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"Optimize the Mixed Proportions of Geopolymer Concrete to achieve Desired Strength by using RSM Method"

Naresh Gulati[1], Dr. M. P Verma[2], Dr. Raghvendra Singh[3], Ashish Kant Ahirwar[4]
[1]*Ph.D Scholar, Madhyanchal Professional University, (School of engineering) Bhopal, M.P., India*
[2, 4]*Faculty Department of Civil Engineering, School of engineering and technology, Madhyanchal Professional University Bhopal*
[3]*Prof. UEC Ujjain, Department of Civil Engineering"*

Abstract: GGBFS-FA-based GPC offers a clean and sustainable development technology alternative. In this study, the RSM method was used to optimize the mixed proportions of geopolymer concrete to achieve desired strength criteria. Four factors and four levels were considered: binder content, including four combinations of FA and GGFBS dosage, dosage of super plasticizer (0.5, 1.0, 1.5 and 2%), Na2SiO3/NaOH ratio (1.5, 2.0, 2.5 and 3), and molarity (6, 8, 10 and 12). Using these ingredients and factors, the effect of compressive strength was examined. The RSM approach using an L16 orthogonal array was employed to find the optimum condition of every factor while limiting the number of experiments.
The findings indicated that the optimum synthesis conditions for maximum compressive strength obtained from the binder comprised 45% of FA, 45% of GGBFS and 10% of silica fume, 1.5% dosage of super plasticizer.
Keywords: geopolymer concrete; fly ash; mix design; RSM; silica fume; Minitab

I. INTRODUCTION

A. General

Concretes with various purposes have become more popular as urban building has progressed at a fast pace. Researchers have evaluated several types of concrete that are commonly used, including heavy concrete, self-compacting concrete. GPC is a potential green construction material that is also cost-effective. The by-products of the polymerization processes are known as geopolymers involving alkali activators and aluminosilicate-rich materials

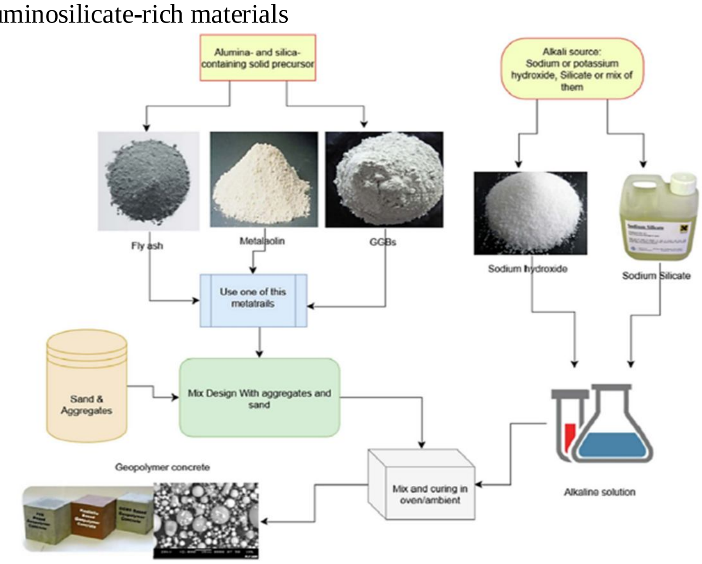

Fig 1 GPC manufacturing

B. Objectives of the Study

To develop a response surface model and determine the optimum mix design for geopolymer concrete using multi-objective optimization of response surface methodology.

II. LITERATURE REVIEW

Abiola Adebanjo et.al (2023) in the research paper, Soft computing methods were used to design and model the compressive strength of high-performance concrete (HPC) with silica fume. Box-Behnken design-based response surface methodology (RSM) was used to develop 29 HPC mixes with a target compressive strength of 80±10 MPa.

Cement (450-500 kg/m3), aggregates (1500-1700 kg/m3), silica fume (SF) (20-45% weight of cement) and water-binder (w/b) ratio of (0.24 - 0.32) were provided as input factors while the compressive strength at 7 and 28 days were analysed as responses. Datasets for the artificial neural network (ANN) prediction were generated from 87 experimental observations from the compressive strength test.

