DURABILITY STUDY ON FLY ASH BASED GEOPOLYMER CONCRETE WITH PARTIAL REPLACEMENT OF FLY ASH BY WASTE GRANITE POWDER

K.Sivasankari[1], P.Senthamilselvi[2]
PG student, Department of Civil Engineering, Government College of Engineering, Salem, India[1]
Assistant Professor, Department of Civil Engineering, Government College of Engineering, Salem, India[2]

***ABSTRACT* --- This Research Work deals with the Durability study on fly ash geopolymer concrete with partial replacement of flyash by waste granite powder in M35 grade geopolymer concrete. Waste granite powder an industrial by product obtained from Granite making industry can be identified as an alternative to fly ash. By using this in construction purpose, it reduces the solid waste disposal problem and other environmental issues .Waste granite powder in geopolymer concrete was found to be beneficial and reduce the overall cost of construction. Geopolymer concrete with 15% replacement of waste granite powder to fly ash gives higher compressive strength in oven curing. Durability study was conducted only for optimum percentage of geopolymer concrete in oven curing. By concluding from this 15% replacement of Geopolymer concrete is more durable than 0% replacement of Geopolymer concrete without affecting the properties and strength of Geopolymer concrete**.

Index terms: Durability test, Geopolymer, Granite, Oven curing.

INTRODUCTION

In our country, concrete is being extensively used in most of the construction activities. Now a days due to the boom in the infrastructure development, the volume of concrete being used in the construction has risen to large level. Recently, composites have been fastly replacing conventional materials in concrete. Some of the composite materials are fiber, slag, fly ash etc. Portland cement contributes to about 5-6% of global CO_2 emission. The damage that this level of pollution is doing to the atmosphere is unsustainable and as such we need to create a substitute for OPC. And also, the production of one ton of cement emits approximately one ton of carbon dioxide to the atmosphere which leads to global warming conditions. This substitute comes in the form of Geo-polymer Concrete (GPC). Geopolymer are formed when various alumina and silica containing materials react under highly alkaline conditions and forms a three-dimensional network of Si-O-Al-O bonds. Geo-comparable mechanical properties and have significantly lower CO_2 emission. As the industries grow, consequently their production of waste also increased in many folds, these waste products from some of the industries may sometimes cause environmental hazards, if not disposed properly. One of such waste industrial waste product is waste granite powder that is used with replacement of flyash. Fly ash based geopolymer had been proved by many studies to provide better resistance against aggressive environment.

As such, this advantage can be used to construct structure that exposed to marine environment. The recent interest is in use of waste and by-products for Geo-polymerizationfrom waste utilization and resource conservation points of view.

II. RESEARCH SIGNIFICANCE

No research data on the durability study of fly ash based geopolymer with partial replacement of fly ash by waste granite powder is cited at present. Geopolymer concrete with waste granite powder at optimum replacement was found be effective in all the durability properties.This Research work provided satisfactory test results regarding the water absorption, acid attack, sulphate attack, sorptivity action.

III. METHODOLOGY

1. To carry out a literature survey on geopolymer concrete and Waste granite powder properties that can be feasible to use in concrete.
2. To compare the durability result of the 0% geopolymer concrete with 15% replacement of fly ash with waste granite powder geopolymer concrete.

IV. MATERIALS COLLECTION

a. Fly Ash

Fly ash is a by-product generated due to combustion of coal in boilers of thermal power plants. Class F ash is the amount of calcium, silica, alumina, and iron content in the ash. Class F concrete is used in structural concretes, high performance concretes, or high sulphate exposure concretes. Generally high fly ash content mixtures are limited to Class F fly ash. Generated from younger softer coal burned found in coal mines.

S.no	Types of test	Values obtained
1.	Specific gravity	1.9
2.	Fineness	7%(IS sieve 90μ)
3.	Normal consistency	33%

TABLE I:Physical Properties of Fly ash

TABLE II:Chemical Properties of Fly ash

S.No	Parameter	Experimental value
1	Loss on ignition(LOI)	1.89%
2	Sand and silica	67.21%
3	Calcium Oxide (CaO)	1.37%
4	Magnesium Oxide (MgO)	0.44%
5	Iron Oxide(Fe_2O_3)	0.39%
6	Aluminium Oxide(Al_2O_3)	18.33%
7	Alkalis	1.61%

b. Waste Granite Powder

Granite powder, one of the by-products in granite stone crushing process, not being used for any applications other than filling-up low-lying areas is identified as a replacement material for fly ash in geopolymer concrete. . Presently, all the processing units are disposing this industrial waste by dumping it in open yards, that nearly occupying 25% of the total area of the industry. The reduction in waste generation by manufacturing value-added products from the granite stone waste will boost up the economy of the granite stone industry. The utilization of granite powder in high performance concrete could turn this waste material into a valuable resource with the added benefit of preserving environment. Therefore, this study focused on the possibility of using locally available granite powder.

