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STUDY ON GLASS POWDER AS PARTIAL REPLACEMENT OF CEMENT IN CONCRETE BY USING SILLICAFUME

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***ABSTRACT**-The global warming is induced by the emission of greenhouse gases, such as CO_2, to the atmosphere. Among the greenhouse gases, CO_2subscribes about 65% of global warming. The global cement industry contributes about 7% of greenhouse gas emission to the earth's atmosphere. In order to address environmental effects affiliated with cement manufacturing, there is a need to develop alternative binders to make concrete. Consequently spacious research is on going into the use of cement replacements, using many waste materials and industrial by products. Efforts have been made in the concrete industry to use waste glass as partial replacement of coarse or fine aggregates and cement. . In this examine, finely powdered waste glasses are used as a partial replacement of cement in concrete and compared it with conventional concrete. This work extensive study the possibility of using Glass powder as a partial replacement of cement for new concrete.M_{30} grade concrete was used. Glass powder was partially replaced as 5%, 10%, 20% and 30% and tested for its compressive, Tensile and flexural strength up to 30 days of age and were compared with those of conventional concrete,and silica fume used from the results attained, it is found that glass powder can be used as cement replacement material upto particle size less than 75µm to prevent alkali silica reaction.*

***Key words**: Glass, recycling, alkali-silica reaction.*

I. INTRODUCTION

The demand in the manufacturing ofconcrete is increasing day by day, the utilization of river sand as fine aggregate leads to study of natural resources, lowering of water table, sinking of the bridge piers, etc as a common treat. Experiments has been made in using crushed glass as fine aggregate in the replacement of river sand .The crushed glass was used as coarse aggregate in concrete production but due to its flat and elongated nature which enhances the decrease in the workability and allocated the drop in compressive strength.

Glass is unformed material with high silica content, thus making it potentially pozzolanic when particle size is less than 75µm. Studies have shown that finely ground glass does not contribute to alkali – silica reaction. In the recent, various efforts and research have been made to use ground glass as a replacement in conventional constituents in concrete production as a part of green house management. A major pertain regarding the use of glass in concrete is the chemical reaction that takes place betweenthe alkali in pore solution of concrete and the silica – rich glass particle, which is called Alkali – Silicate reaction can be very detrimental to the stability of concrete, unless appropriate precautions are taken to minimize its effects. ASR(alkali-silica reaction) can be prevented or reduced by adding mineral admixtures in the concrete mixture, common mineral admixtures used to minimize ASR are grained fuel ash (PFA), metkaolin (MK) and silica fume(SF). A number of studies have proven the restraining ability of these materials on ASR(alkali-silica reaction).

II. EXPERIMENTAL INVESTIGATION

Experiment were guided on concrete prepared by partial replacement of cement by waste glass powder of particle size 75µm.The the waste glass powder was replaced by 5%, 10%, 20% and 30% of the binder and the mix design was prepared. The physical and chemical characteristic was examined and the chemical components of the glass powder used in the concrete.

CEMENT

Concrete involves huge amount of consumption of cement depending on the grade of concrete. Cement is an important construction constituent produced in virtually all countries. Carbon dioxide (CO_2) is a byproduct of a chemical conversion procedure used in the production of clinker, a component of cement, in which limestone ($CaCO_3$) is converted to lime (CaO).

$$\mathbf{CaCO_3 + heat \longrightarrow CaO + CO_2 \quad \ldots\ldots\ldots \quad (1.1)}$$

CO_2 is also emitted during cement production by petrifaction fuel combustion. The usage of mass quantity of cement leads to consumption of huge naturalresources (i.e., lime) and also involves emission of CO_2 increase. It is reported that production of one M.T. of cement releases one M.T. of CO_2 which leads to global warming. Nearly 5- 8 % of the world's manmade greenhouse gas emissions from the cement industry.

FINE AGGREGATE: Well graded natural river sand passing through 4.75mm sieve was used. Specific gravity was found to be 2.65.

