Quest Journals
Journal of Architecture and Civil Engineering
Volume 8 ~ Issue 4 (2023) pp: 51-55
ISSN(Online) : 2321-8193
www.questjournals.org

Research Paper

Some Investigations for Compressive Strength of Fly Ash Concrete for Mivan Technology by Taguchi Design of Experiments

*Vishakha S. Patil
(Dr. D. Y. Patil College of Architecture. Akurdi, Pune, Maharashtra, India)
Corresponding Author: Vishakha S. Patil

ABSTRACT: *The Indian economy depends heavily on the construction industry, which has contributed to the growth of the nation. India currently has the second-largest urban population in the world. The potential for using Mivan formwork technology in the building industry is bigger. Mivan formwork is a high-tech building material; it is also cost-effective for large-scale construction. The development of high-strength, high-volume fly ash concrete takes into account the sustainability of the building sector and fly ash as a resource-productive material. Large fly ash consumption rates in concrete demonstrate a considerable effect on cement production. Therefore, it is necessary to adopt fly ash in Mivan structures for getting high strength in a low cost as a perspective of affordable buildings. Present paper focuses on analysis on strength of concrete structure by using Taguchi Design of Experiments with L-9 OA. The input control factors selected as Fly ash (30-45-60) in %, Cement paste (335-263-191) in Kg/m^3, Super plasticizer (3.35-2.63-2.865) in Kg/m^3 [1] and Steel fibers (0-0-11.76) in Kg/m^3. The analysis is carried out by using MINITAB-21.1.3 statistical software. With the help of analysis of ANOVA (Analysis of Variance) the statistical significant factor will be selected and further regression equation is going to be used for selecting optimum parameters for concrete structure which will be used for Mivan Technology.*

KEYWORDS: *Compressive Strength, Fly Ash, Affordable Construction, Taguchi DOE, Significant factor.*

R*eceived 01 Apr., 2023;* ***R****evised 10 Apr., 2023;* ***A****ccepted 12 Apr., 2023* *© The author(s) 2023.*
P*ublished with open access at* ***www.questjournals.org***

I. INTRODUCTION

Residential buildings and large-scale housing projects both make extensive use of the MIVAN aluminium formwork system. It is quick, easy, flexible, and economical. When durability is the major concern, it produces work that is of the highest quality and requires the least amount of upkeep. The Indian economy depends heavily on the construction industry, which has contributed to the growth of the nation. India currently has the second-largest urban population in the world. The majority of people live in metropolitan areas. The introduction of international corporations for construction activities in India has aided in expediting project construction. When the same elements are repeated, larger units were developed, such as formworks for slab panels, formworks for columns, beams, etc. Finally, the entire system of formwork is constructed. At first, steel was used, which made it quite heavy. The goal was to lighten the system, so materials for the formwork were expanded to include aluminium, plastic, fibre glass, etc. Aluminum formwork system permits the pouring of walls and slabs simultaneously by providing aluminium formwork for RCC load bearing or RCC framed multi-story buildings.

The potential for using mivan formwork technology in the building industry is bigger. Although this formwork is a high-tech building material, it is also cost-effective for large-scale construction. By using effective construction tools, materials, and time-saving techniques, this new style of building can significantly boost productivity, built quality, and durability of construction work as compared to existing technologies or methods. The development of high-strength, high-volume fly ash concrete takes into account the sustainability of the building sector and fly ash as a resource-productive material. Large fly ash consumption rates in concrete demonstrate a considerable effect on cement production. Therefore, it is necessary to adopt fly ash in Mivan structures for getting high strength in a low cost as a perspective of affordable buildings.

II. LITERATURE REVIEW

Different types of framework have been used in the construction field such as timber framework, steel framework, plastic framework, aluminium framework. Now a days, Mivan (a system of aluminium forms) has been considered in the construction of residential units and mass housing projects [1]. Author has reported the different types of components with material used for development of Mivan technology which is cost effective.