TABLE III:Physical properties of Granite powder

S.No	Types of test	Values obtained
1.	Specific gravity	2.66
2.	Fineness	6% (IS sieve 90
3.	Consistency	33%

TABLE IV:Chemical Properties of waste granite powder

S.No	Parameter	Experimental value
1	Loss on ignition(LOI)	1.19%
2	Sand and silica	58.36%
3	Calcium Oxide (CaO)	1.34%
4	Magnesium Oxide (MgO)	1.29%
5	Iron Oxide(Fe_2O_3)	21.54%
6	Aluminium Oxide(Al_2O_3)	12.63%

c.Fine Aggregate

The locally available river sand was used as fine aggregate in present investigation.The sand was screened at site to remove deleterious aterial and tested as per procedure IS:2386-1963

TABLE V:Physical properties of fine aggregate

S.No	Types of test	Value obtained
1.	Specific gravity	2.71
2.	Fineness modulus	2.63
3.	Water absorption	1%
4.	Grading zone	Zone II

c.Coarse Aggregate

In this investigation, locally available crushed granite aggregate was used. Coarse aggregate in sieve size 20mm passing and 4.75mm retaining in saturated surface dry condition was used.

TABLE 6: Physical properties of Coarse Aggregate

S.No.	Description	Value
1.	Specific gravity	2.82
2.	Water absorption	0.5%
3.	Crushing value	14%
4.	Impact value	7.16%

d.Alkaline liquid

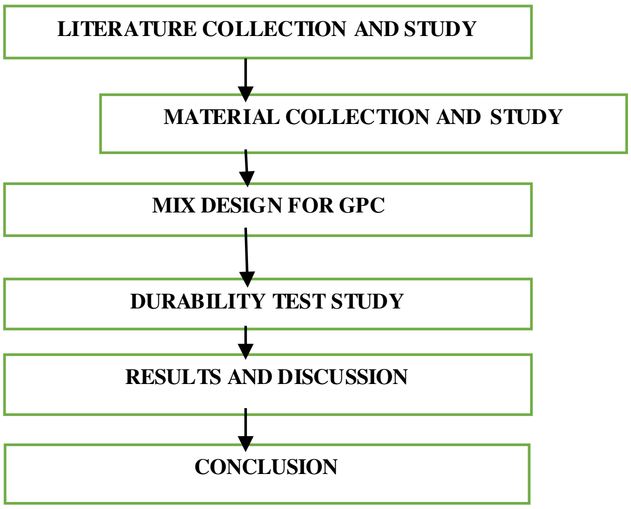
Alkaline Activated Solution (AAS) used here was a mixture of sodium silicate (Na_2SiO_3) and sodium hydroxide (NaOH) with the molarity of 12M. The ratio of the Sodium Slicate to Sodium Hydroxide is 2.5.

V.MIX PROPORTIONS

TABLE 7:Mix proportion for geopolymer concrete for m35 grade by using guidelines is:10262-2009

Fly ash Kg/cm3	Fine aggregate Kg/cm3	Coarse aggregate Kg/cm3	Alkalinity solution Kg/cm3
425.73	585.57	1037.53	191.58
1	1.38	2.44	0.45

VI.METHODOLOGY



VII.TEST RESULTS AND DISCUSSIONS

- Compression test results
- Water Absorption test
- Acid Attack test
- Sulphate Attack test
- Sorptivity test

1.Compressive strength results

Test Specimen: 100x100x100mm cube of geopolymer concrete

TABLE 8:Compressive strength results of fly ash based geopolymer concrete replaced by waste granite into fly ash.

