ANALYSIS OF FLYASH BASED GEOPOLYMER CONCRETE BLOCKS

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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 geofolymer 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 geofolymer concrete mixes are prepared by replacing Portland slag cement (PSC) partially with SF from 0 to 30%. The construction industry uses Portland cement which is known to contribute heavily to CO2 emissions and environmental damage. Incorporating industrial wastes such as demolished old geofolymer concrete, silica fume (SF) and fly ash (FA) as complementary cementing material (SCM) can significantly reduce the overall CO2 footprint of the final geolimer concrete product. However, the use of these complementary 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 incorporating such industrial wastes. The present research is an attempt to study the properties of Geo-polymer concrete in which industrial wastes such as geofolymer concrete, SF and FA are used. Previous studies show that RCA Geo-polymer concrete has poor quality compared to NCA Geo-polymer concrete. The properties of RCA Geo-polymer improve with two types of diuretic bacteriya. Experimental investigations are performed to evaluate the improvement of compreessive strength, capillary water absorption and drying shrinkage of RCA Geo-polymer concrete incorporating bacteriya. The compreessive strength of RCA geofilmer concrete increases by 20% and 35% at cell concentrations of 106 cells / mL for both bacteriya. The capillary water absorption is reduced along with the drying of RCA when bacteriya are incorporated. The improvement of RCA Geo-polymer concrete is confirmed by bacteriyal mineral precipitation, as seen from microstructure studies.

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

I. INTRODUCTION

In India, the Central Pollution Control Board has estimated that solid waste production is around 48 million tonnes per year, of which 25% is from the construction industry. This scenario is not so different in the rest of the world. Recycling of gross geofilmer concrete is profitable and effective for the conservation of natural resources, to reduce construction waste.

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 geofilmer 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 geofolymer concrete, SF and FA are used.

The demolished Geo-polymer concrete can be used as a recycled coarse aggregate (RCA) to form new Geo-polymer concrete (RCA Geo-polymer concrete) by replacing partially or completely natural coarse Aggreegates (NCA). Various researchers have investigated the physical and mechanical properties of RCA Geo-polymer concrete and found that the mechanical strength of RCA Geo-polymer concrete is lower than that of conventional Geo-polymer concrete with NCA. This is due to the highly porous nature of RCA compared to NCA and the amount of substitution of NCA. The physical properties of RCA depend on the quantity of mortar adhered and its quality. The amount of mortar adhered depends on the process of crushing the parent's geophysical concrete. For these reasons, RCA shows greater porosity, greater water absorption, lower density, and lower strength than natural Aggreegates. Previous researchers reported that the compreessive strength decreased by up to 25% due to the above reasons.

II. LITERATURE REVIEW

The literature for the present study is widely reviewed in the direction of geofolymer concrete made from recycled materials for stability. The present study uses bacteriya for the improvement of RCA Geo-polymer Concrete. The present study investigates to assess the mechanical properties of RCA Geo-polymer concrete, SF Geo-polymer concrete and FA Geo-polymer concrete. The variability characteristics of geofolymer concrete made of SF and FA and its effect on fragility curves have also been investigated in this study. For presentation purpose, the literature review is divided into six sections:

i. Studies in RCA Geo-polymer Concrete,
ii. Studies on the application of bacteriya to improve the properties of common Geo-polymer concrete,
iii. Studies on the mechanical properties of SF and FA Geo-polymer concrete,
iv. Study of variability of common Geo-polymer concrete,
v. Studies on fragility curves,
vi. Review of experimental methods used in the present study.

Studies on RCA Geo-polymer concrete

*[Revathi et al. 2013]*Crushed Geo-polymer concrete that results from the demolition of old structures is generated nowadays in large quantities. The current annual rate of generation of construction waste is 145 million tonnes worldwide.

*[Revathi et al. 2013, Pacheco-Torgal et al. 2013]*The area required for land-filling this amount of waste is enormous. Therefore, recycling of construction waste is vital, both to reduce the amount of open land needed for land-filling and to preserve the environment through resource conservation.

*[Ameri and Behnood 2012; and Behnood et al. 2015]*It has been widely reported that recycling reduces energy consumption, pollution, global warming, greenhouse gas emission as well as cost.

*[Rahal 2007, Brito and Saikia 2013]*This in turn is beneficial and effective for environmental preservation, various researchers have examined about the physical and mechanical properties of the RCA and its influence when natural aggregate is replaced partially or fully by RCA to make Geo-polymer concrete. It has been found that the mechanical strength of the RCA Geo-polymer concrete is lower than that of conventional Geo-polymer concrete. This is due to the highly porous nature of the RCA compared to natural Aggreegates and the amount of replacement against the natural aggregate.

