International Journal of Emerging Engineering Research and Technology
Volume 2, Issue 2, May 2014, PP 205-208

Experimental Studies on Replacement of Fine Aggregate with Glass and Fly Ash

M.S.Kuttimarks[1], R.Shruthi[2]
[1]Assistant Professor, [2](BE-Student, Department of Civil Engineering, Sree Sastha Institute of Engineering and Technology, Chennai-123
kuttimarkskmpm@gmail.com

Abstract: *This paper deals with the replacement of fine aggregate by crushed or finely ground glass particles. Concrete can be stated as a building material made from a mixture of broken stone or gravel, sand, cement, and water, which can be spread or poured into moulds and forms a stone-like mass on hardening and this mixture can also be altered by some means. This can also be termed as glass culets by some proportions say 10%, 15% and 20% respectively. The alkali silica reaction minimized by usage of glass cullet's in fly ash. In this study and experiment it was proposed that the use fly ash as cement replacement material and glass aggregate as fine aggregate material partially in concrete. Compressive strength of concrete cubes at 7, 14, and 28days of duration were studied. Based on the test results, the ideal percentage of mix which shows maximum compressive strength was identified.*

Keywords: *Alkali silica reaction, Glass cullets, Fly ash, Compressive strength*.

1. INTRODUCTION

Indian construction industries is facing major issue in the emission of co_2 and it may be due to various reasons like combustion, energy use, demolition and usage of materials etc.,It can be minimized by using alternate resources which will be eco friendly and it helps in utilizing waste products for construction process. All the materials required to produce such a huge quantity of concrete come from the earth's crust. Thus, it depletes its resources every year creating ecological strains. Recent technological development has shown that the waste solid materials are valuable as inorganic and organic resources and can be used to produce various useful products. Industrial wastes, wood pulp, Slag, glass pieces can be used as alternate resources instead of fine aggregate and cement. The challenge for the civil engineering community in the near future is to realize projects in harmony with the concept of sustainable development and this involves the use of alternate or recyclable materials and products manufactured at reasonable cost with the lowest possible environmental impact. The utilization of solid wastes in construction materials is one of such innovative efforts.

1.1. Glass Concrete

Glass materials are recyclable for many number of times but when it reaches a stage were further it cannot be recycled anymore it can be utilized as a alternate for fine aggregate in the concrete production. Glass pieces are crushed down to smaller sizes that compensate the size of fine aggregate. A major concern regarding the use of glass in concrete is the chemical reaction that takes place between silica-rich glass particles and the alkali in the pore solution of concrete, i.e., alkali-silica reaction. This reaction can be very detrimental to the stability of concrete, unless appropriate precautions are taken to minimize its effects. Such preventive actions could be achieved by incorporating a suitable Pozzolonic material such as fly ash, silica fume, or ground blast furnace slag in the concrete mix at appropriate proportions. Glass is an ideal material for recycling. The use of recycled glass in new container helps save of energy. When waste glasses are reused in making concrete products, the production cost of concrete will go down. However, deleterious alkali-silica reaction might occur in glass concrete due to its high silica constituent. Some solutions have been formed to alleviate alkali-silica reaction, but these solutions have some limitations which made it still particularly important to investigate the utilization of glass in concrete. The limitations include the long-term inspecting of the effectiveness of alkali-silica reaction suppressants.

1.2. Alkali Silica Reaction

Fig 1. *Effects of Alkali-Silica reaction*

The ASR reaction is the same as the pozzolanic reaction, which is a simple acid-base reaction between calcium hydroxide, also known as Portlandite, or (Ca (OH) $_2$), and silica (H_4SiO_4, or $Si(OH)_4$). For the sake of simplicity, this reaction can be schematically represented as following:

$$Ca(OH)_2 + H_4SiO_4 \rightarrow Ca^{2+} + H_2SiO_4^{2-} + 2\ H_2O \rightarrow CaH_2SiO_4 \cdot 2\ H_2O$$

This reaction causes the expansion of the altered aggregate by the formation of a swelling gel of calcium silicate hydrate (C-S-H). This gel increases in volume with water and exerts an expansive pressure inside the material, causing spalling and loss of strength of the concrete, finally leading to its failure.