A. S. Srinivasa et.al (2023) research paper reported the work on developing an optimized mix proportion of novel one-part geopolymer (OPG) binder produced by dry blending the solid aluminosilicate precursor and solid alkali source and then adding free water to the blended mix similar to the preparation of Ordinary Portland Cement (OPC). A three-level Box-Behnken Response Surface Method (RSM) design was used to study the properties of OPG mixes at fresh and hardened state and to test and develop the regression models

The detailed experimental programmer design of in this chapter. It covers materials concrete component testing, mix proportioning, experiment details, and test sets, among other things.

III. MATERIALS

1) Cement
2) Sand
3) Aggregate
4) Fly ash
5) Silica Fume (SF)
6) Geopolymer
7) Water

Response surface methodology is a popular mathematical and statistical method for experimental design. The response of interest is affected by several variables, and the objective of this method is to optimize the response. RSM investigates to establish an appropriate relationship between input and output variables and understands the optimal operating condition for a system under research. Or in other words, this technique investigates the effect of the independent variables (Factors) over the response/output, either alone or in combination. The main idea of RSM is to use a sequence of designed experiments to obtain an optimal response. RSM, being a statistical approach, has been extensively employed to maximize the production of certain substances by optimizing the variables that participate in the operation. Design of Experiments (DOE) has been used extensively for this optimization using RSM.

A. Design Of Experiments, DOE

Design Of Experiment (DOE) is a multipurpose mathematical methodology that has been used for planning and conducting experimental programs. DOE (Design Of Experiments) is a branch of applied statistics that are used to perform scientific studies of a system, process, or product in which input variables (Xs) were manipulated to investigate its effects on measured response variables.

1) In the Engineering and Research environment, experiments are often conducted to explore the relationship between the key input process variables (factors) and the output performance characteristics (that define the quality of the material), estimate the relationship, and confirm. Exploring includes understanding data from the process, whereas estimating refers to determining input variables' effects on the response characteristics. The confirmation step verifies the predicted results obtained from the experiments.
2) One of the very popular scientific methods employed by many engineers until the 19th century was OVAT-one variable at a time. In this method, one variable was varied, keeping all other variables fixed in an experiment. However, this approach was later considered inefficient, unreliable, and time-consuming as this largely depends on other factors such as guesswork, luck, experience, etc.

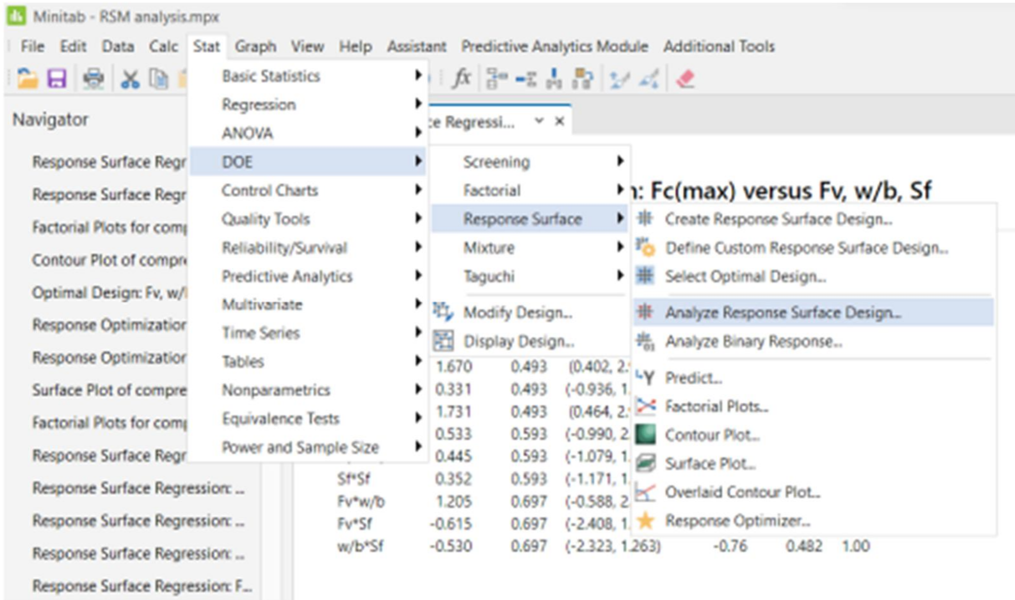

Fig 2 Response surface analysis using Minitab

Table 1 Experimental runs for the possible combinations of the factors generated by Minitab

Run Order	Fv	w/b	Sf
1	3.5	0.21	21
2	3	0.22	24
3	3.5	0.19	27
4	3	0.18	24
5	2.5	0.19	21
6	4	0.2	24
7	3	0.2	30
8	3.5	0.19	21
9	3	0.2	18
10	2.5	0.21	21
11	3.5	0.21	27
12	2	0.2	24

IV. RESULT AND DISCUSSION

A. Response Surface Model

As part of the examination of the study's data, RSM is used to both evaluate and develop models for response prediction. The responses that are being taken into account are the mechanical properties (compressive, flexural, and tensile strengths). To create empirical data on the responses at 7 and 28 days, experimental runs were built using the central composite (CCD) alternative. These data were derived from the experimental runs themselves.