Bajare et al. (2017) has studied the benefits of Mivan technology especially for India [2]. Author has concluded that Mivan technology gives monolithic cellular structure with most minimum weight and the post failure damages get reduced considerably. Also, it is seen that the problem like Honey-combing, Cracks due to shrinkage of concrete and segregation were reported by experimental studies.

The survey of framework in Noida, India has been studied by Khan et al. (2017) [3]. Author has studied the aluminium modular framework and its construction activities of Mivan technology. It is seen that Mivan framework is beneficial in terms of speed of construction, quality, aesthetics, external finishes, maintenance, strength and cost.

Regarding cost of construction of Mivan technology was reviewed by Yadav et al. (2018) [4]. Author concluded that cost of construction with Mivan formwork increases by almost 25-30 % as compared to the conventional method and cost of construction per. Sq.ft in Mivan is as high as 33 % as compared to the conventional method. However, author has reported that Mivan framework can save considerable amount of time in construction of high rise building.

Gulghane et al. (2018) has done the time and cost optimization of construction project using Mivan technology [5]. The cost and time comparison of Mivan technology with conventional formwork technology has been covered in length by the author. It is concluded that construction facilities built by using the Mivan formwork technology is less costly than the conventional method and total cost saving is up to 12.5% for high rise buildings.

Kote et al. (2020) has carried out the comparative analysis regarding Mivan technology with conventional method [6]. It is reported that the per difference. Sq.ft construction cost increases by almost 392 Rs/Sq.ft by Mivan framework and the duration of construction is less than the conventional method by almost 25 % with 534 days, i.e. 1.5 years.

Feasibility study of Mivan framework over conventional framework has been conducted by Shinde et al. (2020) [7]. Author reviewed that current building techniques such as Mivan technology are the best solution to address the need for inexpensive and efficient homes. Also, author have concluded that conventional formwork may be reused 8 to 9 times, however Mivan formwork can be reused 250 to 300 times more than conventional formwork. Mivan formwork avoids the need for changes and repairs brought on by subpar construction.

Sravani et al. (2020) conducted experiments on quality control and site execution on monolithic buildings using Mivan Technology [8]. Authors have carried out various experiments on aggregates, cement, and concrete by Silt Content, Water Absorption and Specific Gravity, Crushing Strength, Sieve Analysis, Impact Strength, Dry Loose Bulk Density, Initial and Final Setting Time, Compressive Strength, Slump cone test, Brick and Tile testing, etc. It is reported that as there is a growth in demand for quality, which is determined primarily by the quality of building materials and the execution process, among other procedures.

A comparative study of rate and productivity analysis of mivan framework with conventional framework was done by Kolekar et al [9] (2020). It is observed that Mivan framework is cost economical, time efficient, and delivers higher quality if the quantity of work is greater through the experiments carried out by author. Also, it is reported that a floor cycle of 7-8 days is obtained with Mivan framework and hence the whole project time is reduced significantly.

On the basis of cost, construction duration, and construction technique, the Mivan method was examined and compared to the conventional way by Ramteke et al. (2022) [10]. According to the investigation, building facilities constructed using Mivan formwork technology are significantly more expensive (i.e., 0.132%) than those constructed using the standard way. Author also concluded that Mivan technology provides advantages such as better material durability, consistent construction quality, decreased formwork system maintenance, and faster activity completion. Kate et el. (2021) done the evaluation and optimization of the sustainable mechanical properties of concrete with and without crimped steel fibers [11]. Author concluded that, the Taguchi strategy is a successful systematic model to lessen the overall investigative work. The process of improving designs for performance and quality is also effective. The current study reveals that high strength-high volume fly ash steel fibre concrete is a more viable alternative sustainable solution for the concrete industry due to its mechanical qualities.

From the above literature, it is concluded that Mivan Technology is beneficial and advantageous for construction of new buildings those are required less time for construction. It is observed that Mivan framework is beneficial in terms of quality, aesthetics, external finishes, maintenance, strength and cost. This formwork technique has a lot of potential in the Indian environment for providing inexpensive homes to its growing population. Mivan formwork eliminates the need for repairs and modifications caused by poor workmanship. Mivan formwork is the best method for high-rise and large-scale building projects. Thus, it may be concluded that the Mivan formwork system is cost effective for recurring and enormous projects, but the conventional formwork method is not. Therefore, present paper focuses to improve the compressive strength (N/mm^2) of concrete structure of Mivan by using input parameters as fly ash, Cement paste, Super-plasticizer and Steel fibers. Taguchi L-9 orthogonal array is used for further analysis.