COARSE AGGREGATE: Crushed aggregate is a maximum size of 20 mm and normal grading. The specific gravity of the coarse aggregates of 2.73 was used. The sieve analysis of coarse and fine aggregates is confirmed to IS10262.

GLASS POWDER:

Glass is an amorphous & transparent material, which is super-cooled liquid and not a solid.Glass can be made verity of forms and sizes from small fiber to meter-sizes pieces.Primarilyglass is produced by melting a mixture of materials such as silica, $CaCO_3$, andsoda ash at high temperature followed by cooling during which solidification occurs without crystallization.Glass has been used as aggregates in road construction,masonry and building materials.Before adding

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glass powder in the concrete it has to be powdered towanted size.Glass powder is obtained from Crushing of glass Pieces.

Crushing of glass piece using Los Angeles Machine

Glass powder can be used as cement replacement material upto particle size less than 90µm

Fig: glass powder

The Physical and Chemical properties of glass powder are shown in following tables.

S.NO	PHYSICAL PROPERTIES OF GLASS POWDER	
1	Specific gravity	2.6
2	Finess passing 150µm	99.5
3	Finess passing 90µm	98

Table:Physical properties

S.NO	PHYSICAL PROPERTIES OF GLASS POWDER	
1	pH colour	10.25
2	colour	Grayish white

Table: Chemical properties

Chemical Composition of cement and Glass Powder is as shown in below.

S.O	PROPERTIES	WATER GLASS POWDER(GLP)	CEMENT
1	SiO_2(%)	70.22	23.71
2	CaO(%)	11.13	57.27
3	MgO(%)	-	3.85
4	Al_2O_3(%)	1.64	4.51
5	Fe_2O_3(%)	0.52	4.83
6	SO_3(%)	-	2.73
7	Na_2O(%)	15.29	-
8	K_2O(%)	--	0.37
9	Cl (%)	-	0.0068
10	Loss on ignition (%)	0.80	7.24

Table : Composition of cement and Glass Powder

SILICA FUME:

Silica fume is highly reactive pozzolanic substance and is a byproduct from the production of silicon or ferro- silicon metal. It is composed from the flue gases from electric arc furnaces. Silica fume is very fine powder, with particles about 100 times minor than average cement grain. It is available in a water slurry form. It is used at 5% to 12% by mass of supplementary cementitious materials for concrete structures that requires high strength.

Fig: Silica fume

The uses of glass in concrete is the chemical counteraction that takes place between the alkali in pore solution of concrete and thesilica – rich glass particle, which is called Alkali – Silicate reaction.ASR can be prevented or reduced by adding mineral admixtures are in the concrete mixture, common mineral admixtures used to minimize ASR(alkali-silica reaction)is silica fume(SF).

Chemical Composition of silica fume is shown in table:

CHEMICAL COMPOSITION	PERCENTAGE
SiO_2	9403
Al_2O_3	0.09
Fe_2O_3	0.10
CaO	0.30
MgO	0.43
SO_3	-
K_2O	0.83
Na_2O	0.27

Table :Composition of silica fume

CONCRETE MIX DESIGN:

Mix design for M_{30} grade of concrete was prepared by using the guidelines of IS: 10262-2009 (Recommended Guidelines for Concrete Mix Design).

The mix proportion of the material is 1:1.51:2.39 and the water to cement ratio is 0.45.The replacement levels of cement, glass powder were used in terms of 5%, 10%, 20% and 30% in concrete. Silica fume is used as admixture.

CASTING OF CONCRETE SPECIMENS:

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The test moulds are kept ready beforepreparing the mix. The bolts of the moulds are tightened carefully because if not kept tight the concrete slurry may come out of the mould when compaction process takes place. Then moulds are cleaned and oiled on all contact surfaces and concrete is filled into moulds in 3 different layers and blows(25)must be given to each layer. The top surface of concrete is struck off level with a trowel. The identification number and date of casting are put on the top surface of the cubes and cylinders. CastedCubesand cylinders are de-molded after 24 hours and kept for curing.

