INVESTIGATION ON BEHAVIOUR OF MSW GEOPOLYMER CONCRETE

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***Abstract*— *Concrete is the most versatile, durable and reliable construction material. Next to water concrete is the most used material, which requires large quantities of Portland cement. The use of Ordinary Portland Cement leads to the emission of Carbon dioxide, cause global warming and rise the atmospheric temperature. Then the major problem faced is disposal of municipal solid waste. In order to overcome the problem of emission of Carbon dioxide and land fill we have used Geopolymer concrete based on MSW ash. The concrete is made of MSW ash, fly ash, Sodium hydroxide, Sodium silicate, Fine aggregate, and Coarse aggregate. The Flyash, MSW ash, and activators such as Sodium hydroxide(NaOH) and Sodium silicate(Na2SiO3) are used as binder. The concrete is made with 20% and 30% replacement of MSW ash in total binder content. The grade chosen for the concrete is M30 and the activators is mixed for 14 molarity(14M). Various test was handled in laboratory and the strength of the concrete is discussed in this project.*

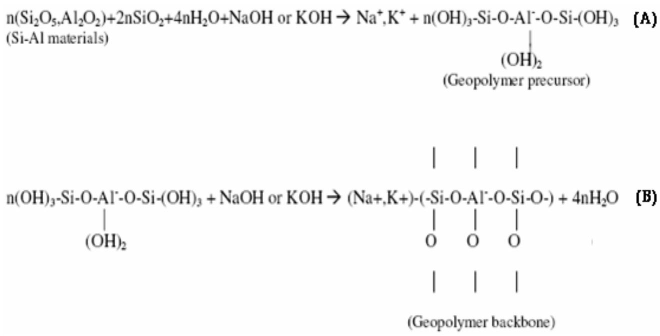
***Index Terms*— MSW. Concrete, Reduction of emission of CO_2, Geo-polymer concrete, Flyash, Innovative construction material.**

1. INTRODUCTION

Portland cement has been a very satisfactory hydraulic binder for structural applications for a long time now; however, there are many new issues stemming from its ever increasing use. Cement production consumes huge quantities of virgin materials, is energy-intensive, and leads to high emission of the greenhouse gas ie., CO_2. Again, Sulphur dioxide emission also can be very high, depending upon the type of fuel used. Installation of new cement plants is becoming increasingly capital-intensive. Finally, of late, many cement concrete structures have exhibited early distress and problems, which has an adverse effect on the resource productivity of the industry. „

Geopolymer Concrete‟ (GPC) is a type of inorganic polymer composite, which has recently emerged as a prospective binding material based on novel utilization of engineering materials. It has the potential to form a substantial element of an environmentally sustainable construction industry by replacing/supplementing the conventional concretes. GPC can be designed as high strength concrete with good resistance to chloride penetration, acid attack. Sulphate attacked. The geo-polymeric concretes are commonly formed by alkali activation of industrial alumino silicate waste materials such as fly ash (FA) and ground granulated blast furnace slag (GGBS), and have very small footprints of greenhouse gases when compared to traditional concretes. Because of possible realization of even superior chemical and mechanical properties compared to Ordinary Portland cement (OPC) based concrete mixes, and higher cost effectiveness.

The reaction of fly ash with an aqueous solution containing Sodium Hydroxide and Sodium Silicate in their mass ratio, results in a material with three dimensional polymeric chain and ring structure consisting of Si-O-Al-O bonds,



2. PRELIMINARY AND EXPERIMENTAL INVESTIGATIONS

2.1 General

This chapter explains about the practical of the progress in our project such as preliminary examination of materials like specific gravity, Sieve analysis, Liquid and Plastic limit. Also properties and specifications of material using such as clay, orange peel, eggshell, quarry dust and limestone powder were illustrated and studied detailed.