Mix	Percentage replacement	Average compressive strength(N/mm^2)		
		7 days	14 days	28 days
G0	0%	23.50	34.45	43.8
G05	5%	24.66	36.21	46.72
G10	10%	26.15	37.59	49.61
G15	***15%***	***27.15***	***40.23***	***53.62***
G20	20%	24.41	36.45	48.86

2. Water Absorption test results

Test Specimen: 100x100x100mm cube of geopolymer concrete

Test procedure: oven dried for 24hours duration using hot air oven. After oven drying and 28 days exposed in atmospheric condition the specimens were immersed in water for 48 hours duration.

TABLE IX:water absorption test results for 0%

Specimen	days	dry weight (Kg)	saturated weight (Kg)	water absorption (%)
1	0	2.293	2.342	2.135
2	0	2.218	2.277	2.661
3	56	2.242	2.295	2.363
4	56	2.298	2.357	2.567

TABLE X:water absorption test results for 15%

specimen	days	dry weight (kg)	saturated weight (kg)	water absorption (%)
1	0	2.356	2.391	1.485
2	0	2.307	2.342	1.517
3	56	2.369	2.397	1.181
4	56	2.325	2.363	1.163

3.Acid Attack test

Test Specimen: 100x100x100mm cube of geopolymer concrete

Test procedure: Sulphuric acid (H_2SO_4) solution with 5% concentration was used as the standard exposure solution

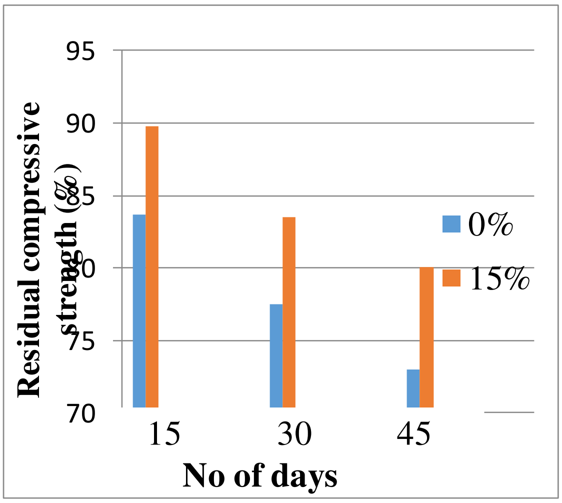


Chart 1:comparison of strength for acid attack test

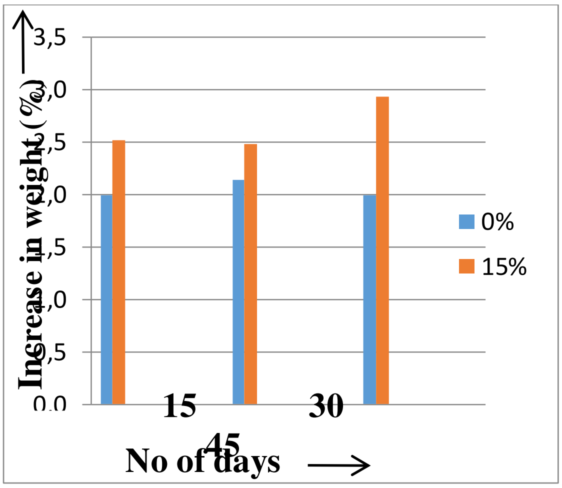


Chart 2:comparison of mass for acid attack test

4.Sulphate Attack Test

Test Specimen: 100x100x100mm cube of geopolymer concrete

Test procedure: Sodium sulphate ($Na2SO4$) solution and Magnesium sulphate solution($MgSO4$) with 5% concentration was used as the standard exposure solution.