COMPRESSIVE STRENGTH OF CONCRETE

The bottom of the concrete cube is placed on the platform of the compression testing machine. The load is applied gradually till the concrete cube gets failed. The corresponding reading is noted which gives the compressive strength of that cube. Similarly the compression strength values of all cubes are found.

For each mix cubes of size 100mm were cast to determine the compressive strength using a 200T capacity Compression Testing Machine (CTM). Tests were carried out a different ages on 28days. Tests were conducted as per IS 516-1959

Compressive strength = P/A

Where,

P = Ultimate load in N

A = Area of the cube inmm^2

SPLIT TENSILE STRENGTH OF CONCRETE

The concrete cube is placed diagonally on the platform of the compression testing machine. The load is applied gradually till the concrete cubes get failed. The corresponding reading is noted which gives the compressive strength of that cube. Similarly the compressive strength values of all the cubes are found. All the compressive strength and the split tensile values are noted and tabulated.

For each mix three cubes of size 100mm were cast to determine the split tensile strength. The specimens were tested in a 200T capacity Compression Testing Machine (CTM). Tests were carried out on 28days. Tests were conducted as IS 516-1959.

Tensile strength = 0.52 P/A

Where,

P = Ultimate load in N

A = Area of the cube in mm^2

4 FLEXURAL STRENGTH OF CONCRETE

Calculation of the flexural strength of the specimen shall be expressed as the modulus of rupture f_b which if 'a' equal the distance between the line of fracture and the nearer support, measured on the center line of the tensile side of the specimen in cm, shall be calculated to the nearest 0.05 MPa as follows:

$f_b = P*l/(b*d^2)$

when 'a' is greater than 20 cm for 15 cm specimen, or greater than 13.3 cm for a 10·0 cm specimen, or

$f_b = (3p*a)/(b* d^2)$

when 'a' is than 20 cm but greater than 17 cm for 15 cm specimen, or less than 13·3 cm but greater than 11 cm for a 10 cm specimen

where,

d = measured depth in cm of the specimen at the point of failure,

b = measured width in cm of the specimen,

l = length in cm of the span on which the specimen was supported, and

p = maximum load applied to the specimen in kg

If 'a' is less than 17 cm for a 15 cm specimen, or less than 11 cm for a 10 cm specimen, the results of the test shall be discarded.

RESULT AND DISCUSSION:

1) **Compressive strength:**

The test was carried out conforming to IS 516-1965 to obtain compressive strength of concrete at the age of 28 days. The specimens(cubes) were tested using compression testing machine (CTM) 2000 kN.

MIX	% REPLACEMENT OF GLASS POWDER	AVERAGE COMPRESSIVE STRENGTH AT 28 DAYS (N/mm^2)
G1	0	37.42
G2	5	42.60
G3	10	44.91
G4	20	41.74
G5	30	38.71

2) **Tensile strength:**

The test was carried down conforming to IS 516-1959 to obtain split tensile strength of concrete at the age of 28 days. The cylinders were tested by using compression testing machine (CTM) of capacity 2000Kn.

MIX	% REPLACEMENT OF GLASS POWDER	AVERAGE TENSILE STRENGTH AT 28 DAYS(N/mm^2)
G1	0	2.28
G2	5	2.36
G3	10	2.49
G4	20	2.51
G5	30	2.44

3) **Flexural strength:**

. The test was carried down conforming to IS 516-1959 to obtain Flexural strength of concrete at the age of 28 days. The prisms were tested using flexural testing machine.

