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Effects On Properties Of Geo-Polymer Concrete Partially Replacing Natural Sand With Plastic Sand.

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Abstract: The basic reason behind selecting this topic is to reduce CO2 emission and reduce plastic pollution. The purpose of this study is to overcome the plastic material which are being wasted are used as a fine aggregate in Geo-polymer concrete mixture. In geo-polymer 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. Plastic granules were used as the replacement for fine aggregate. The compressive and the tensile strength of different specimens were conducted to check the property of plastic granules and how effective is the specimen compared to normal concrete. Six mixes were made to compare with the increments of 0%, 5%, 10%, 15%, 20%. All the stages of replacement showed a notable decrease in compressive strength. After being known that compressive strength was less, tensile strength showed significant strength. The alkaline liquids used in this study for the geo-polymerization process are sodium hydroxide (NaOH), and sodium silicate (Na2SiO3).

The test specimens were cubes, cylinders and beams. The geo-polymer concrete specimens are tested for their compressive and tensile strength at the age of 7, 14 and 28 days. The test result indicates that the combination of fly ash and alkaline solution can be used for development of geo- polymer concrete.

This study insures that reusing waste plastic as a sand substitution aggregate in concrete gives a good approach to reduce the cost of material and solve some of the solid waste problems posed by plastics. Also to know the compressive strength of geo-polymer concrete with plastic waste and to compare the same with geo-polymer concrete without any replacement of fine aggregate.

Index Terms – Geo-polymer Concrete, Plastic Waste, Tensile Strength, Plastic Granules, Compressive Strength.

I. Introduction

For the construction of any structure, concrete is the main material. Concrete usage around the world is second only to water. The main ingredient to produce concrete is ordinary Portland cement. On the other side global warming and environmental pollution are the biggest menace to the human being on this planet today. In India about 3,069,738 thousand of metric tons of CO2 is emitted in the year of 2022. The cement industry contributes about 5% of total global carbon dioxide emission. But the demand of concrete is increasing day by day for its ease of preparing and fabricating in all sorts of convenient shapes. So to overcome this problem, the concrete to be used should be environmental friendly. To produce environmental friendly concrete, we have to replace the cement with some other binder which should not create any bad effect on environment. The use of industrial by products as binder can reduce the problem. The new technology geo-polymer concrete is a promising technique. In terms of reducing global warming, the geo-polymer concrete technology could reduce the CO2 emission to the atmosphere caused by cement and aggregate industries by about 80%. And also proper usage of industrial waste can reduce the problem of disposing the waste products into the atmosphere.

Materials used to create geo-polymer concrete include fine aggregate, coarse aggregate, Pozzolanic powder made of aluminium silicates, and alkaline activator solution. As an alternative, materials including fly ash, silica fume, slag, rice-husk ash, and red mud can be utilized as the raw materials for pozzolanic powder made from alumina-silicates. However, because to its accessibility, fly ash is employed most frequently. Other aspects of geo-polymer concrete, besides strength, are crucial. However, it has been found in several study articles that the durability of GPC varies with different factors. The capacity of GPC to withstand weathering, chemical assault, abrasion, or any other degrading process is what makes it durable. The performance of GPC is evaluated for permeability, abrasion, degradation from frost action, degradation from fire, degradation from sulphate assault, and loss of strength and mass.

1.1 Properties of Geo-Polymer Concrete:

Inorganic binders known as geo-polymers can be distinguished by the following characteristics: Temperature and duration of curing affect compressive strength. The compressive strength rises with curing time and temperature. Since no limestone is used in the production of Geo-polymer cement, it exhibits remarkable corrosion resistance in both acidic and alkaline situations. Particularly for harsh environmental circumstances, it is appropriate. Better durability and thermal stability characteristics are seen in geo-polymer specimens, such as Set at room temperature.

- Early strength gain is possible
- Bleed Free
- Long working life
- Impermeable
- Higher resistance to heat &resists all inorganic solvents.