III. METHODOLOGY

Genichi Taguchi, a Japanese engineer, proposed several approaches to experimental designs that are sometimes called "Taguchi Methods .These techniques make use of mixed-level, two-, and three-level fractional factorial designs. Taguchi supporters seem to favor large screening designs in particular. A general fractional factorial design is the Taguchi Orthogonal Array (OA) design. It is built on a design matrix and uses a highly fractional orthogonal design. Taguchi experimental design L-9 orthogonal array (OA) was used for designing the parameter combinations for each experimental trial (See Table 1). In this orthogonal array, number of factors are 4 and number of levels are 3. Hence total numbers of runs are 9. The response variable chosen is the compressive strength (N/mm^2) of concrete structure of 90 days. The input control factors selected as Fly ash (30-45-60) in %, Cement paste (335-263-191) in Kg/m^3, Super plasticizer (3.35-2.63-2.865) in Kg/m^3 and Steel fibers (0-0-11.76) in Kg/m^3 [11]. Table 1 shows the input parameters and their settings for experimental runs with the assigned factors to each of the columns of OA.

Table 1 Actual Experimental Design with Result

Expt. Run	Fly ash (%)	Cement paste (Kg/m^3)	Super plasticizer (Kg/m^3)	Steel fibers (Kg/m^3)	Compressive strength (N/mm^2)
1	30	335	3.350	0.00	73.16
2	30	263	2.630	0.00	71.85
3	30	191	2.865	11.76	72.86
4	45	335	2.630	11.76	68.16
5	45	263	2.865	0.00	66.35
6	45	191	3.350	0.00	65.49
7	60	335	2.865	0.00	62.17
8	60	263	3.350	11.76	58.65
9	60	191	2.630	0.00	59.77

IV. RESULT AND ANALYSIS

The experimental work is carried out on concrete specimens, consisting of fly ash and ordinary Portland cement (OPC) as binder material as confirmed with Bureau of Indian Standard (BIS) 12,269 [11]. Performance-based delaying To make the concrete mix workable, crimped steel fibres and super plasticizer are utilized. Author used a pan mixer is used for preparing the concrete mixtures in the lab [11]. For the compressive test, the cubes are cast with dimensions of 150 × 150 × 150 mm. After getting sufficient curing, the test specimens are removed from the curing tank and dried at room temperature. By using Taguchi experimental design with L-9 OA, the statistical investigation is carried out on the experimental data achieved through Minitab 21.3.1.

The main effects plots for Compressive strength (ANOM) and the table of analysis of variance (ANOVA) are shown in Figure 1 and Table 2 respectively. It is observed from the ANOVA table, that Fly ash is the statistically significant factor in this experiment. Since the P-value in the ANOVA table for any input parameter is less than 0.05 at the 95.0% confidence level. It is noticed that the highest P-value is 0.000 in the ANOVA table. Since the P-value less than 0.05, hence that term is statistically significant at the 95.0% confidence level. The percentage contribution of the input variables influencing the compressive strength are Fly ash: 95.42%, Cement paste: 3.40%, Super plasticizer: 1.15% and Steel fibers: 0.03%. The effect of each input variables on the Compressive Strength are considered in detail using ANOM plots.