MIX	% REPLACEMENT OF GLASS POWDER	AVERAGE FLEXURAL STRENGTH AT 28 DAYS(N/mm^2)
G1	0	4.21
G2	5	5.08
G3	10	5.76
G4	20	5.21
G5	30	5.63

CONCLUSION:

Conventional concrete demonstrate at 28 days compressivestrength as 37.42 N/mm^2, split tensile strength of2.28N/mm^2 and flexural strength of 4.21N/mm^2

1. Replacement of glass powder in cement by 5%,10%, 20%and 30% increases the compressive strength by 12.15%,16.6%, 10.34% and 3.32% respectively.
2. Replacement of glass powder in cement by 5%,10%, 20%and 30% increases thesplit tensile strength by 3.38%, 8.01%, 9.52% and 6.55% respectively
3. Replacement of glass powder in cement by 5%,10%, 20%and 30% increases theflexural strength by 17.12%,26.90%, 32.20% and 25.22% respectively.
4. Glass powder concrete by using silica fume increases the compressive,tensile and flexural strength effectively, when comparedwith the conventional concrete.

REFERENCES:

Journal Papers:

[1] Aimin Xu and Ahmad shayam, "Value – added utilization of waste glass in concrete", Cement and concrete research, vol.34,81-89,2004.

[2] Carpenter,A.J. and Cramer,C.M, " Mitigation of ASR in pavement patch concrete that incorporates highly reactive fine aggregate", Transportation Research Record 1668, Paper No. 99-1087,pp.60- 67,1999.

[3] Chi sing lam, chi sun poon and Dixon chan, " Enhancing the performance of pre – cast concrete blocks by incorporating waste glass – ASR consideration", Cement and concrete composites, vol: 29pp, 616-625,2007.

[4] Christopher cheeseman, " Production of sintered light weight aggregate using waste ash and other industrial residues", Belgium, 2011.

[5]Federio.L.M and Chidiac S.E, " Waste glass as a supplementary cementitious material in concrete – Critical review of treatment methods", Cement and Concrtet Composites, vol,31,606-610,2001.

[6]Idir.R,Cyr.M and Tagnit – Hamou.A, " Use of waste glass as powder and aggregate in cement based materials", SBEIDCO – 1st international Conference on Sustainable Built Environment Infrastructures in Developing Countries ENSET Oran (Algeria) – October 12-14, 2009.

[7]IIkerbekirtopcu and mehmetcanbaz, " Properties of concrete with glass
", Cement and Concrete Research, vol:34,267-274,2004.

[8]. Jin.W, Meyer.C, and Baxter.S, "Glasscrete – Concrete with glass aggregates", ACI Materials Journal, vol. 97.pp. 208-213, 2000.

[9]Mageswari.L.M and B.Vidivelli, " The use of Sheet Glass Powder as Fine Aggregate Replacement in Concrete", the open Civil Engineering Journal, vol:4,65-71, 2010.

[10]MalekBatayneh, Iqbal Marie, Ibrahim Asi, " Use of Selected waste Materials in Concrete Mixes", Waste Management, vol. 27, 2007.

[11] Narayanan Neithalath and Nathan Schwarz, " Properties of Cast – in – Place Concrete and Precast Concrete Blocks Incorporating Waste Glass Powder", The open Construction and Building Technology Journal, vol:3,42-51, 2009.

[12] Pereira de Oliveira. L.A, J.P. castro – Gomes, P. Santos, " Mechanical and Durability Properties of concrete with Ground waste Glass Sand", International conference on durability of Building Materials and components, Turkey, 2008.

[13]Samtur.H.R, " Glass Recycling and Reuse," university of Wisconsin, Madison Institute for Environmental Studies, Report No.17, March 1974.

[14] Seung Bum Park and Bong-Chum Lee, " studies on expansion properties in mortar containing waste glass and fibers", Cement and concrete Research, vol:34,1145-1152, 2004.

Books:

[1] M.S.Shetty, "*Concrete Technology Theory and Practice*" (S.Chand and Company Ltd. New Delhi, 2006).

[2] M.L.Gambhir, "*Concrete Technology*", (Tata McGraw-Hill Publishing Company Limited, New Delhi, 2006).