1.2 Introduction to Plastic Waste (Granules):

Plastic granules are raw material produced in different sizes and shapes. When plastic granules are melted and poured into the mould, they take shape practically. For this reason, plastic granules raw 4 material are preferred in different sectors. A plastic granule, which is the raw material form of plastic, is frequently used today due to its low cost and easy manufacture. Plastic granules are the form of raw material in the form of small grains used in the production of plastic materials. Granular raw material appears as a thermoplastic polymer type. Plastic granules, which are generally produced from polymers, are used in many applications due to their low cost.

1.3. Objectives:

- To study the optimum usage of plastic waste as a replacement of fine aggregate in geopolymer concrete.
- To study the effects of alkaline solutions on geopolymer concrete by replacing natural sand partially with plastic waste.
- To study the workability, strength and durability properties of Plastic waste based geopolymer concrete.
- To compare standard specification for natural aggregate and plastic granules.

II. RESEARCH METHODOLOGY

The goal of the current effort is to create concrete that can be weight of it and has high strength and durability. The main aim is to use waste materials that can be natural hazards, so we take fly ash to replace cement and partially replace natural sand with plastic waste granules. Utilizing plastic granules and fly ash reduces construction costs. The bases react with the fly ash and other types of lime, including slaked lime, to create sodium alumina silicate and calcium silicate, which serve as a binder for the fine sand and coarse aggregate. In concrete, sodium hydroxide and sodium silicate concentrations are varied, and the impact on compressive strength and tensile strength is recorded. The laboratory investigation was conducted to determine the suitability of locally accessible unprocessed fly ash for the production of geo-polymer concrete and the impact of various parameters on compressive strength of geo-polymer concrete, including the mass ratio of alkaline liquid to fly ash, the mass ratio of sodium silicate to sodium hydroxide, and the molar concentration of sodium hydroxide liquid in alkaline activator. Class-F fly ash and several types of lime, including quick, slaked, and hydrated lime, are employed in the current study in varying amounts as cementitious materials for the creation of GPC mixes. In the current experiment, the catalytic liquid is a solution of sodium silicate and analytical-grade sodium hydroxide. OPC is not at all used in these mixes

2.1Material Used:

1) Fly Ash
2) Fine Aggregate
3) Coarse Aggregate
4) Alkaline Solution
5) Plastic Granules

2.1.1 Fine Aggregate:

a) Physical Properties of Fly Ash:

Specific Gravity	2.12
Unit Weight	14.39
Liquid Limit	24
Loss of Ignition	0.40

b) Properties of fine aggregate:

Sr. No	Property	Result
1)	Particle Shape, Size	Rounded 4.75mm
2)	Specific Gravity	2.40
3)	Silt Content	9.44
4)	Fineness Modulus	2.7%
5)	Zone-II	7
6)	Water Absorption	1.18%

c) Sieve Analysis of Fine Aggregate:

IS Sieve Size (mm)	Weight Retained	Percentage Retained (%)	Cumulative Percentage Retained (%)	Total Passing Percentage (%)
4.75	0	0	0	100
2.36	210	21	21	79
1.18	238	23.80	44.8	55.2
0.6	327	32.70	77.5	22.5
0.3	225	22.50	100	0
0.15	0	0	100	0
Pan	0	0	100	0

d) Specific Gravity of Fine Aggregate:

Weight of Pycnometer (W1)	1525
Weight of Pycnometer +Water + Fine Aggregate (W2)	1708
Weight of Oven Dried Fine Aggregate (W3)	667
Weight of Surface Dried Fine Aggregate (W4)	967
Specific Gravity= W3/[W4-(W3-W2)]	2.40
Water Absorption in percentage = [(W4-W3)/W3]X100	1.80

2.1.2 Coarse Aggregate:

Sr. No	Property	Result
1)	Particle Shape, Size	Angular
2)	Specific Gravity	2.77
3)	Bulk Density	1620 kg/m3
4)	Fineness Modulus	6.87
5)	Max. Size	10mm

