Scientific Journal of Impact Factor (SJIF): 5.71
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406
International Journal of Advance Engineering and Research Development
Volume 5, Issue 04, April -2018

THE EXPERIMENTAL STUDY ON UTILIZATION OF GRANITE WASTE DUST IN GEOPOLYMER CONCRETE

Divyesh Viradiya[1], Siddharth G. Shah[2], Dhaval Dara[3]

[1] Civil Engineering Department, Marwadi University
[2] Civil Engineering Department, Marwadi University
[3] Civil Engineering Department, Marwadi University

Abstract — *The main activity of the mining industry is the sawing and polishing process of rock blocks. This activity produces a large amount of mud consisting essentially of SiO_2, Al_2O_3, Fe_2O_3, and CaO. This is estimated at 32-40 cubic meters/day [1]. After the stone was air-dried, it became a very good material that was easily inhaled by humans and animals. It was thought to cause severe lung disease in the local people and could cause serious damage to the environment, such as soil and groundwater contamination, if not effectively treated before treatment. It has been shown that utilization of waste materials which are rich in aluminosilicate content can be used in geopolymer concrete. Through geopolymerisation waste materials can be transformed in building material with excellent mechanical and durable properties like acid resistance and fire resistance. In this research work, polymerization of Granite waste in replacement of fly ash (Class F) with different alkali-activators based on combinations of Na_2SiO_3 and NaOH has been investigated. The geopolymer concrete was prepared with varying doses of granite waste dust in replacement of fly ash like 10%, 30%, 50%, 70%, 100%. The geopolymer concrete is prepared with 0.5 alkaline solutions to fly ash ratio. The compressive strength of 16-65 MPa was obtained in different replacement of granite dust in geopolymer concrete. The performance of these geopolymer concretes in aggressive environments has also been studied using tests for acid resistance and Rapid chloride penetration test. Compared with ordinary concrete, all geopolymer concretes exhibit excellent acid corrosion resistance (5% of H_2SO_4+HCL).*

Keywords- *Granite Dust, geopolymer concrete, green concrete, waste utilization, Fly ash*

I. INTRODUCTION

Due to the increase in carbon dioxide and greenhouse gases and the handling of industrial waste, the world is facing challenges from global warming and climate change. The development of sustainable and environmentally friendly technologies ensures low energy consumption and the lowest CO_2 emissions. Geopolymer technology can be a viable solution to this goal. Replacing ordinary Portland cement (OPC) with geopolymeric cement can reduce carbon dioxide emissions by 80% to 90%. The alkali-activated material has become an alternative to OPC, and it seems to have good durability and environmental impact [2]. The amount of use of concrete across the world is second after the water. Ordinary Portland cement is commonly used as the main binder for the production of concrete. The environmental issues related to the production of OPC are well known. Due to the calcination of limestone and the combustion of fossil fuels, the huge amount of CO_2 released during the manufacture of OPC, which consumes a plenty of natural resources. In addition, the range of energy needed to produce OPC. The global cement industry contributes approximately 1.35 billion tons of greenhouse gas emissions per year, accounting for 7% of the total man-made greenhouse gas emissions [Hardjito et.al. 2004]. Therefore, in order to protect the global environment from the impact of cement production, OPC uses ground polymer concrete instead. Davidovits [1988] proposed that alkaline liquids can be used to react with silicon (Si) and aluminum (Al) or by-products such as fly ash and rice husk ash in geologically-derived raw materials to form binders. Since the chemical reaction that occurred, in this case, was a polymerization process, he coined the term geopolymer to represent these binders. It is also called Zero cement concrete or green concrete. There are two main components of geopolymers, raw materials, and alkaline liquids. That source materials based on alumina-silicate mineralogy should be rich in silicon (Si) and aluminum (Al). These can be by-product materials such as fly ash, granite dust, slag, rice-husk ash, red mud etc. can be used as source material. The choice of raw materials for making the polymer depends on many factors such as availability, type of application, cost and the specific needs of the end user. Alkaline liquids are usually sodium or potassium based. The commonly used alkaline liquid for polymerization is a combination of NaOH and Na_2SiO_3.

