"Analysis of Geopolymer concrete in Recycled Materials for Economical Behavior of the Structure"

Paresh Suryavanshi
RNTU, Bhopal
R17ET2CT0029

Prof. Amit Kumar Ahirwar
Guide & Proff. CE department
RNTU, Bhopal

Prof. Kapil Soni
Head Of CE department
RNTU, Bhopal

Abstract— Mechanical properties, such as compreessive, flexural and tensile splitting strength, considering an additional 10% volume of SF Geo-polymer concrete, as recommended by international codes, to partially replace slag cement to partially to medium strength, Geo-polymer concrete has not been investigated. till now. The present study investigates the mechanical properties of medium strength SF geo-polymer concrete made according to this construction practice by partial replacement of slag cement. The effect of SF on the strength of compreessive, flexural and tensile splitting of rigid Geo-polymer concrete is investigated. Seven geo-polymer concrete mixes are prepared by replacing Portland slag cement (PSC) partially with SF from 0 to 30%. The Indian standard recommends reducing the target strength of conventional Geo-polymer concrete in terms of water-to-cement ratio (w / c). In the present study, to propose the relation of compreessive strength with water-cement ratio, the behavior of RCA Geo-polymer concrete prepared from two samples of parent geo-polymer concrete with different age groups is investigated. The effect of age and number of recycling on properties such as capillary water absorption, drying shrinkage stress, air content, flexural strength and tensile splitting strength of RCA Geo-polymer concrete are investigated. And the compreessive strength gradually decreases with the number of recycling.

Key Words: Geo-polymer concrete, Recycled coarse aggregate, Ureolytic bacteriya, Fly ash, Cement, Variability, Fragility.

I. INTRODUCTION

Most engineering constructions are not environmentally friendly. The construction industry uses Portland cement which is known to contribute heavily to CO2 emissions and environmental damage. The volume of construction in India has increased rapidly over the last two decades. Using a variety of complementary cementing materials (SCMs), particularly SF and FA, as cement replacements can result in a substantial reduction in the overall CO2 footprint of the final Geo-polymer concrete product. The lower the amount of Portland cement used in the production of geo-polymer concrete, the lower the impact of the Geo-polymer concrete industry on the environment.

The use of demolished geo-concrete, SF and FA in the construction industry is more holistic as it contributes to ecological balance. However, the use of these waste materials in the construction industry, especially in making Geo-polymer concrete, is highly challenging. Significant research efforts are required to study the engineering properties of Geo-polymer concrete made from such industrial wastes. The present research is an attempt to study the properties of Geo-polymer concrete in which industrial wastes such as geo-polymer concrete, SF and FA are used.

This research focuses on important aspects that were not reported in any of the published literature:

i. Me. The effect of gradual recycling of coarse aggregation on the properties of Geo-polymer concrete has been carried out.

ii. Although the construction industry has shifted from OPC to PSC in Geo-polymer concrete worldwide, the focus of research is surprisingly largely limited to OPC. Studies on RCA / bacteriyal / SF / FA Geo-polymer concrete using PSC make this research worthwhile.

iii. This research is also demonstrated through the case study of fragility and reliability analysis of a building made of SF / FA geo-polymer concrete and the importance of probabilistic models.

II. EXPERIMENTAL METHODS AND SETUP

- **Compreessive Strength**

The compreessive strength of the specimens is determined after 7 and 28 days of treatment, respectively, with surface drought conditions as per Indian Standard IS: 516959. Both molds size 150 × 150 × 150 mm and 100 × 100 × 100 mm are used for the evaluation of compreessive strength. lack of adequate robustness and inability to accommodate microgrid uncertainties.

Compreessive testing machine for Geo-polymer concrete

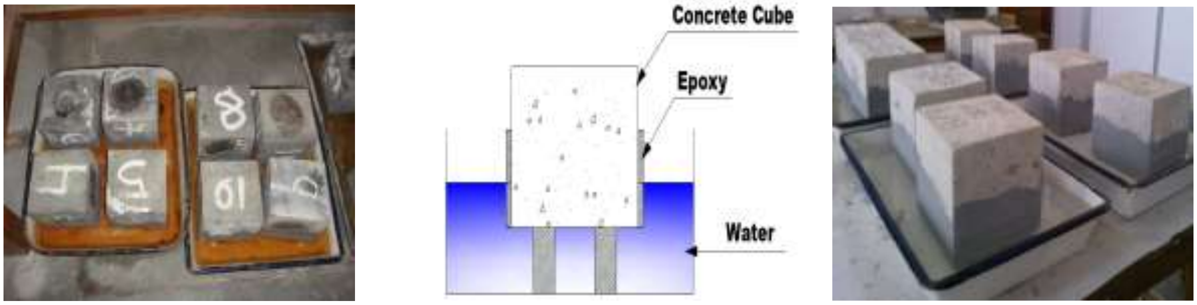
- **Capillary Water Absorption**

Capillary water absorption is measured by recording the respective weight of the cubes after continuous immersion. Capillary action is calculated using the following relation as a function of time.

$$\Delta W = S \times \sqrt{t} \quad \text{……….. (2.1)}$$

where,

Δ is the cumulative amount of water absorbed per unit area (gm/mm2) during the time of immersion (t) and *S* is the coefficient of capillary water absorption Wt



(a)Mortar of Geo-polymer concrete block (b) Schematic view of Capillary water absorption (c) Geo-polymer concrete Specimens

Capillary water absorption test set up

- **Flexural Strength**

Flexural strength of Geo-polymer concrete was found out as per IS: 516-1959. Prism of size 100×100×500 mm was taken for the experiment.