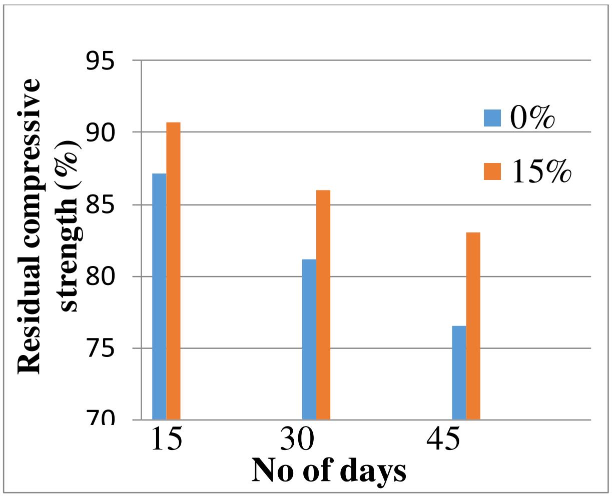


Chart 3:comparison of strength for sulphate attack test

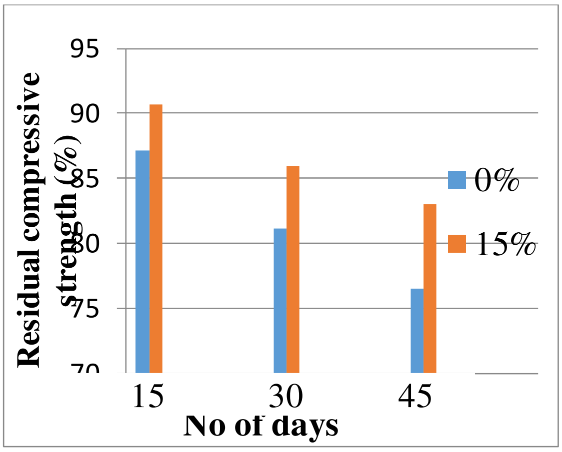


Chart 4:comparison of mass for sulphate attack test

5.Sorptivity test result

Test specimen: 100mm dia and 50 mm height

TABLE XI:sorptivity test result for 0% replacement

Specimen	Sorptivity value
1	0.037112
2	0.039565
3	0.034500

TABLE XII:Sorptivity test result for 15%

Specimen	Sorptivity value
1	0.008225
2	0.010106
3	0.010000

replacement

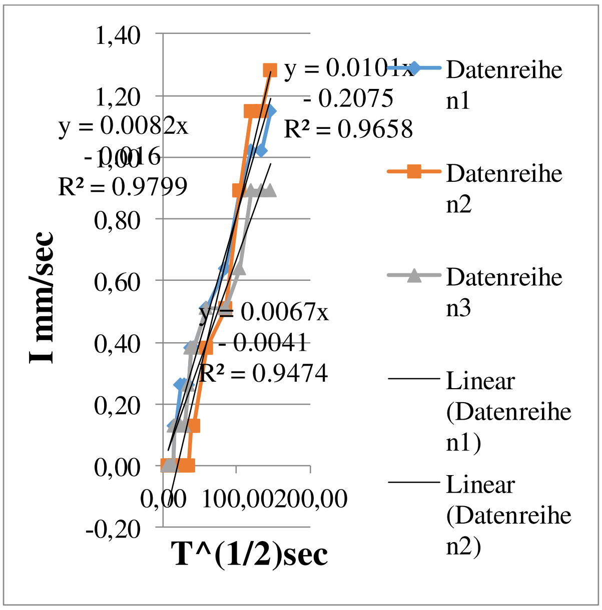


Chart 5:Combined sorptivity results for 15% replacement

VIII.CONCLUSIONS

1. Waste granite powder an industrial by product obtained from Granite making industry can be identified as an alternative to fly ash. By using this in construction purpose, it reduces the solid waste disposal problem and other environmental issues.
2. Using waste granite powder in geopolymer concrete was found to be beneficial and reduce the overall cost of construction.
3. The properties of waste granite powder were similar to fly ash and also there is no major difficulty in handling the Geopolymer concrete with waste granite powder.
4. Geopolymer concrete with different percentage of waste granite powder, 15% replacement of waste granite powder to fly ash gives higher compressive strength in oven curing.
5. Durability study was conducted only for optimum percentage of geopolymer concrete in oven curing.
6. In water absorption test, the water absorption of 15% replacement is lesser than the water absorption of 0% replacement.

7. In acid attack test, the percentage loss in compressive strength of 15% replacement (19.95%) is lesser than the percentage loss in compressive strength of 0% replacement (26.97%).
8. In sulphate attack test, the percentage loss in compressive strength of 15% replacement (16.95%) is lesser than the percentage loss in compressive strength of 0% replacement (23.49%).
9. In sorpitivity test, the sorpivity value of 15% replacement (0.00944) is lesser than the sorpitivity value of 0% replacement (0.03709).

By concluding from this 15% replacement of Geopolymer concrete is more durable than 0% replacement of Geopolymer concrete without affecting the properties and strength of Geopolymer concrete.

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