*[Amnon 2003 and Kang 2013]*The physical properties of the RCA depend mainly on the adhered mortar and generally RCA shows more porosity, more water absorption, low density and low strength as compared to the natural aggregate Geo-polymer concrete. It is reported that up to 25% reduction in compreessive strength has been occurred due to above reasons.

Barbudo et al. (2013) studied the influence of the water reducing admixture on the mechanical performance of the recycled Geo-polymer concrete. This study shows that use of plasticizers may improve the properties of recycled Geo-polymer concrete.

R. Rahal (2007) investigated the mechanical properties of recycled aggregate Geo-polymer concrete in comparison with natural aggregate Geo-polymer concrete.

Tabsh and Abdelfatah (2009) studied the behaviour of recycled aggregate and their mechanical properties. It is reported that the strength of recycled Geo-polymer concrete can be 10–25% lower than that of natural aggregate Geo-polymer concrete. It is reported that though the recycled aggregate are inferior to natural aggregate, their properties can be considered to be within the acceptable limits.

Kou et al. (2011) investigated the long term mechanical properties and pore size distribution of the recycled aggregate Geo-polymer concrete. It is reported that after 5 years of curing, the recycled aggregate Geo-polymer concrete had lower compreessive strength and higher splitting tensile strength than that of the natural aggregate Geo-polymer concrete.

Kou and Poon (2009) studied the self-compacting Geo-polymer concrete made from both recycled coarse and fine recycled aggregate. The different tests covering fresh, hardened and durability properties were investigated and the results show that both fine and coarse recycled Aggreegates can be used in self-compacting Geo-polymer concrete. The similar observation was also made by Grdic *et al.* (2010).

Li in (2009) has developed mix design for pervious recycled Geo-polymer concrete with compreessive strength and water seepage velocity as verification indexes. The Volume of voids is also tested for feasibility of new proposed mix design.

Fathifazl et al. (2009) proposed a new method of mixture proportioning for Geo-polymer concrete made with coarse recycled Geo-polymer concreteAggreegates. The new method was named as “equivalent mortar volume” in which the total mortar volume was kept constant.

Bairagi et al. (1990) proposed a method of mix design for recycled aggregate Geo-polymer concrete from the available conventional methods. It has been suggested that the cement required was about 10% more in view of the inferior quality aggregate.

*[Silva et al. 2015]*It has been reported that Geo-polymer concrete made with 100% recycled Aggreegates is weaker than Geo-polymer concrete made with natural Aggreegates at the same water to cement ratio (w/c) and same cement type. Many published literature, reported that RCA Geo-polymer concrete with no NCA reduces the compreessive strength by a maximum of 25% in comparison with NCA Geo-polymer concrete. A similar trend was observed in the case of tensile splitting strength and flexural strength.

III. EXPERIMENTAL METHODS - SETUP

Experimental Methods and Setup as per Indian Standards
All the experimental work done in this research only confirms the Indian standard. This section briefly describes the methods used to conduct the experimental program.

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. Three specimens are tested for a specific range, and the average compreessive strength of three specimens is considered to be the compreessive strength of the specified range.

Tensile Splitting Strength
Tensile partitioning capacity of Geo-polymer concrete as per IS: 516-1959 was found. Cylinders of size 150 × 300 mm and 100 × 200 mm are used to obtain tensile splitting strength of geofolimer concrete during the entire experiment.

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

Capillary Water Absorption
In the present study, capillary action through Geo-polymer concrete is largely found using Geo-polymer concrete cubes shaped in mm. After 28 days of curing and sequentially casting, the cubes are allowed to dry in an oven at 1050C until a constant weight gain is achieved. One dimensional water flow is maintained for the measurement of capillary action by coating the cube with epoxy resins, leaving the top and bottom surfaces.

Summary
The following primary objectives of this research are identified from a detailed literature review (discussed in Chapter 2) conducted on materials that can be used in Geo-polymer concrete by recycling for sustainability:

- To study the relationship of / w / c ratio and compreessive strength, the effects of age and recycling number on the properties of RCA Geo-polymer concrete.
- Study on the improvement of engineering properties of RCA Geo-polymer concrete using C bacteriya.
- Ice Investigate the mechanical properties of low to medium strength SF Geo-polymer concrete incorporated with 10% additional cement volume according to construction practice.
- To illustrate the variation in the properties of both F SF and FA Geo-polymer concrete.

Environmentally friendly and sustainability of engineering structures can be improved indirectly when more recycled waste materials are incorporated in Geo-polymer concrete. The first part of the present study focuses on the properties of Geo-polymer concrete made using RCA. The relationship between the water-to-cement (w / c) ratio and the compreessive strength of RCA Geo-polymer concrete has been studied to understand its behavior compared to ordinary Geo-polymer concrete. The effect of age and number of recycling are some parameters that affect the quality of RCA Geo-polymer concrete. There have been several experimental tests to investigate these issues.

