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OVERVIEW ON L9 TAGUCHI OPTIMIZATIONAL METHOD

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ABSTRACT

This paper presents the results of an experimental investigation carried out to optimize the mix proportions of the concrete by the Taguchi method of parameter design. The concrete mix design is done by the L9 orthogonal array that is 34. When a new material is used in the concrete all the mix variables are taken into account so that it may cost so much, it means more need for money, material, personnel and time. In order to reduce the number of mix combination in concrete, the Taguchi method is used. In this project the cement sand and aggregate are partially replaced by cement as fly ash, river sand as M-sand and the compression values are taken and the value is compared with the conventional concrete special concrete compression value is compared with the conventional concrete and S/N value is taken from the compression value and the comparison of the values are done. In order to attain good strength and to avoid cracks, sisal fiber is added in the concrete with a percentage of (1, 1.5, and 2).

Keywords: optimization, compressive strength, fly ash brick, Taguchi method, sisal fiber.

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1. INTRODUCTION

In this, the Taguchi method are used to optimize the combination of a selected parameters because it has so many numbers of combination that is a full factorial method and it is difficult to do project so that Taguchi method are used to optimize the number of combinations to make the project cost-effective. The concrete mix designs are done by the L9 orthogonal array that is 34. When a new material is used in the concrete all the mix variables are taken into account so that it may cost so much, it means more need for money and material, personnel, time. In order to reduce the number of mix combination in concrete, the Taguchi method is used in this the materials are partially replaced with cement to fly ash, Sand to m-sand, and coarse aggregate is replaced by the selected percentage and sisal fiber is added to avoid the cracks fiber is mixed with the concrete and cubes are casted.

The concrete cube should be properly cast and the compaction should be done properly so that no air bubbles will not be present inside the concrete cube. After the concrete cube are cast. The cube is cured and they are tested for 7 days, 14 days and 28-day compression test. This teste is done in a compression machine. The results of an experimental investigation carried out to optimize the mix proportions of the concrete by the Taguchi method. The compression values that is conventional concrete and special concrete compression value are compared with the conventional concrete so that we will get a compression graph and S/N value is taken from the compression mean value. The mean value and the S/N values are plotted in the graph so the graphs are compared and we can get a final value.

2. MATERIAL PROPERTIES

2.1. Cement

Ordinary Portland cement (7.5 Grade) was used in all test specimen. Properties are tested by referring IS 12269-1987. The specific gravity of cement was 3.13. Standard consistency of cement is 34%. The fly ash was used as a partial replacement of cement by different proportions.

2.2. Fly ash

Fly ash is one of the binding materials used in this project with cement and it is partially replaced with cement.

2.3. Fine Aggregates

The fine aggregate utilized was the normal sand free from pollutions and passing through 4.75 mm IS sieve. The specific gravity was found to be 2.65, and the fine aggregate is partially replaced with M-sand.

2.4. Coarse Aggregates

The locally available course aggregate passing through 20 mm IS sieve and retained on 10 mm IS sieve was used. The specific gravity of coarse aggregate was found to be 2.8.

2.5. Fibers

In this study sisal fiber is used for the project and these fibers are taken from the cactus plant leaf and its fibers are added with the percentage of 1, 1.5 and 2.

3. METHODOLOGY

Taguchi method is a powerful tool for optimizing the performance characteristic of a process. The aim of a parameter design experiment is to identify and design the settings of the process parameters that optimize the chosen quality characteristic and they are least sensitive to noise factors. In the present study, the goal of the project is to evaluate the effects of process parameters on the performance measure and the optimum combination of control factors that would maximize the compressive strength, of the concrete (prepared in the laboratory), which is chosen as the quality characteristic.

Selection of control factors and their levels are made on the basis of some literature review on the subject. Four control factors such as water/binder–ratio, fly ash, m-sand, and sisal fibers are selected for the study. Each of the four control factors is treated at three levels. The choice of three levels has been made because the effect of these factors on the performance characteristic may vary.

An orthogonal array is a fractional factorial design with pairwise balancing property. Using array design the effects of multiple process variables on the performance characteristics can be estimated simultaneously while minimizing the number of the test run. An L9 (34) standard orthogonal array is chosen for the present investigation S/N ratios are three types, i.e. the smaller is the better, the higher is the better, and the nominal is the finest. The formula utilized to design for analyzing S/N percentage, it is shown below.

3.1. Smaller is better

It is chosen when the goal is to minimize the response. The S/N can be calculated for smaller the better

$$\frac{S}{N} ratio = -10\, log_{10}\, \frac{1}{n}\sum_{i=1}^{n} yi^2$$

3.2. Larger is better

It is chosen when the goal is to maximize the response. The S/N is calculated for larger the better.

$$\frac{S}{N} ratio = -10\, log_{10}\, \frac{1}{n}\sum_{i=1}^{n} \frac{1}{yi^2}$$

3.3. Nominal is better

It is chosen when the goal us to target the response and it is required to base the S/N on the standard deviation only. The S/N is calculated for smaller the better.

$$\frac{S}{N} ratio = -10\, log_{10}\, \frac{1}{n}\sum_{i=1}^{n} (y_i - y_0)^2$$

4. RESULT AND DISCUSSION

The universal testing machine has been used to measure the compressive strength of the concrete specimens. The three compression readings are recorded for each combination as shown in Table 6. These parameters are taken from a designed experiment to analyze the mean function.

