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Use of Plastic Granules in Geopolymer Concrete as a Partial Replacement of Fine Aggregate

Shubham Paymal[1], Saurabh Pawar[2], Shubhendu Kesarkar[3], Satish Bothikar[4] Swapnil Kurhade[5]

[1]B.E Civil Student of Pimpri Chinchwad College of Engineering Pune
[2]B.E Civil Student of Pimpri Chinchwad College of Engineering Pune
[3]B.E Civil Student of Pimpri Chinchwad College of Engineering Pune
[4]B.E Civil Student of Pimpri Chinchwad College of Engineering Pune
[5]Professor of Pimpri Chinchwad College of Engineering Pune

Abstract - *The basic reason behind selecting this topic is to reduce CO2 emission and reduce plastic pollution. As we know that concrete consist of cement as main constituent and while production of cement, CO2 is emitted thus contributing 7% of world CO2 emission. Globally there has been a growing demand for new construction material that low greenhouse gas emission. In geopolymer concrete there is no use of cement which will reduce the use of cement. As plastic takes very long time to degrade, which can have adverse effects on environment such as polluting soil and sea, death of animals. Use of plastic granules in this geopolymer concrete will help in reducing plastic pollution in environment.*

Key Words: **Fly ash, Geopolymer, Lightweight concrete, Recycled plastic Granules, Sodium Hydroxide, and Sodium Silicate**

1. INTRODUCTION

Geopolymer concrete is a type of concrete that is made by reacting aluminate and silicate bearing materials with a caustic activator. Commonly, waste materials such as fly ash or slag from iron and metal production are used, which helps lead to a cleaner environment. Plastic granules geopolymer concrete is an eco-friendly construction material which uses fly-ash and plastic granules (partially) instead of Ordinary Portland cement and fine aggregate respectively. The constituents of above concrete are fly-ash, aggregates, sand, plastic granules, alkaline activators, water. Use of above concrete reduces demand of Ordinary Portland cement which is responsible for emission of Carbon dioxide (CO2). The effects of replacement levels on the properties of the RPB geopolymer concrete were investigated. The mechanical properties of the RPB geopolymer concrete were determined. This study aims to contribute a deeper understanding on the utilization of RPB in the geopolymer products such as blocks /bricks and thus, reducing the amount of Portland cement used for environmental friendly purpose.

In this research paper we are going to compare the properties of geopolymer concrete containing plastic granules as a partial replacement of fine aggregate and fly ash with conventional concrete.

2. LITERATURE REVIEW FINDINGS

1. 16Malkaline solution gives high early strength.
2. Solution to binder ratio of 0.40 gives good bonding.
3. Oven curing must be done with optimum temperature of 60 ^{o}C for 24 hours.
4. Flow table test is recommended for workability test.
5. Alkaline activator is mainly responsible for strength of geopolymer concrete.
6. The optimum quantity of AAS is 200kg/m3.
7. Steam curing was done using steam tent which included thermocouples.
8. Internal temperature of steam tent was about 80 0C to maintain temperature about 60 0C.
9. The specimens were wrapped with thin vinyl sheet to avoid loss of water due to evaporation.
10. Test data show that the compressive strength of dry-cured geopolymer concrete is approximately 15% larger than that of steam-cured geopolymer concrete
11. Compressive strength of geopolymer concrete does not vary with the age of concrete in reference to curing i.e. curing must be done upto 24 hours max 48 hours more than that will not increase the strength.

3. Mix Proportion of Plastic granules geopolymer Concrete (PGGC) for 1 cubic meter

Table 1: Quantity of PGGC for 1 m^3

Material	Quantity(Kg/m^3)
Fly Ash	500
Water for solution	122.6
AA Solution	200
Mass of NaOH Solution	80
Mass of Na_2SiO_3 Solution	120

Mass of solid NaOH	36.4
Mass of solid Na_2SiO_3	41.4
Coarse Aggregate	1030.99
Fine Aggregate	480.25
Plastic granules	70.68