Several studies have reported that mineral precipitation by bacteriya enhances the properties of ordinary Geo-polymer concrete. In order to enhance the properties of RCA Geo-polymer concrete, the compreessive strength, durability and compressibility of RCA Geo-polymer concrete mixed with bacteriya were investigated in the present study. Subsequent research on cement mortar incorporating B. sphaericus has been carried out to understand the effect of bacteriya on microarray analyzes and mortar properties. (All experimental tasks such as RCA preparation, bacteriyal culture, sample preparation, and testing are described in Chapter 3)

SF has been reported to improve the properties of Geo-polymer concrete due to its pozzolanic activity. Previous studies on SF Geo-polymer concrete have focused on Portland cement and high strength Geo-polymer concrete. International codes indicate a 10% increase in cement when using SF Geo-polymer concrete in construction. The present study investigated the mechanical properties of low-medium strength SF Geo-polymer concrete made using the above construction method using slag cement. Similar studies are also conducted using the FA. (Chapter 4 presents the mechanical properties of SF and FA Geo-polymer concrete).

Uncertainties in loading and the capabilities of construction members are missing. The fluctuating nature of the mechanical properties (compreessive strength, flexibility and tensile separation strength) can have a significant impact on the performance of structures. Probability distribution models that represent the fluctuating nature of simple Geo-polymer concrete are available in the literature. The present study sought to propose possible explanations of the mechanical properties of SF and FA Geo-polymer concrete using three statistical goodness of fit tests. Several two-parameter distributions were chosen to find the best-fit model that closely interprets the experimental data (this thesis describes the variation in the mechanical properties of SF and FA Geo-polymer concrete using different probability distribution functions). The proposed probability distributions are used to study the probability performance of simple buildings made of SF and FA Geo-polymer concrete in probabilistic framework work.

IV. CONCLUSION

The aim of the present work was to investigate the relation of w / c ratio with the compreessive strength of RCA Geo-polymer concrete, considering its age and number of recycling and the behavior of RCA Geo-polymer concrete in relation to capillary water absorption, drying shrinkage, air. Had to study.Material, flexural strength and tensile splitting strength. Experiments are conducted to study the above mentioned aspects and following are the major findings of the present study.

It is well known that the properties of Geo-polymer concrete made with RCA are lower than that of normal Geo-polymer concrete. The first part of this chapter discussed aspects such as the number of recycling and the age of RCA and its effects on the mechanical properties of RCA Geo-polymer concrete. The second part of this chapter presents the experimental results of increasing the mechanical properties of RCA Geo-polymer concrete using two types of urolitic bacteriya. The final part of this chapter examined the properties of cement and cement mortar that contained bacteriya. The main findings from each part of the study are summarized below.

The following main specific conclusions are define and drawn from current research:

- 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.
- The addition of Bacillus subsilis and Bacillus sphaericus improves the properties of RCA Geo-polymer concrete such as compreessive strength, capillary water absorption and drying shrinkage. Compreessive strength of RCA geofolimer concrete in 28 days b. About 21% for subtilis (B-3A) and B. An optimal cell increase is found with respect to the control of 36% RCA for Sphericus (B-3B). Concentration of 106 cells / ml. B. as calcite. Calcium carbonate precipitation by subtilis and B. sphaericus is confirmed through microstructure analysis using SEM, EDX and XRD. B. Subtilis and b. Sphericus RCA Geofolymer can reduce the drying shrinkage stress and capillary water absorption of concrete and thereby increase durability.
- To reach an optimal value at 20% G, the compreessive and splitting tensile strength of Geo-polymer concrete is gradually increased by an SF dose of 5%. A cap of about 21% is found at 20% replacement compared to previous studies. This cap can be attributed to the use of 10% excess cement. To reach an optimal value at 25%, the flexural strength of the geofilmer concrete prism increases gradually with the increase of the SF dose. Compared to previous studies a cap of about 10% is seen in 20% replacement.
- The present study proposes a description of the variation of mechanical properties such as compreessive strength, flexibility strength and tensile separation strength of SF and FA Geo-polymer concrete based on the three statistical goodness of Study Fit Test.
- Prob The seismic performance of selected common buildings using SF and FA Geo-polymer concrete in the framework of probability is estimated by the brittle curves and reliability indices, incorporating the proposed probability distributions. It has been found that 15% to 20% of the partial replacement of cement with SF and 20-40% of the partial re-installation with FA provides good seismic performance of the frames.

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