2.2. Materials used

1) Flyash
2) GGBS
3) Coarse aggregate

4) Fine aggregate
5) sodium Hydroxide
6) Silicate solution
7) MSW As

2.3 Properties and Investigations

1. Fly ash

TABLE 1
COMPOSITION OF FLYASH

Chemical properties % by mass	Flyash
$SiO_2+Al_2O_3+Fe_2O_3$	90.5%max
SiO_2	58% max
CaO	3.6% min
SO_3	1.8% min
Na_2O	2% max
L.O.I	2%min
MgO	1.91% min

2. Fine aggregate

The Specific gravity test and finesse modulus test for sand was done using pycnometer and sieve respectively in laboratory, the fine aggregate which was used is concluded as ZONE II

TABLE 2
SPECIFIC GRAVITY TEST ON FINE AGGREGATE

Weight	Kg
w_s	0.1
W_{bw}	1.520
w_{bsw}	1.580
Specific gravity	2.5

Specific gravity $G = W_S/W_W$

$W_W = W_S+W_{BW}-W_{BSW}$

$G = 0.1/0.04$

$= 2.5$

TABLE 3
FINESS MODULUS OF FINE AGGREGATE

IS Sieve	Weight of soil retained (g)	Cumulative weight retained (g)	Soil retained as %	Soil passing percentage
4.75 mm	002.96	002.96	00.296	99.704
2.36 mm	021.62	024.58	02.458	97.542
1.18mm	240.00	264.58	26.458	73.540
600 micron	410.00	644.58	64.458	35.542
300 micron	305.00	979.58	97.958	02.050
180 micron	016.20	995.78	99.578	00.430
150 micron	001.41	997.19	99.719	00.281
90 micron	001.44	999.63	99.963	0.137
75 micron	000.43	999.06	99.906	0.044
Pan	000.94	1000.00	100.000	0

3. Coarse aggregate

The Specific gravity test and finesse modulus test for sand was done using pycnometer and sieve respectively

TABLE 4
SPECIFIC GRAVITY TEST ON COARSE AGGREGATE

Weight	Kg
w_s	0.2
W_{bw}	1.480
w_{bsw}	1.610
Specific gravity = 0.04	2.85

Specific gravity G $= W_S/W_W$

W_W $= W_S + W_{BW} - W_{BSW}$

= 0.07

G = 0.2/0.07 = 2.85

TABLE 5
FINESS MODULUS OF COARSE AGGREGATE

IS Sieve	Weight of aggregate retained (kg)	Cumulative weight retained (kg)	Aggregate retained as %	Passing percent age
40mm	0.000	0.000	0.000	100
25mm	0.025	00.025	00.17	99.83
20mm	6.350	06.375	42.50	57.50
16mm	4.825	11.200	74.66	25.34
12.5 mm	3.365	14.565	97.10	02.90
10mm	0.230	14.795	98.63	01.37
6.3 mm	0.170	14.965	99.77	00.23
4.75 mm	0.002	14.967	99.78	00.22
Pan	0.040	15.000	100.00	00.00

3. MIX DESIGN AND REPLACEMENT RATIO

Unit weight of concrete = 2400 Kg/m^3
The aggregate occupies the largest volume (about 75 to 85% by mass) in GPC
The unit total volume occupy by the aggregate is assumed 77%

Max. of combined aggregate = 76/100*2400
= 1825 Kg/m^3

The grading of coarse aggregate = 70%(20mm)
= 70/100*1825
= 1277.5 Kg/m^3

The grading of fine aggregate = 30%
= 30/100*1825
= 547.5 Kg/m^3

Assume Alkaline liquids to binder ratio is 0.5
Assume Alkaline solution is 0.5 Kg/m^3
The total mass of flyash and Alkaline solution

