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Utilization of Silica Fume andSteel Powder as an Additive in Concrete

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Abstract: Cement concrete are designed to resist the disastrous surrounding effects such as hightemperature variations, high humid environments, coastal areas, industrial areas and other pollutant types. Engineers are continuously studying its properties and performance by blending several waste and modern materials in cement or other aggregates. The major advantage of these materials is the replacement of cement or other ingredients partially in concrete and presenting the comparable cementitious property. The use of waste material can consume these materials and also saves the principal ingredients of concrete. This can also improve the properties of concrete in fresh and hydrated states or may presents the properties comparable to the basic properties of concrete. In the current study a set of experiments had been performed to compare the use of 3 different types of mixes formed by replacing cement by silica fume, sand by steel powderand in third mix both the materials are used together. Cement and sand were replaced in different proportions such as 10%, 15%, 20%, 25%, and 30% by these materials. The ingredients are mixed in 1:1:2 proportions. The properties studied are 7 days, 21 days and 28 days compressive strengths and compaction factor. The main conclusions drawn are inclusion of silica fume increases the compressivestrength up-to a certain proportion and then reduces the strength, it also effects the setting time and consistency. Steel powder increases the strength but reduces the compaction factor. Comparatively higher early strength gain (7-days) is obtained with steel powder concrete.

Keywords: concrete, steel powder, silica fume, compressive strength, replacement.

I. INTRODUCTION

Utilization of steel powder or other desecrate materials such as silica fume in preparing concrete for various civil engineering projects is a subject of high significance. Integration of extra materials in concrete or mortar affects its several characteristics such as strength, compaction factor and other relative performances.

There are various purposes of applying additional materials as substitute to cement and other components in concrete – first is the financial saving obtained by replacing a considerable part of the Portland cement or other ingredients with these materials and second is enhancement in the properties of concrete.

The ecological aspects of cement are now receiving more concern of researchers, as cement developing is liable for about large amount of total worldwide waste emissions from manufacturing sources. The trend of mixing several kinds of additional materials in building engineering is now growing. This has double advantage –

1) To reduce the quantity of deposited waste.
2) To conserve natural resources.

Partial substitution of sand or cement in concrete minimizes the energy consumption and thus, decreases the global warming. Current practice may permit up to a certain limit of reduction in the content of cement or sand in the concrete mix.

A. Additives Used In The Present Study

Cement and sand are the main materials needed for fulfilling the modern infrastructureneeds. As an outcome, the construction and concrete industry worldwide is facing growing challenges in conserving material and energy resources, as well as reducing its CO_2 emissions. According to the International Energy Agency, the main concern for cement producers are the increase in energy efficiency and the use of substitute wastes or other wastematerials. Consequently, it is converting into employ the substitute material in cement concrete.

Silica fume is a significant material utilized in the building production. During the last decade, considerable attention has been given to the use of silica fume as a partial replacement of cement to produce high-strength concrete. Silica fume is added to cement concrete to improve its properties, in particular its compressive strength, and other resistance. Silica fume consists of fine particles with particles very small to the size of the average cement particle size. Because of its extreme fineness and high silica content, silica fume is a very effective material particle.

Steel powder is formed from steel cutting factories during the sawing and finishing of steel parts, and almost 20 - 25% of the processed steel is converted into the powder. Deletion of the steel powder from the steel cutting places is a noteworthy environmental trouble today.Though, waste material from steel industry can be used to enlarge several properties of concrete. It has been analyzed that typically compressive strength increased withaccumulation of this powder in place of cement or sand. Therefore, employment of the steel dust in a variety of industrial sectors particularly the civil engineering projects, would aid to defend the surroundings.
Reprocess of these waste materials in construction industry is an inventive run towards sustainable and ecological construction. Utilization of waste materials in construction has been considered as ecological, however, this thought has been not accepted widely between the researchers as these materials imposes severe deleterious effects on the concrete. But, through proper concrete mix design the reprocessed concrete can achieve target strength and is appropriate for broad variety of applications in Civil engineering.

To estimate the efficiency of silica fume and steel powder as substitute constructionmaterial, following properties of concrete were requisite to be tested.

