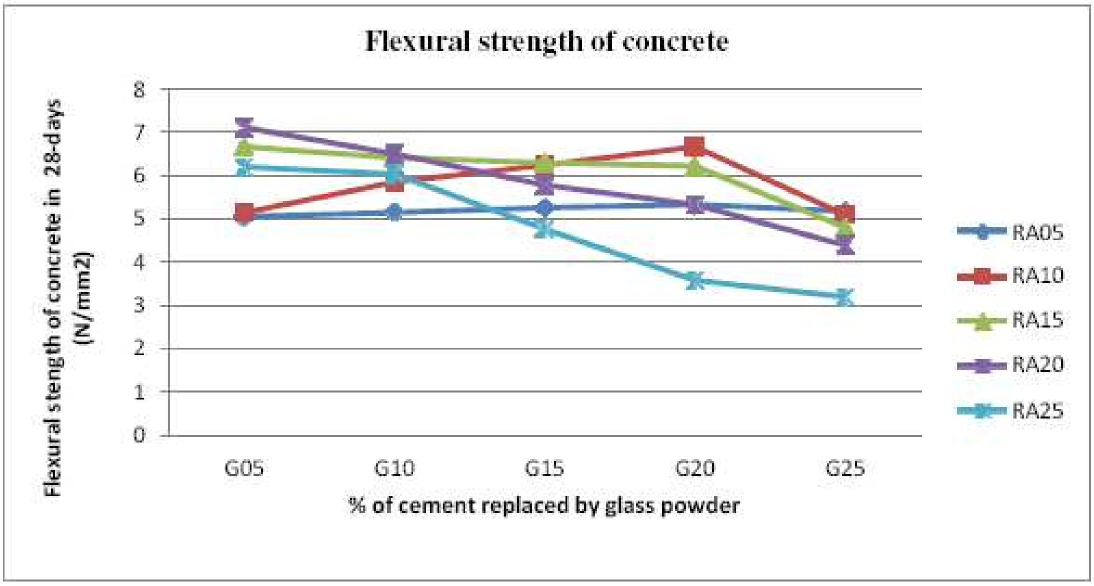

Figure No. 2.14: - Flexural strength of concrete in 28-days at 5%, 10%, 15%, and 20%25% constant of glass powder

