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Appication of Taughi Method for the Design of Concrete Mixes

Prince Arulraj, Felix K Regi, Philo Mariya, Merin k Varghese, Abel Antony johns

Abstract: ***Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability.Many parameters determine the strength, workability and durability of concrete.The objective of this study is to find out the influence of each parameter on the strength and to cost of concrete by conducting the minimal number of experiments. Parameters considered for the study are water-cement ratio,slump,size of aggregate, grade ofcement specific gravity of fine aggregate gravity of coarse aggregate and zone. Taguchi method is a statistical approach for theanalysis of the factors influencing a system and to design the experiment with minimum number of trials. A16 x16 matrix has been developed as per Taugchi method and the seven parameter were varied accordingly. Sixteen M30 mixes were designed and cast. The compressive strength, splittensile strength and workability were determined. The factors influencing the strength and cost of concrete were ranked according to the order of influence.***

I. INTRODUCTION

Taguchi and Konishi (1987) developed a statistical method named Taguchi method for conducting the minimal number of experiments which could give the full information of all factors that affect the performance parameter.Taguchi realized that the best opportunity to eliminate the variations in the quality is during the design and manufacturing process. Consequently, he developed a strategy for quality engineering that can be used in both contexts.In this paper an attempt has been made to determine the influence of the seven parameters on concrete mix design and cost of concrete. Parameters considered for the study are water-cement ratio, slump, size of aggregate, grade of cement specific gravity of fine aggregate gravity of coarse aggregate and zone. The mix considered for analysis is M30.Taguchi method is used to design the experiments. As per Taguchi method, L16 matrix was developed and cube and cylinder were cast as per the L16 matrix. The results wereanalyzedstatically to determine the influence of each parameter on the strength and cost of concrete mixes.

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***** Correspondence Author (s)
Prince Arulraj, Professor and Dean, Karunya Institute of Technology and Sciences
Felix K Regi, Final year UG Students ,Department of Civil Engineering@Karunya Institute of Technology and sciences
Philo Mariya, Final year UG Students ,Department of Civil Engineering@Karunya Institute of Technology and sciences
Merin k Varghese, Final year UG Students ,Department of Civil Engineering@Karunya Institute of Technology and sciences
Abel Antony johns, Final year UG Students ,Department of Civil Engineering@Karunya Institute of Technology and sciences

II. LITRATURE REVIEW

Box and Bisgaard (1988) stated that"The enemy of mass production is variability. Success in reducing it will invariably simplify processes, reduce scrap, and lower costs". The main objective in the Taguchi method is to design robust systems that are reliable under uncontrollable conditions).The method aims to adjust the design parameters (known as the control factors) to their optimal levels, such that the system response is robust – that is, insensitive to noise factors, which are hard or impossible to control. Anoop C A, and Pawan Kumar(May 2013) used Taguchi's experimental design method to determine the settings of the process parameters. Orthogonal arrays of Taguchi, the signal-to-noise(S/N)ratio, the analysis of variance(ANOVA) and regression analyses were employed to find the optimal processparameter level and to analyze the effect of these parameters on the weld propertiesfor aluminum alloy 7039. Conformation test with the optimal levels of welding parameter was carried out in order to illustrate the effectiveness of the Taguchi optimum method.

Ramesh Chandra Mohapatra(2018) made an attempt to optimize the thermal properties of rice husk reinforced polymer composites materials using Taguchi technique. The results showed that the combination of rice husk particle size of 250 mm with volume fraction of filler material (45%) with vinyl ester as the matrix material was found to be beneficial for minimizing the thermal properties of rice husk particles reinforced polymer composites and the degree of contribution of the parameters to the system were volume fraction > particle size > polymer resin.

Gunavant K. Katel,and Sunil B. Thakare(2018)carried out to find out the effect of addition of fly ash additions in cement paste systems based on Class C. Nine mixtures were prepared and replaced by fly ash at dosage rates of 15, 30, and 45 % by mass of cement paste material for achieving the maximum possible exact responses at 7, 28 and 56 days. The optimal parameters for compressive strength of high volume fly ash concrete mixture were found and the influences of each parameter affecting the compressive strength were evaluated by using Taguchi method.