1) Compressive strength after different curing periods
2) Initial and final setting time
3) Workability

II. TESTING METHODOLOGY

Fractional replacement of cement or sand in concrete with waste materials affects variety of physical and chemical properties of the concrete and mortar. In the present work, several properties of concrete and mortar mixes are identified to evaluate the effect of waste materials on the performance of concrete. Following table 3.1, will presents theses parameters along with testing techniques are as followings.

Table 1 parameters identified and testing techniques

PARAMETERS	SIGNIFICANCE	TESTING
Compressive Strength (7 Days)	In 7 days, concrete can gain almost 40% of the 28 days compressive strength.	Compression testing machine
Compressive Strength (21 Days)	7-day test may be help to detect potential problem with concrete or testing procedure at the lab. In 7 days, compressive strength is almost 65% of the 28 days strength.	Compression testing machine
Compressive Strength (28 Days)	To evaluate quality and characteristics of concrete. Concrete mixes are recognized by their respective 28 days strength.	Compression testing machine
Initial Setting Time	Time period available for the transportation and placing of concrete after mixing. It marks roughly the end of the period when the wet mix can be moulded into shape.	Vicat Apparatus
Final Setting Time	The final setting time is the point at which the set cement has acquired a sufficient firmness to resist a certain defined pressure.	Vicat Apparatus
Workability	Workability represents the effort which is to be done to compact the concrete in a given module.	Slump Test

Collection of waste materials

↓

Replacement of cement and sand in concrete with these materials in 5%, 10%,15%, 20% and 30% weight of ingredient

↓

Evaluation of strength, setting times and workability of concrete from abovemention tests

↓

Comparison of results for all the materials on each selected parameter

III. EXPERIMENTAL WORK

This chapter presents the outcomes of laboratory experiments and compares thedata obtained for several supplementary materials.

A. *Replacing Cement And Sand*

Experiments had been performed to compare the use of 3 different types of mixes formed by replacing in Ist cement by silica fume,in IInd sand by steel powder and in third mix both the materials are used together. Cement and sand were replaced in different proportions such as 10%, 15%, 20%, and 30% by these materials. The ingredients are mixed in 1:1:2 proportions. The properties studied are 7 days, 21 days and 28 days compressive strengths and compaction factor.

Cube moulds of 15 x 15 x 15 cm had been used for casting cubes. The weight of constitutes and waste materials obtained by concrete mix design, for each percentage of replacement has been presented in Table 4.1, 4.2 and 4.3.

Table 2 Ration of weight of each constituent (Kg) in concrete for preparing mixes

Water	Cement	Sand	Coarse aggregate
0.5	1	1	2

Table 3 – Proportion of ingredients for M1 mixes after replacing cement by Silicafume

Weight of Materials (Kg)				
% Replacement	Cement	SilicaFume	Aggregate	Sand
0	4	0	8	4
10	3.60	0.40	8	4
15	3.40	0.60	8	4
20	3.20	0.80	8	4
30	2.80	1.20	8	4

Table 4 Proportion of ingredients for M2 mixes by replacing sand by steelpowder

Weight of Materials (Kg)				
% Replacement	Cement	Sand	Aggregate	Steel Powder
0	4	4	8	0
10	4	3.6	8	0.40
15	4	3.4	8	0.60
20	4	3.2	8	0.80
30	4	2.8	8	1.20

Table 5 – Proportion of ingredients for M3 mixes after replacing cement and sand

Weight of Materials (Kg)					
% Replacement	Cement	SilicaFume	Aggregate	Sand	Steel powder
0	4	0	8	4	0
10	3.60	0.40	8	4	0.40
15	3.40	0.60	8	4	0.60
20	3.20	0.80	8	4	0.80
30	2.80	1.20	8	4	1.20

B. *Compressive Strength Test*

Cement and sand in cement concrete has been replaced in 10, 15, 20, 30% with in Ist silica fume and in IInd steel powder respectively, and in third mix both the ingredients have been replaced simultaneously. Their compressive strength has been tested after different curing periods such as 7 days, 21days and 28 days standard curing conditions. Results of compression tests had been showed in table 4.5. 0% replacement represents theoriginal OPC concrete mix. Hence, this table compares concrete prepared by OPC concrete with concrete formed by replacing cement with steel powder for concrete mix M1.

