Parameter Optimization on Compressive Strength of Polyproplene Fiber Concrete

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Abstract- *The intent of this study was to apply of Taguchi Design of Experiments (DOE) in the compressive strength of slag based geopolymer composite with polypropylene fiber. Generally, a large number of experiments were usually required as to decide a suitable mixture for finding the needed requirements of polypropylene fiber concrete. For that purpose, Taguchi's approach with an L27 orthogonal array and three-level factor to reduce the numbers of experiment was adopted. Five control factors, namely, contents of binder material type, binder percentage, Polypropylene fibers aspect ratio, and polypropylene fibers percentage were used. Three responses (workability, strength, cost) were evaluated. The Taguchi orthogonal array gives the best possible outcomes in less experimental trial. The obtained results were evaluated by analysis of variance (ANOVA) method to determine the optimum level of each factor.*

Keywords- Geopolymer; ANOVA; Design of experiment (DOE).

I. INTRODUCTION

Geopolymers are cement-free eco-friendly construction materials with much lower of carbon dioxide release than traditional ordinary Portland cement (OPC) concrete. Geopolymers are the product of alkali activation of analuminosilicate source. A wide range of raw materials such as fly ash, slag, rice husk ash, silica fume and volcanic ashes, individually or together, are used as the aluminosilicate source. Due to its low price and availability ground granulated blast slag (GGBS), fly ash is the most attractive source for production of aluminosilicategeopolymers.. Regardless of the aluminosilicate source, geopolymersmaybe of interest for reinforcing and their worldwide future usage needs more special attentionin this area.

Reduction of CO2 released during the production of cement is major issues of construction industry. In this work behavior of M40 grades of concrete is studied by varying different parameters such Binder type fly ash (FA), ground granulated blast slag (GGBS) Taguchi method of design of experiments was used to determine the optimum mix proportions of concrete with minimum cement content. A standard L27 orthogonal Array (OA) was selected for the experimental programmed with five parameters at four levels, giving rise to a total of 76 trial mixes. Therefore, tewel trial mixes were chosen for casting and testing in each case, i.e. for each concrete grade and pozzolana type. Results were analyzed manually as well as by Taguchi method in terms of Signal to Noise ratio (S/N). Influences of the parameters on concrete mixes obtained in both cases are comparable to each other. The study showed that both mineral and chemical admixtures can be effectively used to reduce the cement content in concrete. For the materials and range of parameters used in this research the present study has established optimum mixes both in terms of target strength and workability using Taguchi method.

Fiber Reinforced Concrete (FRC) may be defined as composite materials made with Portland cement, aggregate, and incorporating discrete discontinuous fibers. The use of polypropylene fibers has increased tremendously in construction of structures because addition of fibers in concrete improves the toughness, flexural strength, tensile strength and impact strength as well as failure mode of concrete. Polypropylene twine is cheap, easily available, and like all manmade fibers of a consistent quality. Concrete is a mixture of cementatiousmaterial, aggregate, and water. Aggregate is commonly considered inert filler, which accounts for 60 to 80 percent of the volume and 70 to 85 percent of the weight of concrete. Aggregate is classified as two different types, coarse and fine. Coarse aggregate is usually greater than 4.75 mm, while fine aggregate is less than 4.75 mm. but for fine aggregate, there is alternative material is available, which is artificial crush sand. [11]

This research therefore studies the effects of polypropylene fiber in improving concrete strength. The main focus being on the optimal quantity of polypropylene fiber for improved compressive strengths of concrete. Destructive and non destructive tests were carried out on the samples after 7 and 28 days of curing. Compressive strength tests were performed on the polypropylene fiber concrete. The results of the test samples are then accessed via statistical tools. [7]The

Setting time, workability & Compressive strength of geopolymer concrete and paste were investigated in the available literature Rao and Rao

The main objective of this study is to evaluate statistically the effects of various binding material, their amounts, different polypropylene fiber volume fractions and different aspect ratio on the compressive strength of polypropylene fiber concrete. These parameters are optimized by using Taguchi experimental design and analysis techniques. As a result an optimal combination of the parameters resulting in the highest compressive strength is determined.