CS= +16.86 + 4.19*A – 1.72*B
FS= +2.33 + 0.2530*A – 0.2426*B
TS= +0.2700 + 0.0605*A – 0.0736B – 0.0270*A*B + 0.0105*A2 + 0.0355B2

B. Analysis of Variance of the Response Model

The coefficient of determination (R2) is the most crucial variable since it indicates how well the constructed model fits the experimental data. It is to be known that when the R2 value is higher better model will be produced. These can be written in percentage or expressed as $0 \leq R2 \leq 1$. R2 values of 92%, 72%, and 99% are achieved for the developed models in this case for the compressive, flexural, and tensile strength of the models, respectively. Moreover, the signal-to-noise ratio of a model can be quantified with the help of the Adequate precision (Adel. Press.) Value. A ratio greater than 4 is desirable and can be used to navigate the design space for a model. Based on the model validation the adequate precision value which was obtained are 20.0219, 10.6227, and 43.9728 for compressive, flexural and tensile strength.

The study was carried out with a 95% level of confidence, which means that any model or model term with a probability of less than 5% is statistically significant. Since all three models had probability values of less than 5%.

Table 2 Minitab Results

Response	Source	Sum of Squares	df	Mean Square	F-value	p-value	Significanc e
Compressive Strength (MPa)	Model	164.01	2	82	54.07	< 0.0001	significant
	Residual	15.17	10	1.52			
	Lack of Fit	15.17	6	2.53			
	Pure Error	0	4	0			
	Cor Total	179.17	12				
Flexural Strength (MPa)	Model	0.9828	2	0.4914	13.03	0.0016	significant
	Residual	0.3772	10	0.0377			
	Lack of Fit	0.3772	6	0.0629			
	Pure Error	0	4	0			
	Cor Total	1.36	12				
Tensile Strength (MPa)	Model	0.0846	5	0.0169	204.48	< 0.0001	significant
	Residual	0.0006	7	0.0001			
	Lack of Fit	0.0006	3	0.0002			
	Pure Error	0	4	0			
	Cor Total	0.0852	12				

Actual vs. Predicted comparisons for the compressive, flexural and tensile strength of the models respectively, which will be used to further evaluate the models' strengths. The graphs illustrate the relationship between the experimental data and the predicted outcome of the generated models. The way the data points line up along the 45 lines of fit shows that the predicted response and the actual response are pretty close to each other. As a result, the models' strength and accuracy are validated.