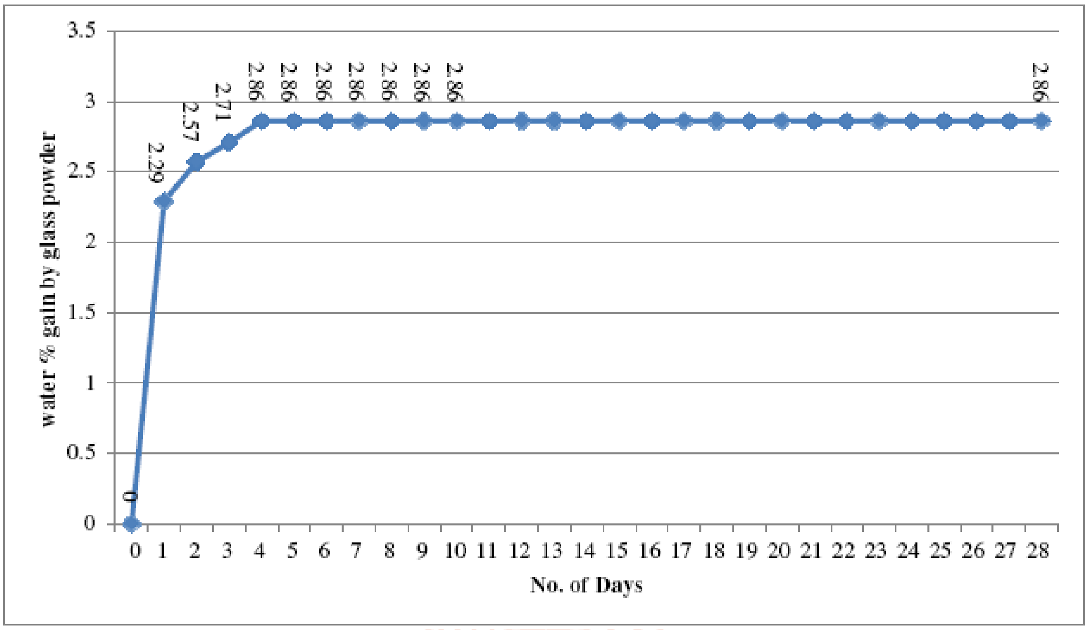

Figure No. 2.15 :- Water absorption by glass powder from 1to28 Days

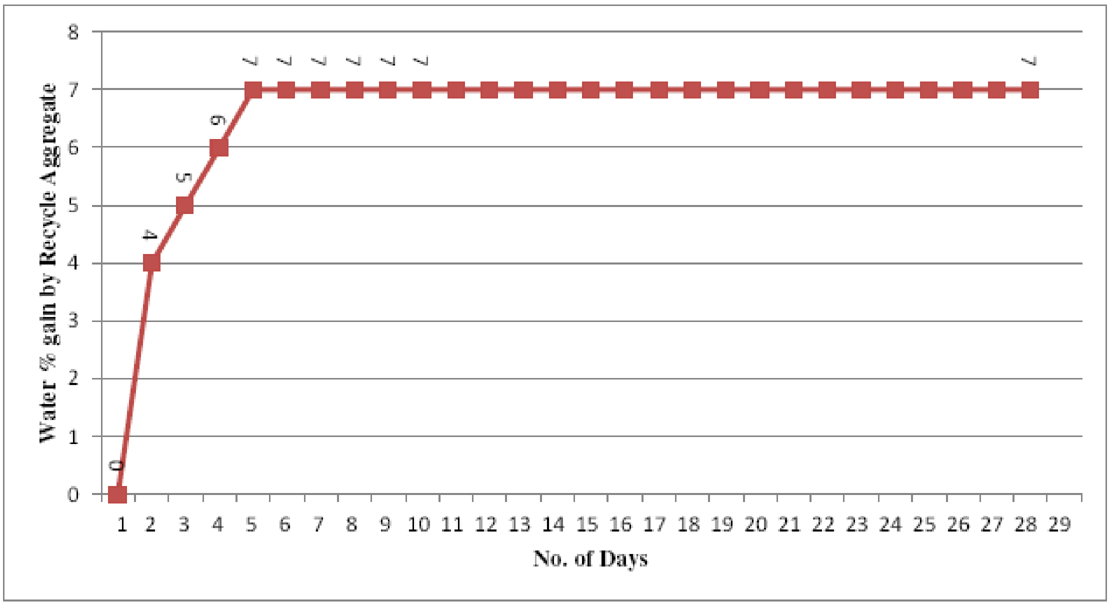

Figure No. 2.16: - Water absorption by Recycled aggregate from 1 to 28 Days

2.2. COST ANALYSIS

Table 2.2.1- Cost analysis for per cubic meter of controlled concrete

Sr. No.	Item	Weight (kg/m^3)	Rates Rs. /kg	Cost (Rs/m^3)
1.	Cement	530	5.300	2809.000
2.	River sand	532	5.000	2660.000
3.	Coarse Aggregate	1236	1.400	1730.400
4.	Plasticizer	3.71	57.000	211.470
Total=				**7410.870**

Table 2.2.2- Cost analysis for per cubic meter of modified concrete(G5RA20)

Sr. No.	Item	Weight (kg/m^3)	Rates (Rs/kg)	Cost (Rs/m^3)
1.	Cement	503.500	5.300	2668.550
2.	River sand	532.000	5.000	2660.000
3.	Coarse Aggregate	988.800	1.400	1384.320
4.	Glass Powder	026.500	0.500	13.250
5.	Recycled Aggregate	247.200	0.300	74.160
6.	Plasticizer	004.240	57.000	241.680
Total=				**7041.960**

Table 2.2.3- Percentage change in cost (Rs./m3)

Concrete Mix	Cost (Rs. $/m^3$)	Decrease in cost (%) with respect to controlled concrete
Controlled concrete	**7410.870**	
Modified concrete (G5RA20)	**7041.960**	**4.98%**

Table 2.2.4- Cost analysis for per cubic meter of modified concrete(G10RA20)

Sr. No.	Item	Weight (kg/m^3)	Rates (Rs/kg)	Cost (Rs/m^3)
1.	Cement	477.000	5.300	2528.100
2.	River sand	532.000	5.000	2660.000
3.	Coarse Aggregate	988.800	1.400	1384.320
4.	Glass Powder	053.000	0.500	26.500
5.	Recycled Aggregate	247.200	0.300	74.160
6.	Plasticizer	004.240	57.000	241.680
Total=				**6914.760**

Table 2.2.5- Percentage change in cost (Rs./m3)

Concrete Mix	Cost (Rs. $/m^3$)	Decrease in cost (%) with respect to controlledconcrete
Controlled concrete	**7410.870**	
Modified concrete (G10RA20)	**6914.760**	**6.69%**

Table 2.2.6- Cost analysis for per cubic meter of modified concrete(G20RA10)

Sr. No.	Item	Weight (kg/m^3)	Rates (Rs/kg)	Cost (Rs/m^3)
1.	Cement	424.000	5.300	2247.20
2.	River sand	532.000	5.000	2660.000
3.	Coarse Aggregate	1112.40	1.400	1557.360
4.	Glass Powder	106.000	0.500	53.000
5.	Recycled Aggregate	123.600	0.300	37.080
6.	Plasticizer	004.240	57.000	241.680
Total=				**6796.32**

Table 2.2.7- Percentage change in cost (Rs./m3)

Concrete Mix	Cost (Rs. $/m^3$)	Decrease in cost (%) withrespect to controlled concrete
Controlled concrete	**7410.870**	
Modified concrete (G20RA10)	**6796.320**	**8.29%**