Figure 3.2 Flexural testing machine for Geo-polymer concrete

III. MATERIALS AND MIXTURE PROPORTION

i. Geo-polymer concrete wall constructed for drainage purpose (unused) (three years old)
ii. Crushed Geo-polymer concrete cubes and beams (from zero to one year old) from the Structural Engineering Laboratory

Type of aggregate	Age /No. recycling	Specific gravity	Bulk density (kg/l)	Loose bulk density (kg/l)	Water absorption (%)	Impact value (%)	Crushing value (%)	Fineness modulus
RC-1	0-1 year	2.28	1.209	1.04	4.269	26.910	24.514	3.18
RC-2	3 year	2.06	3.112	0.89	5.160	28.194	24.817	2.25
N2-RC-1	2	2.18	0.974	0.93	4.843	31.703	26.449	2.82
NCA	0	2.63	1.77	1.53	0.91	23.84	20.16	2.64

Properties of RCA of different age

Type of Materials	Specific Gravity	Water Absorption (%)
Portland Slag Cement	2.815	-
Sand	2.458	0.0451

Properties of cement and fine aggregate

Chemical components	Percentages (%)
SiO_2	8
CaO	39
MgO	6.5
Fe_2O_3	8
Al_2O_3	22

Chemical composition of Portland slag cement

Properties	Value
Specific Gravity	2.615
Fineness by Sieve analysis	1.3%
Normal consistency	28%

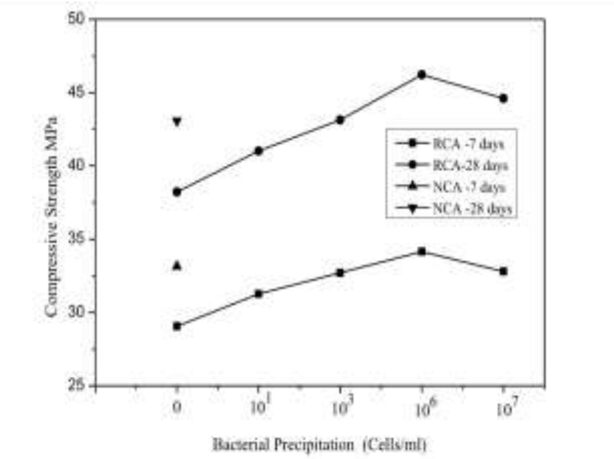
Physical properties of Portland slag cement

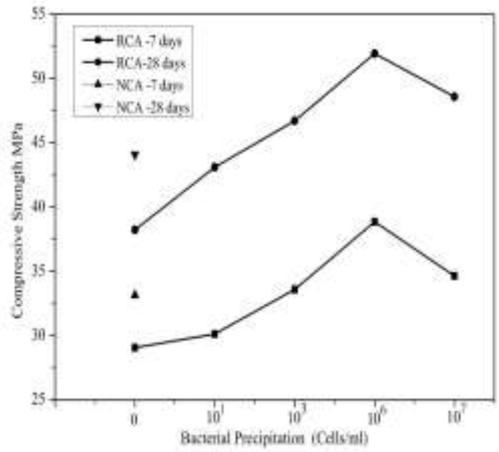
IV. EXPERIMENTAL RESULTS

Compreessive Strength: The average compreessive strength for samples with different concentration of bacteriya at 7 days and 28 days is presented. It has been observed that the compreessive strength of bacteriyal geo-polymer concrete increases with increasing cell concentration for both 7 days and 28 days strength. However, the trend reverses after a cell concentration of 106 cells / ml.

Mixture Name (RCA Geo-Polymer Concrete)	7 Days		28 Days	
	B. subtilis	B. sphaericus	B. subtilis	B. sphaericus
NCA (0 cells/ml)	33.15	33.15	44.08	44.08
Control (0 cells/ml)	29.06	29.06	38.22	38.22
B-1 (10^1 cells/ml)	31.27	30.13	41.02	43.10
B-2 (10^3 cells/ml)	32.70	33.59	43.13	46.71
B-3 (10^6 cells/ml)	34.15	38.86	46.22	51.93
B-4 (10^7 cells/ml)	32.80	34.63	44.60	48.55

RCA Geo-Polymer Concrete Effect of bacteriya on compreessive strength (MPa) at 7 & 28 days