III. METHODOLOGY

An attempt has been made to determine the effect of water/cement ratio, specific gravity of fine aggregate, specific gravity of coarse aggregate, slump, size of aggregate and grade of cement on concrete mixes and cost of concrete mix.

An excel program has been developed where the input parameters can be varied to attain different concrete mixes.

The nine input parameters are given below :

- Required target strength(rangingfrom M10-M45)
- Type of cement (OPC 33,43,53)
- Exposure conditions (extreme, mild, moderate, severe, very severe)
- Zone (Zone 1,2,3,4)
- Workability (10-150)
- nominal size of aggregate(10,12,20,25,40mm)
- Quality control (good, fair, very good)
- Specific gravity of fine aggregate
- Specific gravity of coarse aggregate

The mix ratio that will bring about the desired strength with the given input parameters can be found using the designed excel spread sheet as per IS 10262:2009.M30 mix was taken into consideration and seven parameters are varied to attain various results to identify the proper control factors and obtain the optimum results. Using Taguchi method a 16*16 matrix is prepared where two factors vary in four levels and five factors vary in two levels. Compressive strength and split tensile strength of each mix was found out and the results were analyzed using statistical analysis.Parameters considered and values assigned at different levels as shown in table1.parameter considered and values assigned at different levels.

Table 1:Parameter considered and values assigned at different levels

Water cement ratio	Slump value	Size of aggregate	Specific gravity of fine aggregate	Specific gravity of coarse aggregate	Type of cement
	50	10			
0.303	75	12	2.68	2.75	43
0.404	100	20	2.38	2.4	53
	125	25			

Table2:Given the details of L 16 matrix designed as per Taguchi method

	A	B	C	D	E	F	G
1	1	1	1	1	1	1	1
2	2	2	2	1	1	2	2
3	1	3	3	2	2	1	1
4	2	4	4	2	2	2	2
5	2	1	2	2	2	1	2
6	1	2	1	2	2	2	1
7	2	3	4	1	1	1	2
8	2	4	3	1	1	2	1
9	2	1	3	1	2	2	2
10	1	2	4	1	2	1	1
11	2	3	1	2	1	2	2
12	1	4	2	2	1	1	1
13	1	1	4	2	1	2	1
14	2	2	3	2	1	1	2
15	1	3	2	1	2	2	1
16	2	4	1	1	2	1	2

The values of the parameter considered for varied trials are given in table 3

Table3: Values of Parameter considered.

S NO	Water Cement ratio	Slump value	Size of coarse aggregate	Zone	Specific gravity of fine aggregate	Specific gravity of coarse aggregate	Grade of concrete
1	0.33	50	10	2	2.68	2.75	43
2	0.404	75	12	2	2.68	2.4	53
3	0.33	100	20	3	2.36	2.75	43
4	0.404	125	25	3	2.36	2.4	53
P5	0.404	50	12	3	2.36	2.75	53
6	0.33	75	10	3	2.36	2.4	43
7	0.404	100	25	2	2.68	2.75	53
8	0.404	125	20	2	2.68	2.4	43
9	0.404	50	20	2	2.36	2.4	53

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10	0.33	75	25	2	2.36	2.75	43
11	0.404	100	10	3	2.68	2.4	53
12	0.33	125	12	3	2.68	2.75	43
13	0.33	50	25	3	2.68	2.4	43
14	0.404	75	20	3	2.68	2.75	53
15	0.33	100	12	2	2.36	2.4	43
16	0.404	125	10	2	2.36	2.75	53

Sixteen three cubes and Three cylinders of M30 mix were casted and cured for 28 days. Compressive strength and split tensile strength were found and results obtained were analyzed using statistical software. As cost can also be calculated automatically using excel sheet, the costs obtained are also used for analysis using statistical software to find out the most influencing parameter on cost which calculations the cost of concrete mixes.The cost of materials alone were considered and the labour cost is not included Results obtained from compressive test and split tensile test are given in table 4.