= 2400-1825
= 0.2+1.480-1.610 = 575 Kg/m^3

Flyash and Alkaline solution = 1+0.5
= 1.5 Kg/m^3

Flyash = 552/1.5
= 383.33 Kg/m^3

Mass of Alkaline solution = 575-383.33
= 191.67 Kg/m^3

Sodium silicate and Sodium hydroxide solution to be 2.3 %

Sodium hydroxide solution = 191.67/ (1+2.3)
= 59.81 Kg/m^3

Sodium silicate solution = 191.67-59.81
= 136.9 Kg/m^3

TABLE 6
MIX PROPTION FOR M30 GRADE CONCRETE

Ingredients of geopolymer concrete	Fly ash	NaOH	Na_2SiO_3	Sand	Coarse aggregate
Quantity (kg/m^3)	383	59.81	136.9	547.5	1,277.5
Proportion	1	0.5		1.42	3.33

4. PREPARATION OF ALKALAI SOLUTION

In this paper the compressive strength of geopolymer concrete is examined for the mix of molarity of sodium hydroxide in 14M.The molecular weight of sodium hydroxide is 40. To prepare 14 molar sodium hydroxide solution, 560g of sodium hydroxide flakes are weighted and they can be dissolved in distilled water to form 1 lit solution. For this volumetric flask of 1 lit capacity is taken sodium hydroxide flakes are added slowly to distilled water to prepare 1-liter solution. The mixture of sodium silicate solution and sodium hydroxide solution forms the alkaline liquid. A combination of alkaline silicate solution and alkaline hydroxide solution was chosen as the alkaline liquid. Sodium-based solutions were chosen because they were cheaper than potassium- based solutions. The Alkali activator solution has to be prepared 24 hours advance before use. The Sodium hydroxide is available in small flakes and Sodium Silicate in crystal forms depending on the required solution of different morality has to be prepared.

5. MIXING AND CASTING OF CONCRETE

TABLE 7
REPLACEMENT PROPTION OF FLYASH

S.No.	Name	Flyash	MSW ash	Alkaline solution
1	A	100%	-	NaOH-14M
2	B	80%	20%	NaOH-14M
3	C	70%	30%	NaOH-14M

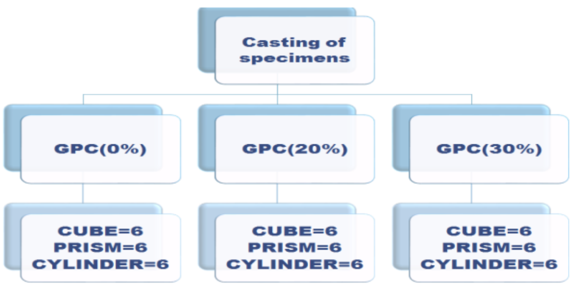
A - GPC, B - GPC(20%), C - GPC(30%), M - Molarity

5.1. Mixing of concrete

Thorough mixing of materials is essential for the production of uniform course. The mixing should ensure that the mass becomes homogeneous, uniform in colour and consistency. The mixing was done by hand mixing of coarse aggregate and cement, adding water at appropriate of mixing.

5.2. Casting and compaction of concrete

After mixing, the moulds are filled immediately by pouring the concrete inside manually by using trowel with three layers. Compaction of concrete is process adopted for expelling the entrapped air from the concrete. In the process of mixing, transporting and placing of concrete air is likely to get entrapped. Compaction is done here is manually with slump test rod in the way of dispersing the homogeneous mix to avoid entrapment of air. Not strong blows as for as for strong concrete is given, blows of 10-15 numbers are given for three layer. During compaction the strokes should be distributed in a surface of concrete, and should not forcibly strike the bottom of the mould. After the top layer has been compacted, a strike off bar is used to strike out the excess concrete. The finishing is done with the trowel by tapping the top surface.