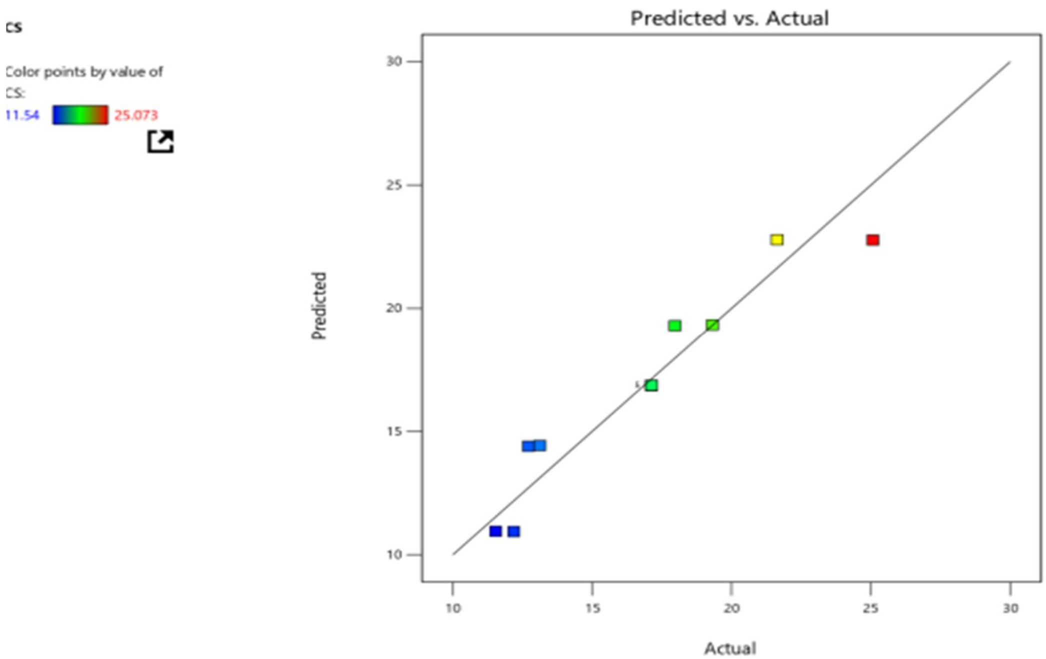

Fig 3 Actual vs Predicted Graph for Compressive Strength

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V. CONCLUSION AND FUTURE SCOPE

The responses were empirically modelled as linear function for compressive and flexural and as quadratic functions for tensile. The models were validated using Minitab, and the results showed a high level of accuracy (R2 values between 72.0 and 99.0%). According to the results of the response surface modelling, the optimum mechanical qualities of GGBS concrete can be achieved by combining 30% crumb rubber with 14M sodium hydroxide. GGBS 80+FA 10+ SF 10.

REFERENCES

[1] Claver Pinheiro, Sara Rios, António Viana da Fonseca, Ana Fernández-Jiménez and Nuno Cristelo, [Application of the response surface method to optimize alkali activated cements based on low-reactivity ladle furnace slag], Construction and Building Materials 264 (2020) 120271.

[2] Chandra Prakash Gour, Priyanka Dhurvey and Nagaraju Shaik, [Optimization and Prediction of Concrete with Recycled Coarse Aggregate and Bone China Fine Aggregate Using Response Surface Methodology], Journal of Nanomaterials, Volume 2022, Article ID 2264457, 11 pages.

[3] Temitope F. Awolusi, Oluwaseyi L. Oke, Olufunke O. Akinkurolere and Olumoyewa D. Atoyebi, [Comparison of response surface methodology and hybrid-training approach of artificial neural network in modelling the properties of concrete containing steel fibre extracted from waste tyres], Cogent Engineering (2019), 6: 1649852.

[4] My Ngoc-Tra Lam, [Using the Taguchi method to optimize the compressive strength of geopolymer mortars], International Journal of Advanced and Applied Sciences, 7(8) 2020, Pages: 1-10.

[5] Mohsen Jafari Nadoushan, Pooria Dashti, Sajad Ranjbar, Ali Akbar Ramezanianpour, Amir Mohammad Ramezanianpour and Rasoul Banar, [RSM-based Optimized Mix Design of Alkali-activated Slag Pastes Based on the Fresh and Hardened Properties and Unit Cost], Journal of Advanced Concrete Technology Vol. 20, 300-312, April 2022.

[6] Mohammed S. Radhi, Ahmed M. H. Al-Ghaban and Imad A. D. Al-Hydary, [RSM Optimizing the Characteristics of Metakaolin based Geopolymer Foam], Journal of Physics: Conference Series 1973 (2021).

[7] S. Oyebisi, H. Owamah, and A. Ede, [Flexural optimization of slag-based geopolymer concrete beams modied with corn cob ash], Scientia Iranica A (2021) 28(5), 2582{259.

