EXPERIMENTAL ANALYSIS OF GEOPOLYMER CONCRETE IN ADDITION WITH RECYCLED CONCRETE AGGREGATES

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ABSTRACT: 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.

Recycled Coarse Aggreegates (RCA) Geo-polymer concrete manufacturing technology can be called eop green Geo-polymer concrete ', as it reduces the environmental hazard of geopolar concrete waste disposal. 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 geofolymer concrete with different age groups is investigated. The number of recycling can affect the mechanical properties of RCA Geo-polymer concrete. 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.

Mix ratio was obtained as per Indian Standard IS: 10262-2009 with 10% excess cement when SF is used as per the construction practice. The optimal dose of SF, for maximum values of compreessive strength, tensile splitting strength and flexural strength over 28 days is determined. The results of the current study are compared to similar results available in the literature associated with Portland cement. The relationship is proposed as simplified equations between the simplified, tensile splitting and the flexural strength of SF Geo-polymer concrete.

Several studies on the construction of sustainable Geo-polymer concrete have promoted the use of industrial waste products such as SF and FA. The design of the structures, using such SF and FA Geo-polymer concrete, for acceptable safety, requires potential clarifications of its mechanical properties. For this purpose, an extensive experimental program on the compreessive strength, flexural strength and tensile separation strength properties of SF and FA Geo-polymer concrete has been carried out. The proposed probability distributions are used to study the performance of ordinary buildings made of SF and FA Geo-polymer concrete through seismic curvature and reliability indices.

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

I. INTRODUCTION

Diversity of physical properties can significantly affect structural performance and safety. Contrary to realism, this phenomenon is usually overlooked, as ume assumes the deterministic value of physical properties in traditional structural analysis and design. This analysis makes the analysis samples less realistic and less satisfactory. With the development of computing facilities, complex structural analyzes, including the probabilistic nature of the various parameters of the structure, are not difficult and necessary for its response against natural loads such as earthquakes and winds. Several studies on variation have been reported in the compreessive strength of Geo-polymer concrete. The variation of the compreessive strength of Geo-polymer concrete is usually represented by the normal distribution in the literature, even if the coefficient of variation does not exceed 15–20%, despite the slight curvature. However, when the coefficient of variation is high, the distortion is considerable and if the quality control is not good, a lognormal distribution is more rational to represent the tail regions of the distribution than a normal distribution. The latest study concludes that the variation of the compreessive strength of Geo-polymer concrete should be characterized using different statistical criteria and different distribution functions.

The inherent variability of cement and SF may not be the same in nature, as SF is a by-product in the carbothermic reduction of high-purity quartz with carbohydrous materials such as coal, coke, wood chips, in the production of silicon and ferrosilicon alloys. . Therefore, the existing literature on the variability of cement geologic concrete may not be useful to describe the variability of geophysical concrete with SF. One of the focus of the present study is to describe the variability of geofilmer concrete using SF that detects the best fitted probability distribution matching the experimental data. An attempt has been made to study the seismic behavior of typical RC structures through fragile analysis considering the variability of SF Geo-polymer concrete obtained from experiments.

FA, which is another material popularly used to supplement cement to produce geofolymer concrete. A part of the present study is also devoted to the investigation of the properties described above for FA Geo-polymer concrete.

Based on a detailed literature review (presented in Chapter 2), the main objective of the current research work was to investigate the properties of Geo-polymer concrete and its possible expansion using various alternative materials (RCA, SF and FA). The following are the sub-goals to achieve the main goal.

i. 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.

ii. To study the improvement of engineering properties of RCA Geo-polymer concrete using bacteriya.

iii. To investigate the mechanical properties of low- to medium-strength SF Geo-polymer concrete incorporated with 10% additional cement volume according to the construction tool.

iv. To elucidate the variability in the properties of both SF and FA Geo-polymer concrete and its implications in the seismic behavior of typical buildings by brittle analysis.

Scope

The following are the scope and limitations of the present study:

i. The current construction industry uses slag cement over ordinary Portland cement. 90% of the cement used in the Indian construction industry is slag cements. The current research, therefore, considers only slag cement for all studies.

ii. In the present study only low to medium strength geofolymer concrete is considered as this type of Geo-polymer concrete is more used than high strength geofilmer concrete.

iii. Only two parameter probability distributions are considered for the description of the variability of SF and FA geopolar concrete.

iv. Only three statistical goodness-of-fit tests, such as the Kolmogorov – Sinmarov, Chi-square, and Log – Likelihood tests, are used to evaluate the best – best likelihood distribution model.