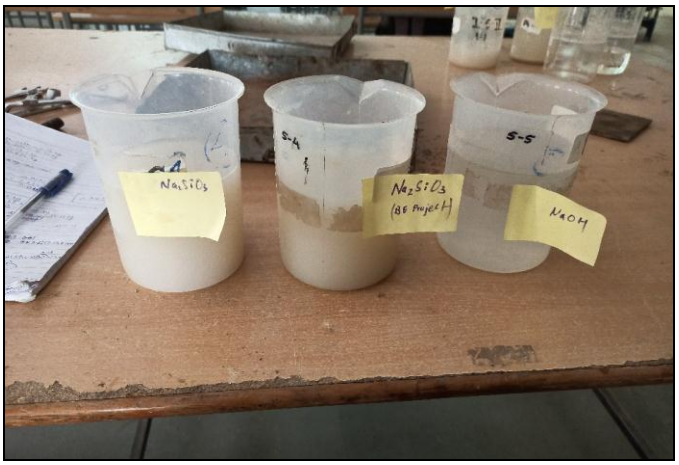

Figure 1: Prepared solutions

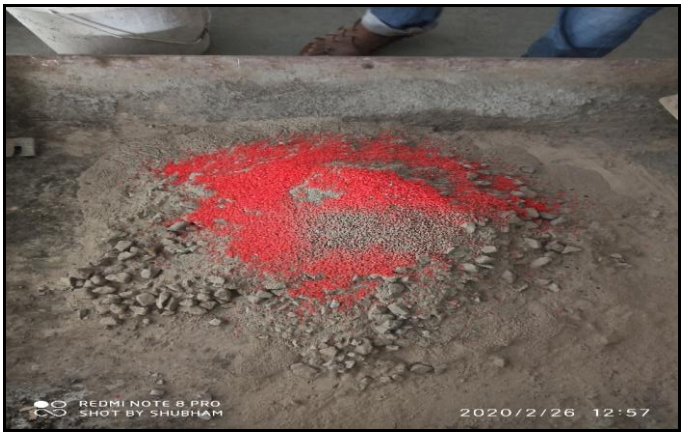

Figure 2: Addition of plastic granules

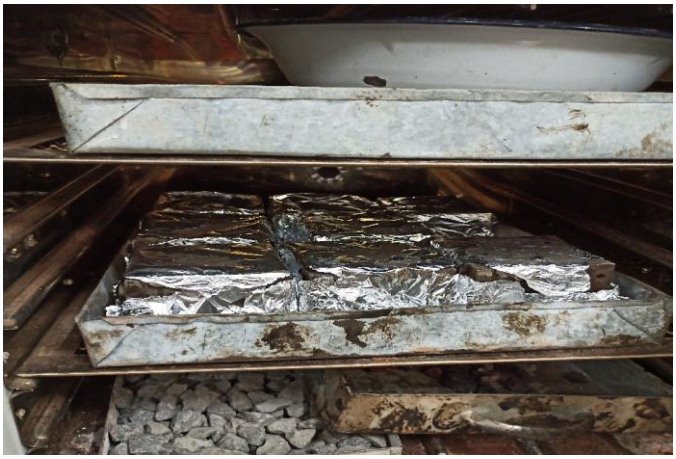

Figure 3: Oven curing of samples

4. Results and Discussion

Table 2: Compressive Strength Test Result for Plastic Granule Geopolymer Concrete For 70X70 mm²

Sr. No.	Age of Concrete (Days)	Area (mmXmm)	Load (KN)	Compressive strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1	7	70X70	21.07	4.3	
	7	70X70	19.6	4	4.26
	7	70X70	22.05	4.5	
2	14	70X70	51.45	10.5	
	14	70X70	54.39	11.1	10.8
	14	70X70	52.92	10.8	
3	28	70X70			23.8

Table 3: Compressive Strength Test Result for Plastic Granule Geopolymer Concrete For 150X150 mm2

Sr. No.	Age of Concrete (Days)	Area (mmXmm)	Load (KN)	Compressive strength (N/mm^2)	Average Compressive Strength (N/mm^2)
1	7	150 x 150	249.75	11.1	
	7	150 x 150	261.00	11.6	11.33
	7	150 x 150	261.00	11.3	
2	14	150 x 150	249.75	19	
	14	150 x 150	261.00	20	19.23
	14	150 x 150	254.250	18.7	
3	28	150 x 150	670.5	29.8	29.8

Observation:

1. For compressive strength for M30 grade plastic granule geopolymer concrete mix 30% plastic granule is shown in Table 4.2 for 7, 14 days and 28 days for cube size 150X150 mm2.

2. For compressive strength for M30 grade plastic granule geopolymer concrete mix containing 30% plastic granule is shown in Table 4.3 for 7, 14 days and 28 days for cube size 70X70 mm2.

3. The results are meeting as per IS standards, if there are more trial mixes then the results will have more satisfied values.

5. Cost Analysis

This heading contains cost of different material used in mixture. The cost analysis is done for 1 m^3 of plastic granule geopolymer concrete.

Table 4: Cost of M30 Grade Plastic Granules Geopolymer Concrete

Sr No.	Material	Unit	Rate	Quantity	Amount
1	FlyAsh	Kg	2	500	1000
2	Solid NaOH	Kg	50	36.4	1820
3	Solid Na_2SiO_3	Kg	50	41.4	1656
4	Fine Aggregate	Kg	1.2	480.25	576.3
5	Coarse Aggregate	Kg	1.1	1030.99	1130
6	Plastic Granules	Kg	4	70.7	282.2
				Total	**6465.1**

Observation:

1. The cost of plastic granules geopolymer concrete is 16% more than the conventional concrete.

2. The increase in price is mainly due to the use of sodium hydroxide and sodium silicate which are costly in market.

3. If the chemicals are available at cheaper rate than these rates then the price of conventional concrete and plastic granules geopolymer concrete will approximately equal to each other.

6. Conclusions

1. The results of 14 days and 28 days testing were slightly less. This might happen because of use of fly ash as fly ash is not a pure binder.

2. The solids in the solutions must be properly dissolved for that they must be used after 24 hours of preparing.

3. Thin vinyl sheet or some covering must be used while oven curing so that water from solution will not evaporate.

4. 30% replacement of fine aggregate was done with plastic granules (HDPE).

5. While removing the specimen from 7X7X7 cm3 proper care should be taken otherwise the specimen will break into pieces.

6. The 7 day and 14 day test results of plastic granules geopolymer concrete are less than conventional concrete this might be because of use of flyash, as fly ash takes more than 14 days to activate and give strength.

7. The cost of plastic granule geopolymer concrete is 20% more than the conventional concrete. This mainly because of price of chemicals used in product. If the chemicals are available at cheaper rate the cost won't matter.

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IS Codes:

1. IS10262:2009: Concrete mix proportioning – guidelines.

2. IS1199:1959: Methods of sampling and analysis of concrete.

3. IS516:1959: Methods of tests for strength of concrete.