1.3. Fly Ash

The inclusion of fly ash in glass fiber reinforced concrete reduces the environmental pollution and improves the workability and durability properties of concrete. In the present experimental investigation glass fibers in different volume fractions with10%, 15% &20%replacement of cement by fly ash has been used to study the effect on compressive strength of the concrete. For each mix standard sizes of cubes were cast and tested for compressive strength at age of 7days and 14 days as per Indian Standards.

2. TESTS ON MATERIALS

Course aggregates are particles greater than 4.75mm are also the raw materials that are an essential ingredient in concrete. Coarse aggregate can also be described as gravel, crushed rock, rocks or stones.

Gradation test is mainly done by Sieve analysis. Sieve analysis is conducted to determine the particle size distribution in a sample of aggregates. Grading pattern of a sample of coarse aggregate is assessed by sieving all the samples successively through a set of sieves mounted one over the other in the order of size by keeping the larger sieve on the top. Specific gravity is the ratio of the density of a substance to the density (mass of the same unit volume) of a reference substance. The fineness modulus values were determined by using Pycnometer.

Table 1. *Sieve Analysis of Fine Aggregate*

Sl.NO	IS. Sieve Size (mm)	Quantity Retained (gm)	% Retained	Cumulative Percentage Retained	Cumulative Percentage Passing	Limits for Zone - II (IS: 383-1987)
1	10.000	000	00.00	000.0	100.0	100
2	04.750	008	00.80	000.8	099.2	90 – 100
3	02.360	045	04.50	005.3	094.7	75 – 100
4	01.180	243	24.30	029.6	070.4	55 – 90
5	00.600	274	27.40	057.0	043.0	35 – 59
6	00.300	340	34.00	091.0	009.0	8 – 30
7	00.150	090	09.00	100.0	000.0	0 – 10

2.1. Setting Time Test for Flyash

Table 2. *Sieve analysis test on coarse aggregate*

Sieve size in (mm)	TRIAL I			TRIAL II			Avg % passed
	Cumulative wt (kg)	% RETAINED	% PASSED	Cumulative wt (kg)	% RETAINED	% PASSED	
31.5	0.000	0	100.0	0.000	00.0	100.0	100.00

25.0	0.058	05.80	94.2	0.055	05.5	94.5	94.35
22.4	0.166	16.60	83.4	0.308	30.8	69.2	76.30
16.0	0.573	57.30	42.7	0.521	52.1	47.9	45.30

Take 400gms of fly ash and weigh it using a pan. Add .75% of water to the fly ash Prepare a paste and fill it in the vicats mould Finally its trimmed off to get a fine base The mould is kept under the apparatus & initially the plunger is passed through. After a visual direct observation when it gets hardened the plunger is again passed through & then the needle which shows the initial setting time of fly ash.

Fig 2. *Vicat Apparatus*

Fig 3. *Various IS sieves*

3. MIX PROPORTION

The mix design has been carried out for M40 grade of concrete as per the IS10262: 2009. Target mean strength for mix proportioning fck´ is 48.25N/mm^2 for the corresponding Water-Cement ratio of 0.45.

Table 3. *Mix ratio of materials*

Water (kg/m^3)	Cement (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)
144 lit	360	542.64	1077.18
0.40	1	1.5	3.0

4. COMPARISON OF RESULTS

The compression strength of concrete is one of the most important and useful properties of concrete. In most structural application, concrete is employed primarily to resist compressive stresses. In the cases where strength in tension or shear is of primary importance, the compressive strength is frequently used as a measure of this specimen. The specimens used for the test included concrete cubes of 150 mm x 150 mm x 150 mm for compression test. The cubes of were tested in compression testing machine. The cubes are tested on the sides without any packing between cube and steel platform of the testing machine. The load at which concrete cracks was recorded.