Table 2 ANOVA Table

Source	DF	Adj SS	Adj MS	F	P	% Contr.
*Fly ash	2	231.76	115.882	62.50	0.000	95.42
Cement paste	2	8.282	4.141	0.11	0.901	3.40
Super plasticizer	2	2.817	1.409	0.04	0.966	1.15
Steel fibers	2	0.017	0.0168	0.00	0.983	0.03
Total	8	242.876	121.4488	--	--	100

**Statistically significant factor*

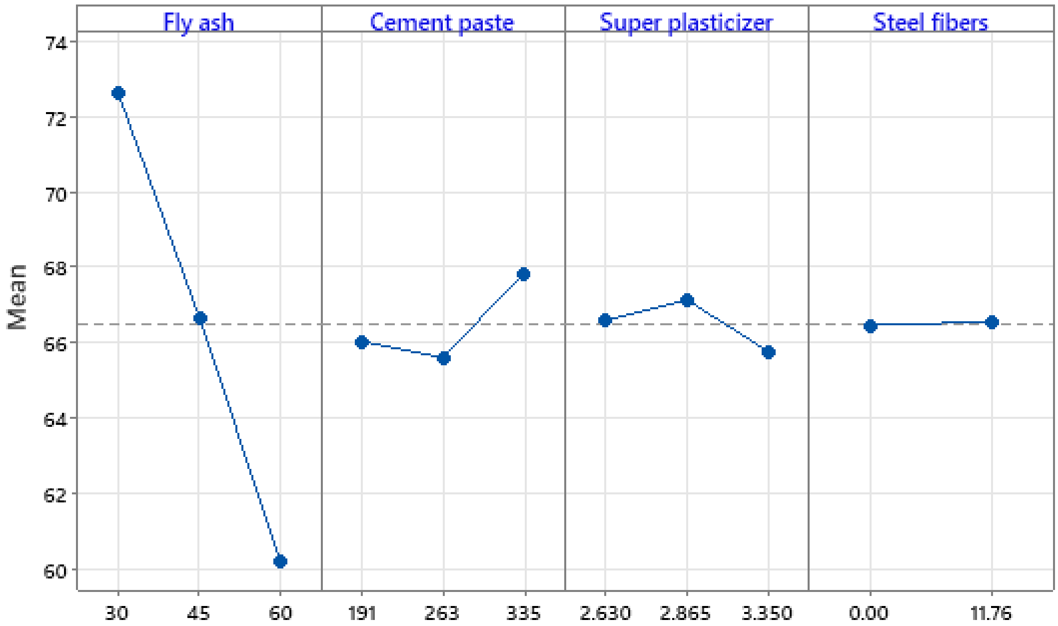

Figure 1 Main Effects Plots for Compressive Strength

From the above graph linear trend of fly ash is observed at different levels. 30 percent of fly ash is found most influencing factor in developing the compressive strength of concrete.

Similarly non linear trend is observed for cement paste when it is used in higher concentration it binds the concrete mix as it works as a binding agent for sand and aggregated but if we use it in less concentration it might resultant in loosen up the sand and aggregate bond. Similar graph goes for the super plasticizer the graph shows non linear trend. Steel fiber is at neutral level as it has no impact on a compressive strength.

The performance of input key parameters on compressive strength is shown in Fig. 1 It is observed that 30% of fly ash, 335 Kg/m^3 cement paste, 3.350 Kg/m^3 super plasticizer, and used or not used steel fibers have a maximum compressive strength.

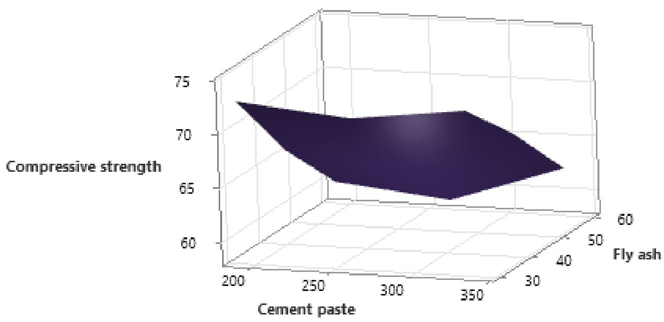

Figure 2 3D Surface Plot of Compressive Strength vs Fly ash & Cement paste

*Corresponding Author: Abdalftah Elbori

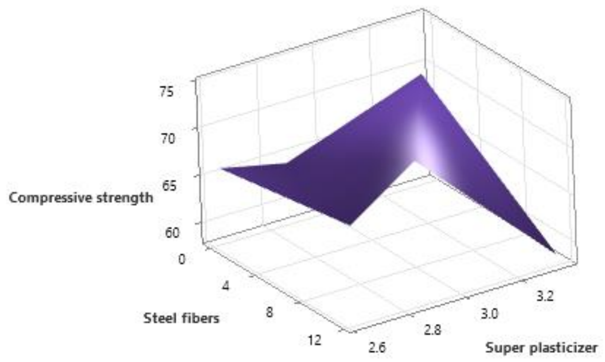

Figure 3 3D Surface Plot of Compressive Strength vs Steel fibers & Super plasticizer