Parameters and levels

Factors		Level 1	Level 2	Level 3
Water/ binder ratio	A	XX	XX	XX
Fly ash (%)	B	XX	XX	XX
M Sand (%)	C	XX	XX	XX
Sisal Fiber (%)	D	XX	XX	XX

Table 2 Full factorial orthogonal array for L_9

Experimental No.	Factor A	Factor B	Factor C	Factor D
1	1	1	1	1
2	1	1	2	3
3	1	1	3	2
4	1	1	2	1
5	1	1	3	3
6	1	1	1	2
7	1	1	1	3
8	1	1	2	2
9	1	1	3	1
10	1	2	1	2
11	1	2	1	3
12	1	2	1	1
13	1	2	2	2
14	1	2	2	3
15	1	2	3	3
16	1	2	3	1
17	1	2	3	2
18	1	2	2	1
19	1	3	1	1
20	1	3	2	3
21	1	3	3	2
22	1	3	2	1
23	1	3	3	3
24	1	3	1	2
25	1	3	1	3
26	1	3	3	1
27	1	3	2	2
28	2	1	2	3
29	2	1	1	3
30	2	1	3	2
31	2	1	2	2
32	2	1	1	2
33	2	1	2	1
34	2	1	1	1
35	2	1	3	3
36	2	1	3	1
37	2	2	3	1
38	2	2	2	3
39	2	2	1	3
40	2	2	3	2
41	2	2	1	2
42	2	2	2	2
43	2	2	2	1

Experimental No.	Factor A	Factor B	Factor C	Factor D
44	2	2	1	1
45	2	2	3	3
46	2	3	1	1
47	2	3	2	3
48	2	3	1	3
49	2	3	3	2
50	2	3	2	2
51	2	3	1	2
52	2	3	3	3
53	2	3	3	1
54	2	3	2	1
55	3	1	3	1
56	3	1	3	2
57	3	1	1	3
58	3	1	1	2
59	3	1	2	1
60	3	1	1	1
61	3	1	2	2
62	3	1	3	3
63	3	1	2	3
64	3	2	3	1
65	3	2	1	3
66	3	2	1	2
67	3	2	2	1
68	3	2	3	2
69	3	2	2	3
70	3	2	1	1
71	3	2	2	2
72	3	2	3	3
73	3	3	2	1
74	3	3	3	1
75	3	3	3	2
76	3	3	1	3
77	3	3	3	3
78	3	3	2	2
79	3	3	1	2
80	3	3	2	3
81	3	3	1	1

In Taguchi the variation of the response is also examined using an appropriately chosen S/N ratio, the S/N ratio is the ratio of the mean (signal) to the standard deviation (noise). These S/N ratios derived from the quadratic loss function and are expressed on a decibel (dB) scale. The formula used to compute the S/N ratio depends on the objective function. Generally, there are three standard S/N equations are widely used to classify the objective function: ‘larger the better’, ‘smaller the better’, or ‘nominal the best.

In the present study compressive strength should be larger so that and our goal is also to maximize the strength. The standard S/N ratio is given below.

$$\frac{S}{N} ratio = -10\ log_{10}\ \frac{1}{n}\sum_{i=1}^{n}\frac{1}{yi^2}$$

Where ‘i’ is the number of a trial; ‘Yij’ is the measured value of quality characteristic for the ith trial and jth experiment; ‘n’ is the number of repetitions for the experimental combination. Signal-to-noise ratios are computed using the above formula for each of the nine experimental combinations.

The comparison between the compression value of conventional concrete and special concrete is plotted in the graph, as shown in figure 1. In the compression graph, the highest value is combination 4which has the highest value of nine combinations. The average values of S/N ratios of the four control factors at each of the levels and from which the levels corresponding to the highest S/N ratio values are chosen for each parameter representing the optimum condition. Here, the optimum condition is the maximization of the compressive strength.

Table 4 Standard orthogonal array $(L_9)3^4$

Experimental No.	Factor A	Factor B	Factor C	Factor D
1	1	1	1	1
2	1	2	2	2
3	1	3	3	3
4	2	1	2	3
5	2	2	3	1
6	2	3	1	2
7	3	1	3	2
8	3	2	1	3
9	3	3	2	1

5. CONCLUSION

The parameters of the mix design are optimized by Taguchi method. An L9 orthogonal array with four control factors and three levels. Selected parameters along with the levels are; water/ binding ratio; fly ash; M-sand; sisal fiber. In this orthogonal combination gives more strength when compared with other orthogonal combination. The total material cost of the project and the time conception is highly reduced.

NOTATION

CI = confidence interval.

DOF = degrees of freedom.

OA = orthogonal array.

QC = quality characteristic.

S/N = Signal-to-Noise ratio (dB).

Smp = Predicted mean of optimum compressive strength.

W/b = water/binder.

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