UTILIZATION OF RSM APPROACH IN OPTIMIZING AND DESIGNING A GEOPOLYMER CONCRETE A REVIEW

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ABSTRACT

Geopolymers are a class of new binder manufactured by activating aluminosilicate source materials in a highly alkaline medium. This binder is considered "environmentally friendly" due to the recycling of industrial waste sources such as fly ash and blast furnace slag.

In any case, to be generally utilized, this fastener needs to guarantee both quality and monetary proficiency. centers around the advancement of the sythesis of ground granulated impact heater slag and fly debris based geopolymers initiated by sodium silicate and sodium hydroxide arrangements. Soluble base actuated folios were first explored during the 1940s with the utilization of GGBS enacted with NaOH arrangement. In 1991, Davidovits created and protected fasteners acquired from the soluble actuation of metakaolin named "Geopolymer". The science of geopolymers is not quite the same as Portland concrete (OPC).In this paper presenting review of literature related to analysis of a RSM approach in geopolymer concrete.

Keywords: alkali-activated slag, fly ash, geopolymer, GGBS, optimization, Response Surface Methodology.

1. INTRODUCTION

It is notable that OPC is a fine powder got by crushing a combination of clinker, which is made by warming limestone, mud, and different materials like fly debris with a couple of percent of gypsum (CaSO4.2H2O) or anhydrite (CaSO4) to a high temperature (roughly 1450°C). The really restricting item, which is gotten from the hydration of clinker with water, is calcium silicate hydrate gels known as "C-S-H" gels. The development of C-S-H, which is an obviously undefined period of variable piece, is

mainly answerable for strength advancement and lattice arrangement in Portland concrete.

Dissimilar to Portland concrete, a salt initiated fastener can be integrated by openness of aluminosilicate materials to concentrated soluble hydroxide (NaOH, KOH) as well as salt silicate (Na2SiO3) arrangements, which are then relieving at room temperature or marginally raised temperature. Source materials for antacid enacted fastener amalgamation ought to be wealthy in silicon and aluminum. These could be normal minerals like kaolinite or metakaolin or one with an observational recipe containing Si, Al, and oxygen. Then again, result materials, for example, fly debris, silica rage, slag, rice husk debris, and red mud could likewise be utilized as source materials. The decision of forerunner for making a salt enacted folio relies upon variables like accessibility, cost, sort of utilization, and explicit interest of end clients.

Source materials for soluble base enacted folio union can be classed into two gatherings:

- first gathering: aluminosilicate materials, for example, metakaolin and class F fly debris produce N-A-S-H gel, likewise called poly(sialates) gel or "geopolymer" when initiated by a basic arrangement.

-second gathering: soluble base earth improved aluminosilicate materials, for example, impact heater slag and class C fly debris produce C-(A)- S-H gel like hydrated calcium silicate gel with high measures of tetracoordinated Al in its design, as well as Na+ particles in the interlayer spaces when enacted by an antacid arrangement.

LITERATURE REVIEW:

Chandra Prakash gour et.al (2022) Author aimed at producing eco-friendly concrete, which can be used for medium-grade strength, using recycled construction waste (RCA) as coarse and bone china fine aggregate (BCA) as fine aggregate. Workability, density, compressive, split tensile, and flexural strength are used to compare the fresh and hardened properties of the concrete. Experimental and statistical research is employed in the current study to evaluate the impact of RCA and BCA on the performance of concrete. To simulate all measurable responses, including workability, density, compressive, flexural, and split strength, RSM (response surface methodology) was utilized. The CCD (Central Composite Design) approach in RSM was used to create and analyse mixes in an experiment. Based on the experiment's results, mathematical models were designed and assessed using the analysis of variance test (ANOVA).

The analysis of variance results demonstrated the statistical significance of each constructed model. Three-dimensional response surface plots created using established regression models were used to investigate the interaction between the respective variables and to optimize the mixing ratio. The results indicate that the optimum utilization of RCA is up to 40% and BCA up to 60% as coarse and fine aggregate replacement in concrete, respectively, which not only helps to reduce costs but also offers sustainability. Finally, it was concluded that the generated models might be employed by obtaining the maximum tested features of concrete to assure a quick mix design approach. To conduct the microstructure study, thin section techniques were used to observe a strong aggregate-matrix interaction.

Mohsen Jafari Nadoushan et.al (2022) in the research paper, the fresh and hardened properties of AAS paste were optimized using the full factorial design of experiments and response surface methodology (RSM). Effects of the main factors including the type and concentration of the alkaline solution (AS), modulus of sodium silicate (MSS), and sodium silicate (SS) to AS ratio on the properties of AAS pastes were investigated experimentally.

The results displayed that among the considered factors, the SS to AS ratio and type of AS have the most impact on the improvement of compressive strength of the mixtures. Finally, the optimized mixture was obtained based on maximum compressive strength and flowability while targeting the minimum cost. This mixture contained a NaOH alkaline activator with a concentration of 6 molars, MSS of 2.29, and SS to AS ratio of 0.4.