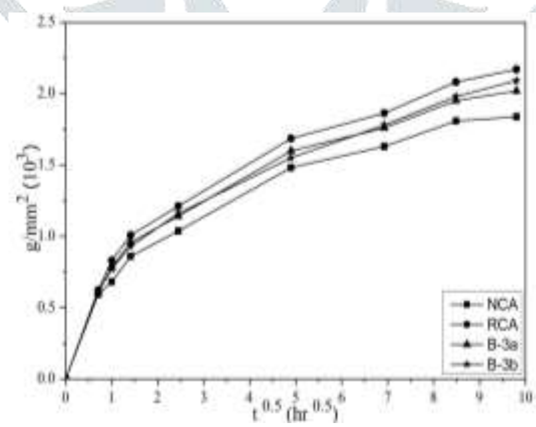


Effect of *B. subtilis* on compreessive strength **Effect of *B. sphaericus* on compreessive strength**

Capillary Water Absorption: The slope of these curves is decreasing in nature; Similar behavior has been observed in previous studies. Water absorption for RCA samples (control, B-3a and B-3b) is higher than for NCA samples, due to the excess water absorbed by the old mortar bound to the RCA. The capillary water absorption of the bacteriyal Geo-polymer concrete sample (b-3a and b-3b) is lower than that of the RCA control sample. This can be attributed to the dense Geo-polymer concrete caused by bacteriyal precipitation of CaCO3.

Type of Geo-polymer concrete	Drying Length (mm)	Water Absorption (%)
NCA	0.135	0.09
RCA Control	0.260	0.17
B-3a (B. subtilis)	0.040	0.03
B-3b (B. sphaericus)	0.090	0.06

Drying shrinkage of the Geo-polymer concrete specimens



Variation of capillary-water-absorption

V. CONCLUSIONS

- It was found that RCA Geo-polymer concrete requires a minimum amount of water based on parent-reared mortar to contribute to strength. This minimum water content in terms of w / c ratio for one year old and two year old RCA Geo-polymer concrete was 0.37 and 0.42 respectively. To obtain high compreessive strength for RCA (as compared to NCA), the w / c ratio must be higher than the above mentioned threshold range.

- ❖ Compreessive strength of Geo-polymer concrete prepared from RC old (RC-2) aggregate was found to be about 6% lower than that of RC-1. The split tensile strength and flexural strength of RC-2 Geo-polymer concrete are 14 to 28% and 6% to 21% lower than RC-1 geofolymer concrete, respectively.
- ❖ Gradual recycling of geocolymer concrete decreases due to greater water absorption of recycled Aggreegates. The compreessive strength of geocollimer concrete after two times of recycling was about 2% less than that of one time of recycling. It was found that capillary water absorption of N2-RC-1 is approximately 9 times higher than both RC-1 and NCA Geo-polymer concrete. In addition recycling RCA Geo-polymer was found to increase the air content of the concrete. Gradual recirculation reduces the divided tensile strength and ductility by 6% and 12%, respectively.

REFERENCES

- ➢ Achal, V., Mukherjee, A., and Reddy, M.S. (2011). "Microbial Geo-polymer concrete: a way to increase the durability of buildings." Journal of Materials in Civil Engineering, 23,730-734.
- ➢ Achal, V., Mukherjee, A., and Reddy, M.S. (2013). "Biogenic treatment improves durability and resolves fractures of Geo-polymer concrete structures." Construction and Building Materials, 48, 1-5.
- ➢ American Geo-polymer Concrete Institute (ACI). (2000). "Guide to the use of silica fume in Geo-polymer concrete." ACI 234R-96, Detroit.
- ➢ American Society for Testing and Materials (ASTM). (2014). "Standard Specification for Slag Cement for Use in Geo-polymer Concrete and Mortars." ASTM C989 / C989M, West Conshohocken, PA.
- ➢ American Society for Testing and Materials (ASTM). (2015). "Standard Specification for Silica Fume used in Cementitious Alloys." ASTM C1240, West Conshohocken, PA.
- ➢ American Society of Civil Engineers (ASCE). (2007). "Seismic Rehabilitation of Existing Buildings." ASCE 41-06, Reston, VA.
- ➢ Ai bairagi, NK, Vidyadhar, HS., And ravande, K. (1990). "Combine the Design Process for Recycled Aggregate Geo-polymer Concrete." Construction & Construction Equipment, 4.
- ➢ Behnood, A., Gharehwaran, M. M., Asl, F. G., and Ameri, M. (2015a). "Effects of copper slag and recycled Geo-polymer concrete Aggreegates on the properties of CIR with bitumen emulsion, rice usb ash, portland cement and fly ash." Construction and Building Materials, 96, 172-180.
- ➢ Bhanja, S., and Sengupta, B. (2005). "Effect of Silica Fume on the Tensile Strength of Geo-polymer Concrete." Cement and Geo-polymer Concrete Research, 35, 743-747.
- ➢ Bilodo, A., and Malhotra, V.M. (2000). "High-Volume Fly Ash System: Geo-polymer Concrete Solution for Sustainable Development." ACI Material Journal, 97 (1), 41-49.
- ➢ Bingal, A.F., and Tohumku, i. (2013). "Effects of different curing regimes on the compreessive strength properties of self-compacting Geo-polymer concrete incorporating fly ash and silica fume." Materials and Design, 51, 12–18.