Table 1. Production of Granite (By States), 2011-2014 [3]

State	Unit	2011-12 Quantity	2012-13 Quantity	2013-14 Quantity
Andhra Pradesh	Cubic Meter	1255683	1787880	2063453
Chhattisgarh	Cubic Meter	-	948	405
Gujarat	Tonne	-	242496	212608
Jammu & Kashmir	Tonne	138147	265393	-
Karnataka	Cubic Meter	358490	304015	331754
Kerala	Cubic Meter	13101469	15227651	13974374
Madhya Pradesh	Tonne	27968	28256	43267
Rajasthan	Tonne	1077000	2850000	3147059
Tamil Nadu	Cubic Meter	266889	273958	273958
Uttar Pradesh	Cubic Meter	23334	23077	24445

Table 2. The chemical property of granite waste and fly ash

Chemical Composition (OXIDE)	Granite Waste(GW) % Wt.	Flyash (class-F) %Wt.
SiO_2	72.56	54.78
Al_2O_3	5.33	23.52
Fe_2O_3	1.91	8.90
CaO	3.76	2.10
MgO	0.58	1.30
Na_2O	0.24	0.33
K_2O	0.17	0.72
SO_3	-	0.63
LOI (Loss of Ignition)	0.89	1.60

II. OBJECTIVE

The main objective of the experiment is to explore the potential use of granite waste with fly-ash to produce sustainable geo-polymer concrete and decide the optimum dosage of the granite waste for the replacement with fly-ash.

III. EXPERIMENTAL PROCEDURES

3.1. Materials

The geopolymer binders used in this research work are class-F Flyash and Granite Waste (GW), the chemical compositions of that are shown in Table 1 which is as per the ASTM C618 [4]. The GW collected from the Dimex Granites, Rajasthan, India was oven dried at 100 ± 2 $^{\circ}$C for 24 hours, then that GW was sieving through 300 μm to eliminate any coarse particles. The use of GW as a binder material in geopolymer concrete satisfies the chemical requirement as per ASTMC618 [4] as that material by having a loss on ignition (LOI) of less than 10%, so it could be useful in the manufacture of geopolymer concrete.

To prepare the alkaline solution or activator, a mixture of sodium hydroxide (NaOH) in form of flake form and sodium silicate (Na_2SiO_3) solution was used in this experiment. In this alkaline solution, the molarity of the NaOH was kept constant at 12M. The prepared alkaline liquid is exothermic in nature, so to cool that solution it was prepared at least one day before to its use in making geopolymer concrete at ambient temperature. The ratios of the Na_2SiO_3 solution to NaOH solution and the alkaline solution to the base material (AS/B) were 3 and 0.5 by mass, correspondingly.

3.2. Mix Proportions and Specimen Preparation.

The different mixing percentage of granite waste and fly ash is shown in table 3.The various proportions of different mixes is shown in table 4. The effect on geopolymer concrete with different percentages of GW and FA (0%, 10%, 30%, 50%, 70% and 100%) is investigated and reported.

Table 3. Mixing percentage

Mixture	GW %	FA %	AK/B	Na_2SiO_3/NaOH
M1	0	100	0.5	3
M2	10	90	0.5	3
M3	30	70	0.5	3
M4	50	50	0.5	3
M5	70	30	0.5	3
M6	100	0	0.5	3

Table 4. Mixture proportions of geopolymer concrete [5]

Constituent	Unit	Quantity
FA+GW	Kg/m3	368
Fine Aggregate	Kg/m3	554.4
Coarse Aggregate		
10 mm	Kg/m3	443.52
20 mm	Kg/m3	580.08
NaOH	Kg/m3	46
Na_2SiO_3	Kg/m3	138
Extra Water	Kg/m3	29.44

Table 5. Compressive strength result

Mixture	GW (%)	Days	Compressive Strength (MPa)
M1	0	3	64.48
		7	65.21
M2	10	3	64.78
		7	66.79
M3	30	3	50.35
		7	52.45
M4	50	3	34.15
		7	37.48
M5	70	3	17.46
		7	18.85
M6	100	3	16.31
		7	17.51

The coarse-grained and fine-grained aggregates were first mixed in a rotary concrete mixer for about 2 minutes; the binders FA and GW were then added and mixed more for about 3 minutes. Then after, alkaline solution and water were slowly added and mixed for additional 6 minutes. The well-mixed geopolymer concrete is then placed into a steel mold and compacted with a road tempering and vibratory table. To avoid the water evaporation from the surface of the specimen, it was covered with plastic film. After that, oven curing at a temperature of 100°C and ambient curing of samples were cured for 24 hours earlier to demolding and testing.