Table 4: Results obtained from compressive test and split tensile test

Matrix	Compressive value	Tensile value
1	39.68	2.785
2	38.805	2.78
3	41.83	2.915
4	40.6	2.8
5	28.63	2.355
6	42.4	3.33
7	45.09	3.45
8	34.485	2.45
9	42	2.945
10	42.65	3.42
11	38.5	2.685
12	41.06	2.87
13	35.5	2.515
14	34.97	2.46
15	31.375	2.36
16	42.3	3.06

The variation of compressive strength with respect toseven parameters are shown in fig 1. From the graph, the most and least influential parameters can be found out. Size of coarse aggregate is found to be the most influential parameter and grade of cement is the least influential parameter on compressive strength of concrete

Statistical analysis was carried out on the cost of concrete to determine the ranking of parameters that influence the cost of concrete

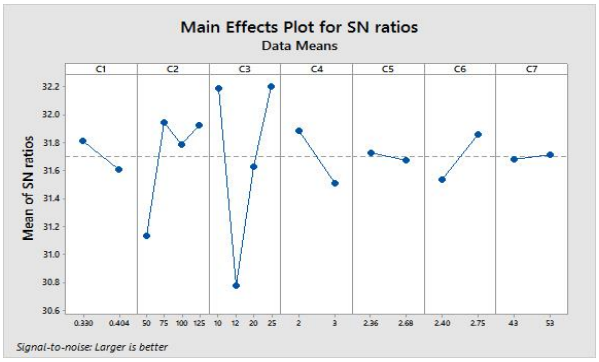

Fig:1 Compressive strength of concrete analyzed using statistical analysis

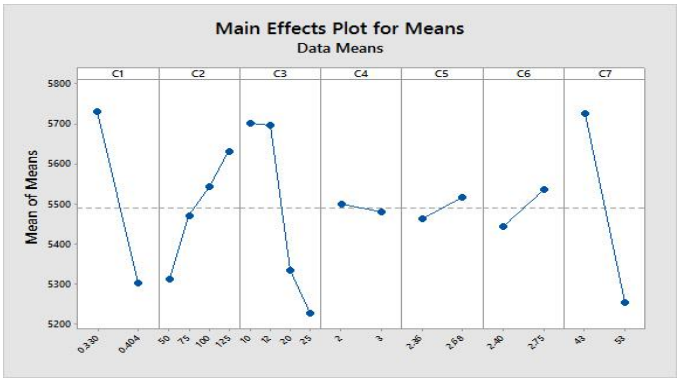

Fig:2 Cost of concrete is analyzed using statistical analysis.

Based on cost of concrete size of aggregate is found tothe most influential parameter followed by grade of cement , water cement ratio, slump, specific gravity of coarse aggregate, specific gravity of fine aggregate and zone number .

Based on it compressive strength the

most influential parameter is found to the size of aggregate followed by slump, zone, specific gravity of fine aggregate, specific of coarse aggregate and grade of cement. The ranking of the parameter are given in table 5.It was found that size of coarse aggregate in the most influence parameter and the zone of fine aggregate is the least influence parameter .The variation in the cost of concrete with respect to the seven parameter are shown in fig 2.

Table 5: Ranking of parameter that influence the cot and strength of concrete

RANK	BASED ON COST	BASED ON COMPRESSIVE STRENGTH
1	SIZE OF COARSE AGGREAGTE	SIZE OF COARSE AGGREAGTE

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2	CEMENT	SLUMP
3	WATER-CEMENT RATIO	ZONE
4	SLUMP	SPECIFIC GRAVITY OF COARSE AGGREAGTE
5	SPECIFIC GRAVITY OF COARSE AGGREAGTE	WATER-CEMENT RATIO
6	SPECIFIC GRAVITY OF FINE AGGREAGTE	SPECIFIC GRAVITY OF FINE AGGREAGTE
7	ZONE	CEMENT

IV. CONCLUSIONS

The most and least influential parameter that effects the cost of concrete mixes are size of coarse aggregate and zone number of fine aggregate .

Based on compressive strength, Size of coarse aggregate is found to the most influential parameter and grade of cement is the least influential parameter.Taguchi method was used to design an experiment in order to find out the effect of seven parameters on the cost and strength of concrete mixes.

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