Table 6 - Results of compression tests for M1 concrete mix in MPa

S. No.	Days	% of Replacement				
		0%	10%	15%	20%	30%
1	7	16.2Mpa	16.5Mpa	16.9Mpa	17.2Mpa	16.8Mpa
2	21	20.1Mpa	20.4Mpa	20.6Mpa	21.1Mpa	20.7Mpa
3	28	24.7Mpa	25.2Mpa	25.4Mpa	25.9Mpa	24.9Mpa

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Table 7 - Results of compression tests for M2 concrete mix in MPa

S. No.	Days	% of Replacement				
		0%	10%	15%	20%	30%
1	7	16.2Mpa	16.7Mpa	17.2Mpa	17.8Mpa	18.2Mpa
2	21	20.1Mpa	20.7Mpa	21.3Mpa	21.8Mpa	22.3Mpa
3	28	24.7Mpa	25.4Mpa	25.9Mpa	26.5Mpa	27.1Mpa

Table 8 - Results of compression tests for M3 concrete mix in MPa

S. No.	Days	% of Replacement				
		0%	10%	15%	20%	30%
1	7	16.2Mpa	16.6Mpa	16.8Mpa	17.1Mpa	17.4Mpa
2	21	20.1Mpa	20.5Mpa	20.8Mpa	21.1Mpa	21.3Mpa
3	28	24.7Mpa	25.1Mpa	25.5Mpa	25.9Mpa	26.3Mpa

C. Slump Cone Test

Along with compressive strength workability of concrete is major parameter required for testing the quality of concrete mix, again by mixing marblepowder in cement concrete in different proportions such as in 10, 15, 20, 30%and performing slump cone test following results were obtained.

Table 9 – Results of workability test

MIX	% Replacement	Slump Value (mm)
M1	0	98
	10	91
	15	83
	20	74
	30	67
M2	0	100
	10	92
	15	87
	20	79
	30	71
M3	0	110
	10	102
	15	96
	20	89
	30	81

D. *Setting Time*

Along with compressive strength and workability of concrete, setting time of cement is major parameter required for testing the quality of concrete mix, again by mixing marble powder in cement mortar in different proportions such as in 10, 20 and 30% and testing setting time by Vicat's apparatus following results were obtained and from results it has been observed that setting time delays by mixing the marble powder –

Table 10 setting time of blended cement mix for M1 mix

S No	Percentage ofreplacement	Initial Setting time (minutes)	Final Settingtime (minutes)
1	0	32	608
2	10	36	615
3	20	38	622
4	30	42	627

IV. RESULTS AND DISCUSSION

Utility of materials such as silica fume and steel powder in construction industry reduces the use of Portland cement and thus reduces the construction cost. In the present research concrete mixes have been prepared by adding these materials in different percentage. Concrete mixes formed are tested for compressive strength and slump values and compared with ordinary Portland cement concrete values. Experimental results have been presented in chapter 4, and this chapter presents thediscussion over these results.

A. *Compressive Strength Test*

It has been observed that from the results of compression tests that -

1) Maximum compressive strength is found at 20% replacement of cement withsilica fume after 7, 21 and 28 days of curing.
2) Maximum compressive strength is found at 30% replacement of sand withsteel powder after 7, 21 and 28 days of curing.
3) Maximum compressive strength is found at 30% replacement of both cementand sand with silica fume and steel powder after 7, 21 and 28 days of curing.
4) Compressive strength of concrete mix increases with high percentage whensand is replaced with steel powder.
5) Compressive strength of concrete mix was increased slowly when both thechief ingredients were replaced by silica fume and steel powder.

Variation of compressive strength with change in proportions of ingredients in all thethree mixes has been presented in following figures.