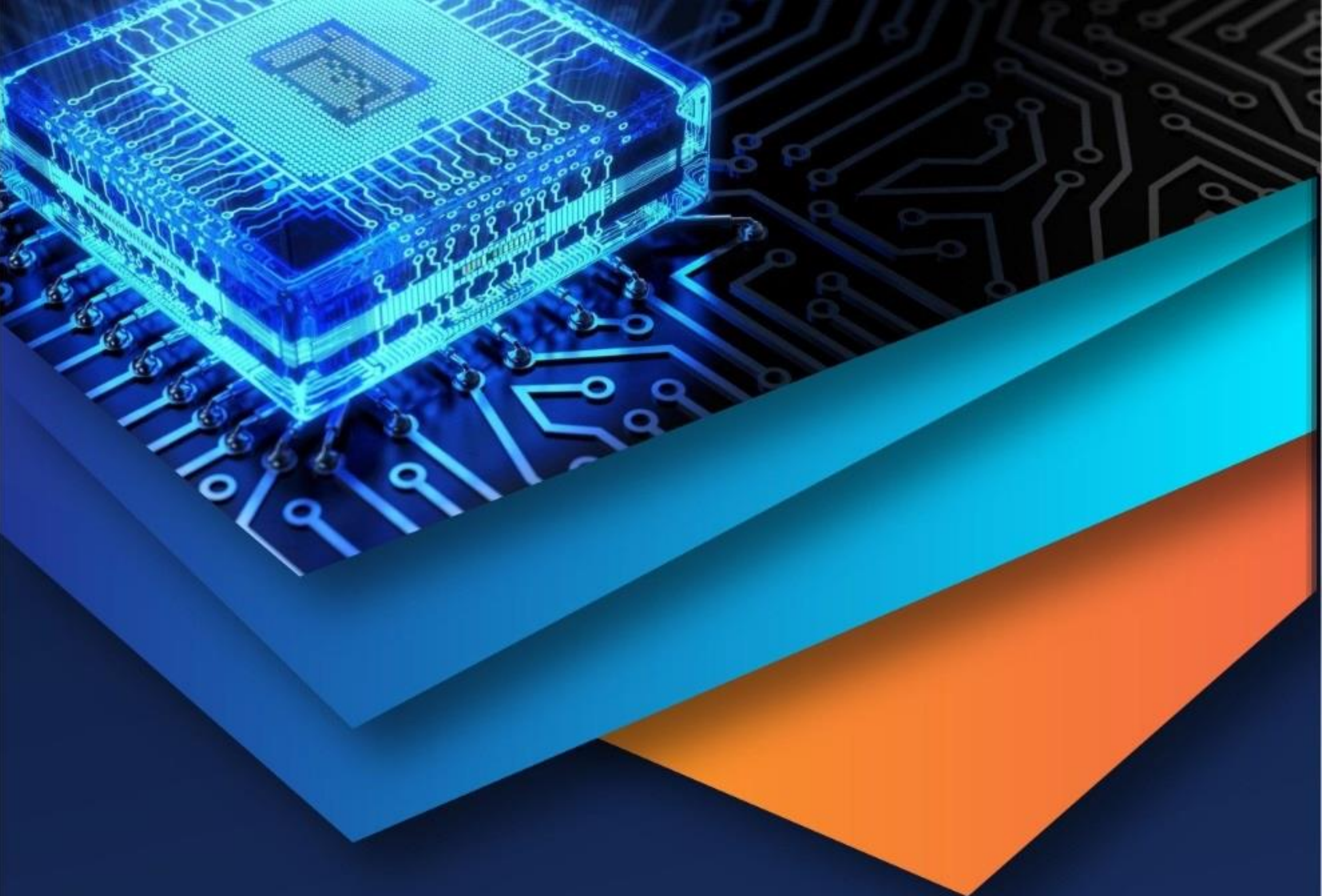
[8] Hoang-Quan Dinh and Thanh-Bang Nguyen, [Composition of ground granulated blast-furnace slag and fly ash-based geopolymer activated by sodium silicate and sodium hydroxide solution: multi-response optimization using Response Surface Methodology], march 2021 • Volume 63 Number 1.

[9] T. Revathi, R. Jeyalakshmi, N. P Rajamane and J Baskarasundararaj, [Application of Response Surface Methodology: Optimum Mix Design of Fly ash geopolymer mortar, a Portland cement free binder for sustainable construction], International Journal of ChemTech Research, Vol.11 No.01, pp 13-22, 2018.

[10] Ankur C. Bhogayata and Shemal V. Dave, [Utilization of Taguchi Method of Optimization in the Mix Design Development of High Strength Alkali Activated Concrete], International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 10 Issue 10, October-2021.

[11] Xiuzhi Zhang, Liming Lin, Mengdi Bi, Hailong Sun, Heng Chen, Qinfei Li and Ru Mu, [Multi-Objective Optimization of Nano-Silica Modified Cement-Based Materials Mixed With Supplementary Cementitious Materials Based on Response Surface Method], October 2021 | Volume 8 | Article 712551.

[12] C.J. Shi, A. Fernández-Jiménez, A. Palomo. New cements for the 21st century: the pursuit of an alternative to Portland cement. Cement and Concrete Research, 2011, 41,750.



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