III. Mix Design Calculations:
Mix Design for Grade M30 Geo-polymer Concrete:
Characteristics Strength required at 28 days = 30MPa
Fly ash Grade = Pozzolana63
Max size of Aggregate = 20 mm
Degree of quality control = Good
Type of Exposure = Severe (IS 456-2000, Table-5)
Workability (Slump) = 100mm (IS 456-2000, cl.7.1)
Fine aggregate = Zone II (IS 10262-2019, Table-10)
Specific gravity of Fine aggregate = 2.40
Specific gravity of Coarse aggregate = 2.77
Specific gravity of Fly ash = 2.3

Step 1:
Target mean strength, f'ck = fck + t x S
Where, t = a statistical value depending on expected proportion of low result t = 1.65 &S = Standard Deviation from Table 2
For M30 Grade concrete & good quality control, S = 5
Target mean strength = 30 + (1.65 x 5) = 38.25MPa

Step 2:
To decide water / cement ratio, this will give 38.25MPa
Select water / cement ration (w/c) = 0.45, This is lesser than 0.45 prescribed in IS 465-2000 for severe condition for reinforced concrete (Table 3.7)

Step 3:
Selection of water content: from IS 10262-2019 Table-4
For 20mm size of aggregate use Maximum water content 186kg
From IS 10262-2019 cl.5.3, for every 25mm add 3%.
For 100mm slump = 186 + (6/100) x 186 = 197kg/m3

Step 4:
Calculation of cement content:
Cement content: 197/0.45 = 437.77 kg/m3
437.77 kg/m3 > 320 kg/m3

Step 5:
Volume of C.A. and F.A.:
Table 3.10, Volume of C.A.corresponding to 20 mm size of aggregate and F.A.
Zone II for W/C ratio = 0.45
Therefore, Volume of C.A. = 0.62 and Volume of F.A = 0.38

Step 6:
Mix Calculation:
i. Volume of GPC = 1 m3
ii. Volume of Fly ash = (Mass of Fly ash/ Specific Gravity of Fly ash) x (1/1000)
= 0.75 x (437.77/ 2.3) x (1/1000) = 0.143 m3
iii. Volume of water = (Water / Specific Gravity of Water) x (1/1000)
= (197/1) x (1/1000) = 0.197 m3
iv. Volume of all Aggregate = 1 - (ii + iii)
= 1 – (0.1807 + 0.197)
= 0.622 m3
v. Mass of C.A = 0.62 x Volume of Aggregate x Specific gravity of C.A x 1000
= 0.62 x 0.622 x 2.77 x 1000
= 1068.22Kg.
vi. Mass of F.A = 0.38 x Volume of Aggregate x Specific Gravity of F.A x 1000
= 0.38 x 0.622 x 2.40 x 1000
= 567.26 Kg

Mix Proportion of Geo-polymer Concrete for M30:

Fly Ash	NaOH	Na2SiO3	F.A	C.A
1	0.130	0.320	1.75	2.50

IV. RESULTS AND DISCUSSION

4.1 Workability Test (Slump Cone Test):

Sr. No	Mix Notation	% Replacement of Natural sand with Plastic granules	Slump (mm)
1	A1	0%	100
2	A2	5%	92.50
3	A3	10%	86.20
4	A4	15%	80.55
5	A5	20%	76.40

4.2 Compressive Strength Test:

Sr. No	Mix Notation	% Replacement of Natural sand with Plastic granules	Compressive Strength (MPa)			
			3 Days	7 Days	14 Days	28 Days
1	A1	0%	24.10	30.25	34.50	37.20
2	A2	5%	25.20	32	35.25	39.50
3	A3	10%	27	33.20	36.90	41.75
4	A4	15%	28.25	33	38.50	42.25
5	A5	20%	25.25	30.15	33.65	40

4.3 Split Tensile Strength Test:

Sr. No	Mix Notation	% Replacement of Natural sand with Plastic granules	Split Tensile Strength (MPa)
1	A1	0%	4.43
2	A2	5%	4.28
3	A3	10%	4.75
4	A4	15%	4.95
5	A5	20%	4.70

4.4 Flexural Strength Test:

Sr. No	Mix Notation	% Replacement of Natural sand with Plastic granules	Flexural Strength (MPa)
1	A1	0%	7.62
2	A2	5%	8.53
3	A3	10%	9.25
4	A4	15%	9.80
5	A5	20%	8.55

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Photo Gallery