Fig 4.. *15% of glass replaced to sand*

Fig 5. *20% of glass replaced to sand*

Fig 6. *Compressive test on concrete*

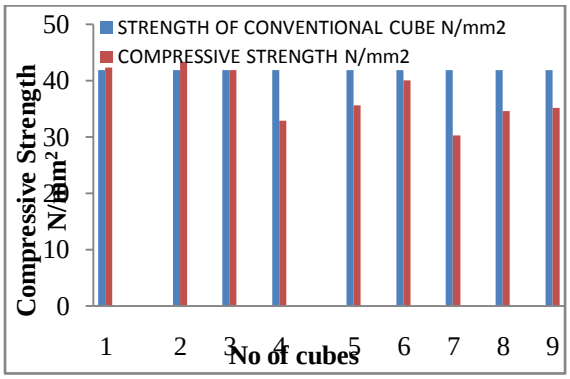

Fig 7. *Comparison of 7 days Compressive strength*

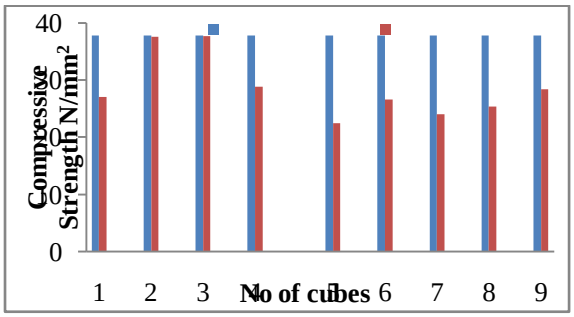

Fig 8. *Comparison of 14 days Compressive strength*

Table4. *Compressive Strength Test In 7 And 14 Days*

CUBE NOs (7^{th} day)	Conventional concrete (N/mm^2)	Glass cullet used concrete (N/mm^2)	CUBE NOs(14^{th} day)	Conventional concrete (N/mm^2)	Glass cullet used concrete (N/mm^2)
G1	41.78	42.22	G11	37.78	27.00
G2	41.78	43.33	G12	37.78	37.50
G3	41.78	41.78	G13	37.78	37.70
G4	41.78	32.89	G14	37.78	28.80
G5	41.78	35.56	G15	37.78	22.40
G6	41.78	40.00	G16	37.78	26.60
G7	41.78	30.20	G17	37.78	24.00
G8	41.78	34.60	G18	37.78	25.33
G9	41.78	35.11	G19	37.78	28.40

5. CONCLUSION

Here concluded several percentage replacement of glass for fine aggregate (10%, 15% and 20%) was done. In general there is compressive strength increase with 15% of glass aggregate and it appears to be true for the compressive strength test. The experimental study in total reveals a better performance with compressive strength. The compressive strength of concrete with 15% of replacement to river sand and 10% fly ash to cement shows the result of 43.33% in 14 days. Compressive strength of concrete cubes at 7, and 14 days of duration were studied. Based on the test results, the ideal percentage of mix which shows maximum compressive strength was identified.

REFERENCES

[1] Agarwal V.C., S.P. Gautam and Vikas Srivastava "Use of glass wastes as fine aggregate in Concrete" in Nov 2012.

[2] Frieda Christy C. and D. Tensing paper on "Effect of Class F Fly ash as partial replacement with cement and fine aggregate in mortar" in April 2010.

[3] Gunasekaran P., T.Phani Madhavi and V.Sampathkumar "Partial Replacement of Cement and Fine Aggregate by using Flyash and Glass Aggregate" in Nov 2013.

[4] IS 460(part I) - 1985 – "Specification for test sieves". Bureau of Indian Standards, New Delhi.

[5] IS 456:2000 "Codes of practice for plain and reinforced concrete". Bureau of Indian Standards, New Delhi.

[6] IS 10262:2009 "Recommended Guidelines For Concrete Mix Design". Bureau of Indian Standards, New Delhi.

[7] Dr.Ing.Carola Edvardsen COWI "Consulting Engineers and Planner AS Lyng" by, Denmark on Environmentally "Green" Concrete Structures in Oct 2001

[8] Iqbal Malik M., Muzafar Bashir, Sajad Ahmad, Tabish Tariq, Umar Chowdhary "Study of Concrete Involving Use of Waste Glass as Partial Replacement of Fine Aggregates" in july 2013.

[9] Jayeshkumar Pitroda, Rushabh A. Shah Paper on Fly Ash Class F: Opportunities for Development of Low Cost Mortar in march 2013.