Fig 2 and 3 shows 3D surface plots of Compressive Strength vs Fly ash & Cement paste and Compressive Strength vs Steel fibers & Super plasticizer, respectively.

V. CONCLUSION

Following conclusion can be drawn out from the above experimentation by using L9 OA of Taguchi DOE-

- It is observed from the ANOVA table, that Fly ash is the statistically significant factor in this experiment. Since the P-value in the ANOVA table for any input parameter is less than 0.05 at the 95.0% confidence level.
- Also, from ANOVA it was concluded that the Cement paste is the secondary contribution in this experiment.
- The above analysis is suggested for the compressive strength improvement of structure which can be used in Mivan Technology also.

ACKNOWLEDGEMENT

The author IS grateful to Ar. Dhananjay Chaudhari, Principal and Ar. Anagha Pathak (Asst. Prof.) of Dr. D Y Patil College of Architecture. Akurdi, Pune Maharashtra for providing the facility to do the research on above topic. Also thankful to Dr. Ketan Jagtap from Govt. Polytechnic, Nashik for guiding the analysis procedure on Minitab Software.

REFERENCES

[1]. Patil K, Mivan technology. International Journal of Engineering and Technical Research (IJETR), 2015, 3, 30-32.
[2]. Bajare R, A review paper on remedies to the common deficiencies faced in mivan technology. IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), 2017, 14, 24-26.
[3]. Khan, A., Impact of mivan formwork over conventional formwork.International Journal of Science and Research (IJSR), 2017, 6, 2060-2064.
[4]. Yadav P, Review paper on conventional and mivan formwork used for construction. International Journal of Advance Research in Science and Engineering, 2018, 7, 101-107.
[5]. Gulghane A, Time and cost optimization of construction project using Mivan Technology. Journal of Engineering Research and Application, 2018, 8, 70-74.
[6]. Kote A, Duration comparison of mivan formwork over the conventional formwork. International Journal for Research in Engineering Application & Management (IJREAM), 2018, in SIGHT'20, 37-39.
[7]. Shinde P, A review paper on feasibility of mivan formwork technology over conventional formwork technology for construction projects. International Research Journal of Engineering and Technology (IRJET), 2020, 7, 1290-1294.
[8]. Shrawani K, Study of quality control and site execution on monolithic buildings using mivan technology. IJESC, 2020, 10, 26369-26372.
[9]. Kolekar P, Analysis and comparison of mivan formwork system with conventional formwork system. International Research Journal of Engineering and Technology (IRJET), 2020, 7, 4906- 4910.
[10]. Ramteke P, To analyzed the building by mivan technology. International Research Journal of Modernization in Engineering Technology and Science, 20222, 04, 1137- 1144.
[11]. Kate G, Optimization of sustainable high-strength-high-volume fly ash concrete with and without steel fiber using Taguchi method and multi-regression analysis. Innovative Infrastructure Solutions, 2021, 6:102, 1-18.
[12]. Indian Standard (IS:12269), Ordinary Portland cement, 53 Grade -specifcation (First Revision), 2013, Bureau of Indian Standard, New Delhi, India.
[13]. Indian Standard (IS: 3812), Pulverized fuel ash-specifcation (Part-1) for use as Pozzolana in Cement, cement mortar and concrete (Second Revision), 20003, Bureau of Indian Standard, New Delhi, India.
[14]. Indian Standard (IS: 383) (1970), Reframed 2022, Specifcation for coarse and fne aggregates from natural sources for concrete (Second Revision. Bureau of Indian Standard, New Delhi, India.