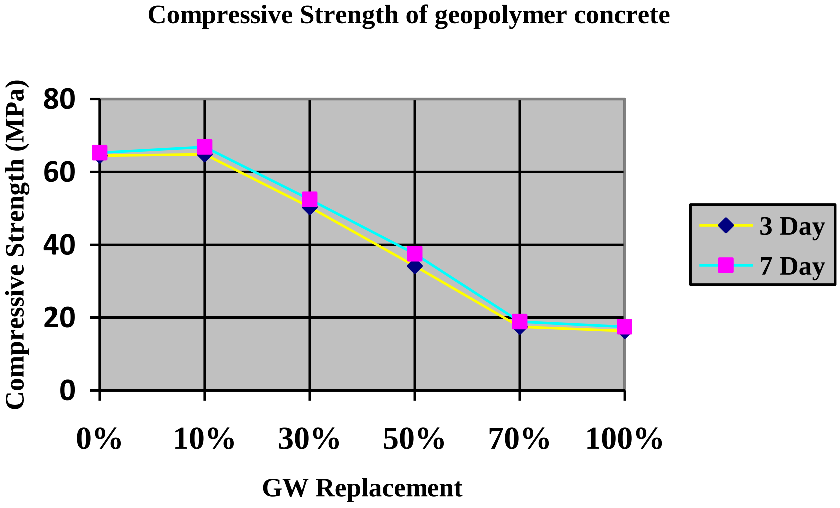
3.3. Test Methods.

The geopolymer concrete specimens were cast in 150 mm cubes for the compressive test, which was carried out at the ages of 3 and 7 days, in accordance with IS 516:1959 [6]. These tensile strength tests were carried out on cylinders of size 100 $\phi \times$ 200 mm. The tests on splitting tensile were conducted based on ASTM C496 [7].

IV. RESULTS AND DISCUSSION

4.1. Effect of GW on strength of geopolymer concrete

The development of the compressive strength for all GW and FA mixtures is presented in Table 5. The replacement of FA with GW up to 10% tends to increase in the 7-day compressive strength of the geopolymer concrete. This occurrence



Figurre 1. Compressive strength of geopolymer concrete

is recognized to the higher content of silica (SiO_2) and higher fineness of GW, which improved the polymerization of the binders. The high fineness of GW had a higher pozzolanic reaction and acted as filler in voids, so it increased the compressive strength of the geopolymer concrete. On the other side, the strength development showed a decreasing trend with a further replacement of FA with GW. That can be defined as the low strength in the geopolymer concrete with high GW content may be recognized to the inadequate polymerization due to its lower content of Al_2O_3.

V. CONCLUSION

Based on the experimental results obtained from this research, the following conclusions can be drawn

(i) The compressive strength of the geopolymer concrete increased with the GW content up to 10% and further replacement of GW showed a significant reduction in the strength.

(ii) The oven curing enhanced the early strength of the geopolymer concrete up to 91%; however, there is a higher strength gain over time for the ambient-cured geopolymer concrete.

(iii) The use of AS/B ratio of 0.5 by mass contributes to dissolution and polycondensation in geopolymer framework that produced higher compressive strength of geopolymer concrete compared to mixes with low AS/B ratio.

(iv) The minimum strength up to 16.31 MPa is achieved with 100 % replacement of FA with GW which show that we can use 100% GW geopolymer for low strength concrete member like pedestrial block etc.

REFERENCES

[1] S. Dhanapandian and B. Gnanavel, "Studies on Granite and Marble Sawing Powder Wastes in Industrial Brick Formulations", Asian Journal of Applied Sciences, Vol. 2, pp 331-340, April 2009.

[2] Fernando Pacheco-Torgal, Joao Castro-Gomes, Said Jalali, Alkali-activated binders: A review Part 1, Historical background, terminology, reaction mechanisms and hydration products, Construction and Building Materials, 22, 2008, pp 1305-1314.

[3] Indian Minerals Yearbook 2015, Government of India, Ministry of Mines, Indian Bureau of Mines
[4] ASTM C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete, ASTM International, West Conshohocken, Pa, USA, 2012.
[5] Vaibhav B. Vasoya, Experimental study on durability of geopolymer concrete, Thesis submitted to Marwadi education foundation's faculty of P.G. studies & research in engineering & technology.
[6] IS 516:1959, "Method of Test for Strength of Concrete", Reaffirmed. 2004, Bureau of Indian standards, New Delhi.
[7] ASTMC496, Standard TestMethod for Splitting Tensile Strength of Cylindrical Concrete Specimens, ASTM International, West Conshohocken, Pa, USA, 2011.