3. Conclusions and Future scope

3.1. DISCUSSION

Literary sources provide no information about the chemical influence of glass powder & Recycled Aggregate in the process of hardening, especially in its early pre-induction hydration period – the period which considerably conditions the cement stone structure formation and its properties. It is well known that glass is a material with an amorphous structure, characterized by a large supply of free energy. The glass powder that has been used in our investigations– contains approximately 11% of Na_2O and K_2O. In the glass structure the ions of these metals have considerably less binding energy as compared to the covalent bond of Si-O in the structural fragment of Si-O - +Na or Si-O - +K. In water solution Na+ and K+ ions are easily diffused fromthe glass to the solution and form sodium and potassium hydroxides in the solution, correspondingly. They are displaced by H+ ions from the water and thus hydrate the surfaces of glass grains. This is a so called ion-exchange mechanism of interaction between glass and water. Since the area of glass grain surface is very large, comparable to the area of cement grain surface,ionic exchange is very active. In our opinion, it is connected with high content of SiO_2 in the glass (near 70 %), which results in the formation of calcium hydro silicate (CSH), as shown in chemical reactions:

2 $(3CaO.SiO_2)$ $+6H_2O$ = 3 Co. $2SiO_2.3H2O+3Ca(OH)_2$

(Tricalcium Silicate) (Calcium Silicate Hydrate) (Calcium Hydroxide)…. (1)$3Ca(OH)_2 + SiO_2 + (n-1) H_2O = CaO.SiO_2.nH_2O$

(Calcium hydroxide) (Glass) (Calcium Silicate Hydrate)…. (2)

As a result of reaction (1) the amount of calcium hydroxide in the cement solution decreases. Consequently, the alkalinity of solution with glass powder additives decreases as well and additional amount of CSH crystal phase in a cement stone is formed. It has been established that the addition of finely ground glass to portl and cement or to portl and cement based concrete accelerates the binding process during pre-induction periods of hydration (2–4 min.) but retards it during after-induction period. However, this does not affect the mechanical strength of the concrete samples after the first day of hardening. The strength of samples with glass is higher as compared to the control samples, because, as has been stated above, glass additives modify the cement stone structure

The strength of concrete is no more affected by the addition of recycled aggregate.

3.2. CONCLUSION

Glass Powder & Recycled Aggregate withstand under any aggressive environment and climatic conditions because of balanced combined physical and chemical properties. In this project flexural strength & cost of modified concrete and controlled concrete is compared. From the observations of test results following conclusions are drawn:

1. When we increase glass powder and recycled aggregate in a range of 5-10%, there is no appreciable increase in the flexural strength in beam specimen, but when the range is 10-15%, there is an appreciable change at a very high rate in flexural strength. Then as we increase the percentage of glass powder and recycled aggregate from 15-20%, then initially flexural strength start from higher level and increase as further 5% variation. Further Increase in glass powder and recycled aggregate percentage, lowers down the flexural strength very considerably and it ends at the flexural strength level, which was arrived at 5% replacement of glass powder and recycled aggregate.
2. Precisely on our experimental study basis 5% glass powder with 20% recycled aggregate, 10% glass powder& 20% recycled aggregate and 20% glass powder with 10% recycled aggregate) provides higher flexural strength hence these combinations of glass powder and recycled aggregates can be considered.
3. Cost per cubic meter of modified concrete is reduced by 4.98% with (5% glass powder &20% recycled aggregate) &6.69% with (10% glass powder& 20% recycled aggregate)& 8.29% with (20% glass powder and 10% recycled aggregate) of controlled concrete.
4. Workability of concrete slightly decreased with increase in percentage of recycled aggregate because recycled aggregate initially absorbs more quantity of water.
5. Water cement ratio is not getting affected as recycled aggregate is fixed at 20% and the ultimate effect of glass powder & recycled aggregate is constant (from the water cement ratio point of view).
6. Initial rate of gain of strength of concrete is low, but at 28-days it meets with the required strength in addition of glass powder and recycled aggregate.
7. Use of glass powder helps in reduceing the use of cement in concrete and leading for reduction in pollution.

8. Use of recycled aggregate in concrete can save the natural source of stone and also produces a greener concrete for construction.
9. Environmental effects of waste and residual amount of cement manufacturing can be reduced.

6.3. FUTURE SCOPE

It is recommended for future studies that the research on the use of glass powder is required to extend to a wider perspective in order to know the actual behavior and effective utilization of glass powder which gives an idea to study more parameters and different governing effect of glass powder on engineering properties of fresh and hardened concrete. Hence, future work can be extended as follows

- This project can be extended to find out the modulus of elasticity of modified concrete.
- To know the effect of different type of glass powder on concrete strength.
- Effect of glass powder on high strength concrete.
- Effect of glass powder on strength of concrete with various w/c ratios.
- Effect of glass powder on strength of concrete with combination of glass powder withdifferent strengthening agent.
- To know the exact reason behind the increment in strength of concrete.
- To know the effect of glass powder on the bond strength between inter-materials and between materials and steel.
- To determine the Durability of concrete.

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