II. REVIEW FROM LITERATURES

The result of an experimental investigation carried out to optimize the mix proportions of the fly ash brick by Taguchi method of parameter design. L9 orthogonal array with four factors and three levels. The effects of water/binder ratio, fly ash, coarse sand, and stone dust on the performance characteristic are analyzed using S/N ratios and mean response data. Finally as water/binder ratio and stone dust play the significant role on the compressive strength of the brick.The use of replacement materials in Portland cement has been gaining much attention in recent years. Given the world situation with respect to cement demand and the cost of energy, binders such as ground granulated blast-furnace slag (GGBS) and pulverized fuel ash (PFA), rice husk ash (RHA) can be used. In blended cements, the replacement material may take part in the hydration reactions and contribute to the hydration products. [10]

There has been a developing enthusiasm for using fibers as support to create composite materials. Researchers lean toward thermoplastic polymeric lattices than thermo sets because of the low generation cycle, lower expense of preparing and high reparability of thermoplastics. Different natural fibers are generally utilized as support as a part of thermoplastic polypropylene (PP) matrix material to get ready composites [1].The utilization of regular fiber polypropylene composite materials in basic applications expanding in the most recent years due to their points of interest in bio degradability, recyclability, ease, ecofriendly and low thickness[2]

III. TAGUCHI METHODS AND RESEARCH MODEL

Taguchi DOE method is a statistical method developed by Genichi Taguchi during the 1950s as an optimization process technique. Taguchi's approach to parameter design provides the design engineer with a systematic and efficient method for determining near optimum design parameters for performance and cost. The first concept of Taguchi that must be discussed is the ''noise factors". The signal–to-noise ratio (S/N) is used in evaluating the quality of the product. The S/N measures the level of performance and the effect of noise factors on performance and is an evaluation of the stability of performance of an output characteristic. [7]

The objective of DOE is to find a set of parameters which gives optimal solution for the process and save the time. Taguchi gives a special design of orthogonal arrays (OA) to study the entire parameter set with a small number of experiments. He recommends the use of the loss function to measure the performance characteristics deviating from the desired value. The value of the loss function is further transformed into a signal-to-noise ratio (η). Generally, three standard S/N equations are widely used to classify the objective function as: 'larger the better', 'smaller the better', or 'nominal the best'. (6)

IV. PHILOSOPHY OF THE TAGUCHI

The philosophy of Taguchi approach is based on three fundamental concepts and has greatly caused the better application and development of techniques and technology in numerous industries these concepts are [2]

- Quality should be designed into the product and not in its inspection.
- To achieve the quality it is best to minimize the deviation from the target and product shall be designed to be insensitive to the uncontrollable environmental factors.
- The cost of quality is measured as a function of deviation from the standard and the losses should measure the system-wide.

V. METHODOLOGY

The steps involved in optimization of process parameters using Taguchi methods are mentioned below:

Step-1: Find out main function, face effect and way of failure.
Step-2: Find out the noise factors, condition where testing is performing and quality characteristic.
Step-3: Identify the purpose to be optimized.
Step-4: Find out the controllable factor and their levels.
Step-5: Select the orthogonal array matrix experiment.
Step-6: Conduct the experiment.
Step-7: Then data is analyzed; predict the optimum levels and the performance quality for responses.

An OA is a fractional factorial design with pair wise balancing property and the effects of multiple process variables on the performance characteristic can be find out with minimizing the number of test runs. Figure 1 shows an L27 (3 x 13) standard orthogonal array as shown in figure 2.

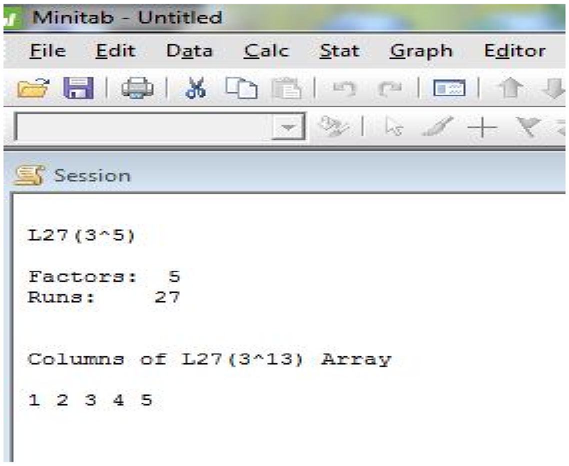


Fig 1: Factors and experimental run count

The responses of experimental run are used to determine the corresponding S/N ratio. The S/N ratio is characterized into three:

SN = log (average value/variance) dB

1. The larger the better

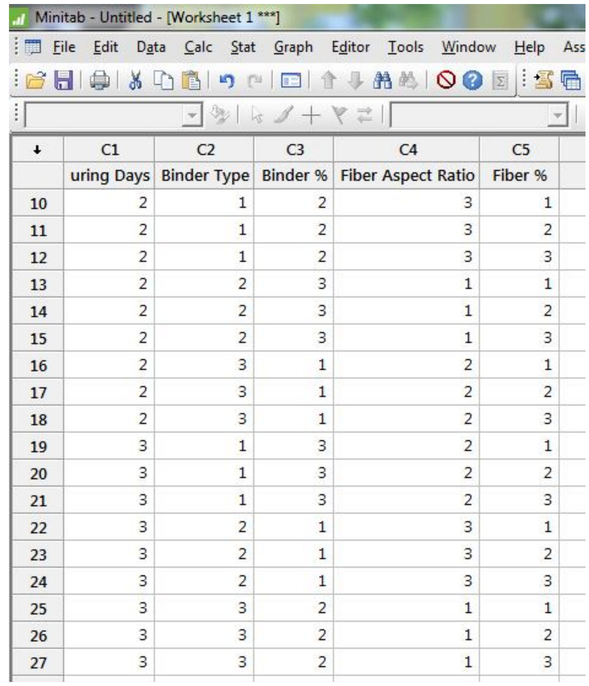
$$S/N = -10\log_{10}\left(\frac{1}{n}\sum_{i=1}^{n}\frac{1}{Y_i^2}\right)$$

2. The smaller the better

$$S/N = -10\log_{10}\left(\frac{1}{n}\sum_{i=1}^{n}Y_i^2\right)$$

3. The nominal value preferred

$$S/N = -10\log_{10}\left(\frac{1}{n}\sum_{i=1}^{n}(Y_i - Y_0)^2\right)$$



	C1 uring Days	C2 Binder Type	C3 Binder %	C4 Fiber Aspect Ratio	C5 Fiber %
10	2	1	2	3	1
11	2	1	2	3	2
12	2	1	2	3	3
13	2	2	3	1	1
14	2	2	3	1	2
15	2	2	3	1	3
16	2	3	1	2	1
17	2	3	1	2	2
18	2	3	1	2	3
19	3	1	3	2	1
20	3	1	3	2	2
21	3	1	3	2	3
22	3	2	1	3	1
23	3	2	1	3	2
24	3	2	1	3	3
25	3	3	2	1	1
26	3	3	2	1	2
27	3	3	2	1	3

Fig 2: Orthogonal array

VI. EXPERIMENTAL PROGRAM

Material

The mix design of M40 is developed by the B.G.Shirke construction company, Pune.The material used for geopolymerconcret is this study were ground blast furnace slag (GGBS) Fly ash (FA). Course aggregate with a aggregate size 10mm and 20mm And The river sand as the fine aggregate were used in this study. The polypropylene fibers of different length (6mm, 20mm, 24mm).

Test and Specimens

A Geopolymer concrete specimen is prepared by mixing the dry material in a pan mixer. It should be noted that the mixing procedure may affect the compressive strength and workability of the geopolymer concrete. The dry materials were mixed for about 1 min and then added the water and admixture in pan mixer.

The mould cubes were casted of size 150mm*150mm*150mm to measure the compressive strength. The specimens were cast in three layers and in each layer compact by the tamping rod. The specimens were keeping in laboratory for 24 hrs. After completation of 24 hrs the cubes were removed from the mould and keep it for curing.

VII. CONCLUSION

From literature review showed that Taguchi method can be used efficiently and economically for designing the experiments and for determining the optimum process parameters. The experimental data is analyzed using Taguchi method for optimal conditions of input parameters. ANOVA carried out on experimental data to find the significant effect of the input parameters. evaluate statistically the effects of various binding material, their amounts, different polypropylene fiber volume fractions and different aspect ratio on the compressive strength of polypropylene fiber high strength concrete. The statistical analysis is carried out by the ANOVA.

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