Ankur C. Bhogayata and Shemal V. Dave (2021) in the research paper, the Taguchi method has been employed to obtain the HSAAC with the design target strength of more than 50 MPa. Several design mixes have been proposed and the selection process of the most effective combination has been established.

Ir was also observed that the microstructural bonding characteristics were largely influenced by the presence of the content of the hydroxide and the strength of the alkaline activators. The strength of the alkaline activators were influenced by the molar content of the sodium hydroxide. The solution of the activators plays a key role and therefore the balanced ratio of the sodium silicate and sodium hydroxide must be investigated with utmost care.

Hoang-Quan Dinh and Thanh-Bang Nguyen (2021) Research paper focused on the optimization of the composition of ground granulated blast-furnace slag and fly ash-based geopolymers activated by sodium silicate and sodium hydroxide solutions. Statistical models are developed to predict the compressive strength and cost of 1 ton of binder using Response Surface Methodology (RSM). In this regard, the effects of three principal variables (%Na2O, Ms and %GGBS) were investigated in which: %Na2O - mass ratio of Na2O in the alkali-activated solution and total solids; Ms - mass ratio of SiO2 and Na2O in the activated solution; %GGBS - mass ratio of ground granulated blast-furnace slag (GGBS), and total binder. Quadratic models were proposed to correlate the independent variables for the 28-d compressive strength and cost of 1 ton of binder by using the Central Composite Design (CCD) method.

The study reveals that Ms has a minor effect on the strength of mortar in comparison with %Na2O and %GGBS. The optimized mixture proportions were assessed using the multi-objective optimization technique. The optimal values found were %Na2O=5.18%, Ms=1.16, and %GGBS=50%, with the goals of maximum compressive strength, the largest amount of fly ash, and reasonable cost for one ton of binder. The experimental results show that the compressive strength of the samples ranged between 62.95-63.54 MPa and were consistent with the optimized results (the variation between the predicted and the experimental results was obtained less than 5%).

Mohammed S. Radhi et.al (2021) research paper investigated the possibility of producing geopolymer foam with high compressive strength and high porosity at the same time. The complexity of the structure, the variety of the process parameters, and the impure nature of the starting materials make it hard to optimize the preparation process of HGPF and to evaluate the influence of each processing parameter on the final conducted characteristics. Response Surface Methodology (RSM) has been utilized to examine the influence of the main process parameters, on the compressive strength, and the physical characteristics of the samples with final aim to optimize the preparation process. The study involved investigation of batch (0.2 of K2O). The studied parameters were (silica content,

water amount, OPC%, H2O2 %, and Olive oil %).

Results stated that Response Surface Methodology is a useful technique to experiments design and optimize the process of hybrid geopolymer foam synthesis. The K-ions substitution of Na-ions improves the compressive strength and increases the

porosity of the produced foam. Regulating the content of silica, water, OPC, H2O2, and olive oil is necessary to produce hybrid geopolymer foam with highest compressive strength and highest porosity, as well as to tailor the pores characteristics such as the amount and the pores size. The direct foaming combined method is suitable strategy to produce hybrid geopolymer foams having pores within micro and macro sizes and this feature makes the produced foams suitable for many applications.

S. Oyebisi et.al (2021) research paper investigated the fexural strength of Geopolymer Concrete (GPC) beams produced by Ground Granulated Blast Furnace Slag (GGBFS) and Corn Cob Ash (CCA). In the Design Of Experiment (DOE), Box-Behnken Design (BBD) of Response Surface Methodology (RSM) was used to optimize the strength. GGBFS was replaced at 0, 20, and 40 wt.% of CCA. The mixes were activated with 14 molar concentration (14 M) of both sodium silicate (Na2SiO3) and sodium hydroxide (NaOH) solutions. The mix design properties such as alkaline liquid-to-binder ratio, binder -to- aggregate ratio, binder ratio, and curing time were statistically employed as continuous (independent) variables to optimize the response factor (flexural strength).

Compared to the control sample (Portland cement concrete), GPC exhibited higher compressive and flexural strengths at up to 40 wt.% of CCA replacement. The models predicted the response of flexural strength with the variability of less than 5%. Moreover, the correlation between the experimental and optimized flexural strengths yielded high precision with 99.6% \R2". Therefore, the response models in this study would be advantageous in optimization of mix design proportions to obtain the target flexural strength of GPC beams produced by GGBFS and CCA.