<u>Experimental Methods and Setup as per Indian Standards</u>

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.

Figure 3.1Compreessive testing machine for Geo-polymer concrete

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.

Figure 3.2 Flexural testing machine for Geo-polymer concrete

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.

The cubes are immersed in water, and a minimum depth of immersion of 5 mm is maintained above the base of the cube. A gap of about 2 mm is maintained between the submerged face and underwater for good contact with water. The immersion periods are 0.5, 1, 2, 4, 6, 24, 48, 72 and 96 hours respectively.

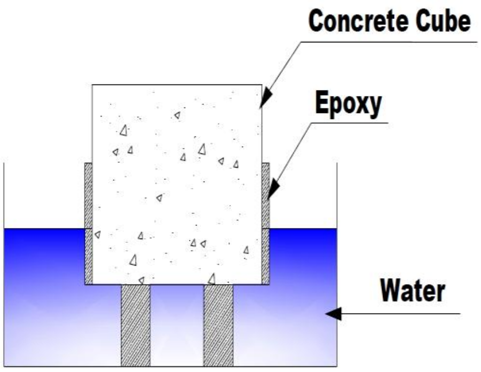
Capillary water absorption is measured by recording the respective weight of the cubes after continuous immersion. Capillary action is calculated using the following relation as a function of time.

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

where,

Δis 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 Specimensof Geo-polymer



(b) Schematic view of Capillary water concrete block absorption

(c) Geo-polymer concrete Specimens

Figure 3.3 Capillary water absorption test set up

Drying Shrinkage

Drying shrinkage test is used to measure the shrinkage of Geo-polymer concrete by determining the change in the length of the Geo-polymer concrete samples due to changes in moisture content. Initial drying shrinkage for RCA Geo-polymer concrete is measured in accordance with Indian Standard IS: 1199-1959. The Geo-polymer concrete prism is de-molded after 24 hours and kept in humid air for seven days. At the end of the moisture curing, the samples were kept in a water tank at 270 C for 20 days. After curing is completed, the length of the sample is measured in wet condition (to an accuracy of 0.005 mm). This length is called the actual wet measurement. The samples were then placed in an oven at 500 C for 44 hours. After this heating period, allow to cool for at least four hours. The reading taken after cooling is taken as dry measurements. Dry shrinkage is measured as the difference between the actual wet measurement and the final dry measurement.

Figure 3.4Dryingshrinkage test for Geo-polymer concrete

Air Content

The pressure method is used to measure air content in freshly mixed Geo-polymer concrete according to Indian Standard IS: 1199-1959. Freshly mixed Geo-polymer concrete is placed inside the bowl after tampering with a row. The required test pressure is slightly above 0.02 kg / cm2. At this moment, the initial height of the water is measured on the gauge glass of the graduated perfect bore tube or stand pipe. Then the test pressure is gradually released, and the final water height is measured. Air content is counted as a number:

$A = A1 - G$ ………(2.2)

Where,

A is the apparent air content in percent by volume of the Geo-polymer concrete, and is equal to the difference between the initial water height and the final water height. ‘G’ represents the aggregate correction factor, in percentage by volume of Geo-polymer concrete which is obtained as per IS: 1199-1959.

Figure 3.5Air content machine

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.

II. 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.

Future Scope

The following are the scope for expansion scenario of the present work:

- Code The present study can be extended to develop the required design code provisions for RCA Geo-polymer concrete to conform to the general Geo-polymer concrete.
- Concrete The current study considered RCA Geo-polymer to be two years, one year and two years old. This study can be extended to consider much older demolished geofolymer concrete to represent more realistic conditions.
- Strain This study can be extended to propose the stress vs. strain relationship of RCA Geo-polymer concrete considering age and number of recycling as different parameters.
- Stress versus strain relationship of G RCA Geo-polymer concrete incorporating bacteriyaGeo-polymer concrete is not available in the literature. This study can be continued in this direction.
- In the present study SF and FA from single source were used. The present study can be extended to develop variability descriptions between different sources.
- This study can be extended to make the bacteriyal Geo-polymer concrete to more commercial friendly.
- Cost benefit analysis can be studied for the use of recycled materials.
- A systematic guideline for designing a permanent geofiller concrete mix using SF RCA / SF / FA or mineral precipitated bacteriya can come separately through specific studies for each of these materials.

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