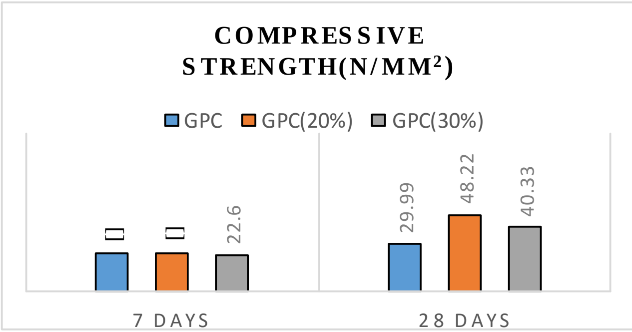


6. RESULT AND DISCUSSION

6.1. Compressive Strength Test

TABLE 8
COMPRESSIVE STRENGTH TEST RRESULT

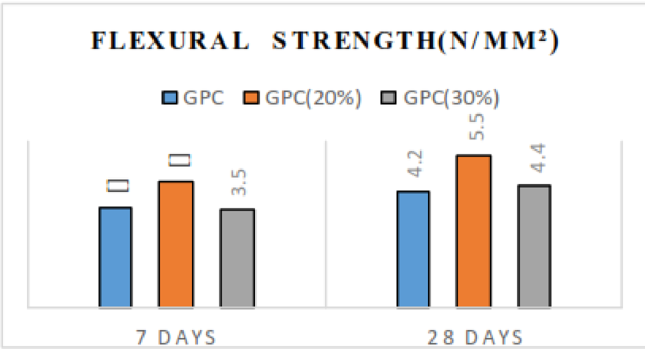
SL.NO	NAME	SPECIMENS	COMPRESSIVE STRENGTH(N/mm²)	
			7 DAYS	28 DAYS
1	A	GPC	23.50	29.99
2	B	GPC(20%)	24.18	48.22
3	C	GPC(30%)	22.6	40.33



6.2. Flexural Strength Test

TABLE 9
FLEXURAL STRENGTH TEST RRESULT

SL.NO	NAME	SPECIMENS	COMPRESSIVE STRENGTH(N/mm²)	
			7 DAYS	28 DAYS
1	A	GPC	3.6	4.2
2	B	GPC(20%)	4.5	5.5
3	C	GPC(30%)	3.5	4.4

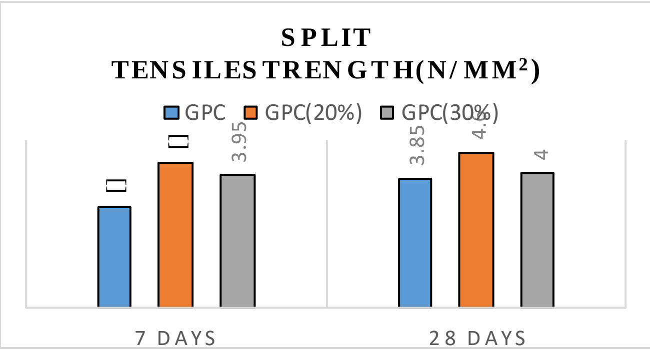


6.3. Split Tensile Strength Test

TABLE 10

SPLIT TENSILE STRENGTH TEST RRESULT

SL.NO	NAME	SPECIMENS	COMPRESSIVE STRENGTH(N/mm²)	
			7 DAYS	28 DAYS
1	A	GPC	3	3.85
2	B	GPC(20%)	4.3	4.6
3	C	GPC(30%)	3.95	4



7. CONCLUSIONS

- We conclude that, in our project we have successfully replaced Municipal solid waste ash up to 20% and 30% of fly ash content in Geopolymer concrete.
- The use of Municipal solid waste ash helps to stop the landfill which also destroys the soil.
- By keeping the concept of Geopolymer concrete, our project is applied. In our experimental project, we fixed the designation of M_{30} grade but we achieved about 48.22 N/mm² for 20% mix of MSW ash in Geopolymer Concrete in place of flyash.
- On increase in ratio of MSW ash in concrete the workability decreases
- At last, our concrete is eco-friendly and never emit any greenhouse gas while hydrating.

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