Xiuzhi Zhang et.al (2021) research paper investigates the effect of supplementary cementitious materials (SCMs) on the fresh and mechanical properties of nano-silica modified cement-based materials (NSMCBM) based on the response surface method (RSM). Fly ash (FA), ground granulated blast-furnace slag (GGBFS), and silica fume (SF) were selected and the Box-Behnken design (BBD) method was used to design mix proportion. Besides, the quadratic term model was used to describe the relationship between independent variables and responses including fluidity, yield stress, plastic viscosity, thixotropy, and 3, 7, 28, and 56 d compressive strength. Based on the quadratic term model, the response surface of each response was drawn to understand the influence of SCMs. Results showed that FA had significant effect on fluidity and thixotropy while three kinds of SCMs had extremely significant effect on plastic viscosity. Response surface plot showed that NS could increase the plastic viscosity of NSMCBM to 1.445 Pa•s (M16). However, the addition of FA and GGBFS decreased the plastic viscosity to 0.9 Pa•s, which was comparable with the reference sample (M17). Such value was 37.7% lower than that of M16. Meanwhile, NS complemented the reduction of compressive strength caused by SCMs. Thus, the synergy effect of SCMs and NS could improve both fresh and mechanical properties. At last, multi-objective optimization was utilized to optimize the proportion of SCMs considering the interaction between SCMs to achieve desirable parameters.

Claver Pinheiro et.al (2020) The aim of research was the application of a response surface method to design the experimental work required to optimise the composition of an alkaline cement based on ladle furnace slag, a specific type of steel slag (SG). Fly ash (FA) was also added, in a precursor role, and the activation was achieved with an alkaline solution prepared with sodium silicate (SS) and sodium hydroxide (SH). The factors/variables considered were the activator index X = SS/ (SS + SH), the precursor index Y = SG/(SG + FA) and the SH concentration (Z). The output variables were the unconfined compression strength and the flexural strength, after 7 and 28 days curing.

Results indicate that the activator index (X) was the most influential variable, followed by the precursor index (Y). Microstructural analysis of selected pastes was also performed, using scanning electron microscopy and energy dispersive spectroscopy. The ideal composition obtained for the alkaline cement was the mixture constituted by X = 0.75, Y = 0.5 and Z = 10 (activator: 75% SS and 25% SH; precursor: 50% SG and 50% FA; SH concentration = 10 molal). This mixture achieved 8.70 MPa of flexural strength and 44.25 MPa of compressive strength which is reasonable for the required application (soil stabilisation).

My Ngoc-Tra Lam (2020) research paper presented the use of the Taguchi method to optimize the compressive strength of geopolymer mortars. The geopolymer was produced from fly ash as a prime material and ordinary Portland cement (OPC) as additive. Fly ash was partially replaced with OPC in the geopolymer mixtures to enhance the compressive strength. The dosage of OPC, the concentration of sodium hydroxide solution (SH), and the curing temperature were considered as the influencing factors on the compressive strength of geopolymer mortars. Three levels of each factor were chosen to carry out this research. As a result, the orthogonal array L9 of the Taguchi method was used to design the experiments. The results of the experiments were analyzed by the signal to ratio (SNR) and the analysis of variance (ANOVA).

This analysis has revealed that the least significant factor in terms of strength contribution is the dosage of OPC content, whereas the curing temperature is the most important factor in terms of strength contribution. This research shows that the optimized value of 7-day compressive strength was obtained in the mixture containing 20% of OPC that was prepared by SH of 12 M concentration and cured at 100oC. In addition, the geopolymer mortar produced by 30% of OPC and SH of 12 M concentration and cured at 100oC gained the maximum compressive strength at 28-day age.

Temitope F. Awolusi et.al (2019) research paper presented a comparative approach between Response Surface Methodology (RSM) and hybridized Genetic Algorithm of Artificial Neural Network (GA-ANN) in predicting the water absorption, compressive strength, flexural strength, split tensile strength and slump for steel fibre reinforced concrete. The
effects of process variables such as aspect ratio, water–cement ratio and cement
content were investigated using the central composite design of response surface
Methodology. The predicting ability of both methodologies was compared using the Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Model Predictive Error (MPE) and Absolute Average Deviation (AAD). Results inferred that RSM performs better in prediction when limited data are used for predicting several properties. In summary, the current study has identified RSM as a preferred option for modelling when several properties of a single product (in this case steel fibre reinforced concrete) are simultaneously investigated with limited experimental data. The study has provided regression models that could help in proportioning the constituents of concrete reinforced with steel fibre extracted from discarded tyres. The aim was to achieve SFRC with minimum water absorption, reasonable slump and improved mechanical properties. This serves as an alternative to industrial fibre which is relatively expensive and as well provides an avenue where a huge amount of waste tyres dumped in environments will be used in concrete for friendly disposal of waste tyres.

T. Revathi et.al (2018) Fly ash geopolymerisation reaction having complex chemistry between the precursors and Activating solution property that has been performed from the RSM suggested experimental design. The experimental values of compressive strength for the optimized process conditions are strongly corroborated with the model predicted attributes. Hence the advancement of statistical tools is useful to minimize the number of trials and predict the target performance of the Geopolymer products at large scale preparation. The application of RSM is unusual in the field of civil engineering particularly in the research of building materials preparation conditions.

CONCUSION:

In this paper we reviewed past publications and authors and determined the utilization of such approaches in construction industry. Following observations are as follows:

- To identify best design mix for maximum compressive strength.
- Surface plot will be generated by considering four factors.
- By conducting ANOVA test, the significant percentage of each factor will be identified.

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