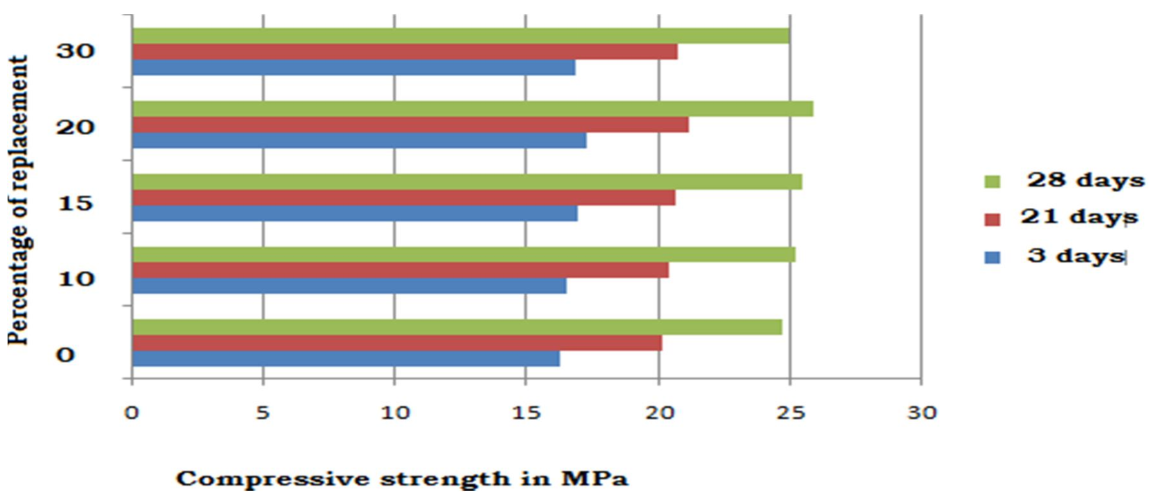

Figure 1 – Variation of compressive strength for M1

The above graph represent that Maximum compressive strength is found at 20%replacement of cement with silica fume after 7, 21 and 28 days of curing

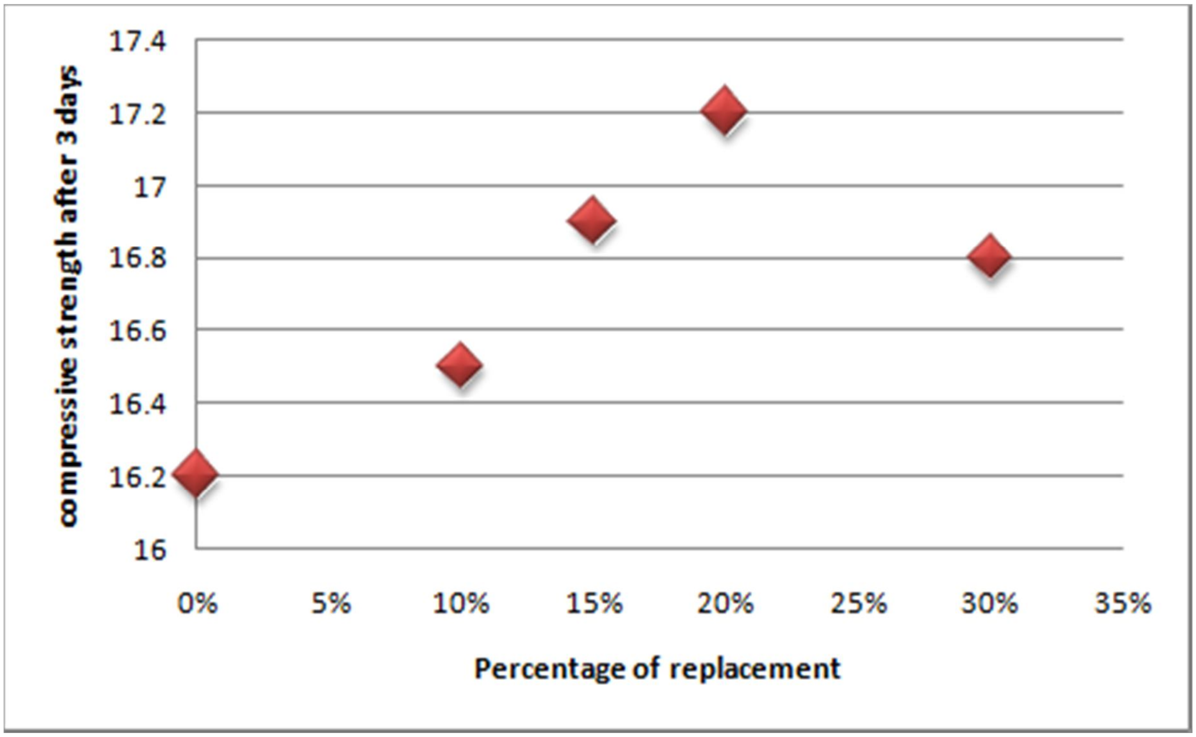

Fig. 2 – 7 days compressive strength for M1

From this figure it is observed that maximum compressive strength is found at20% replacement of cement with silica fume after 7 days of curing.

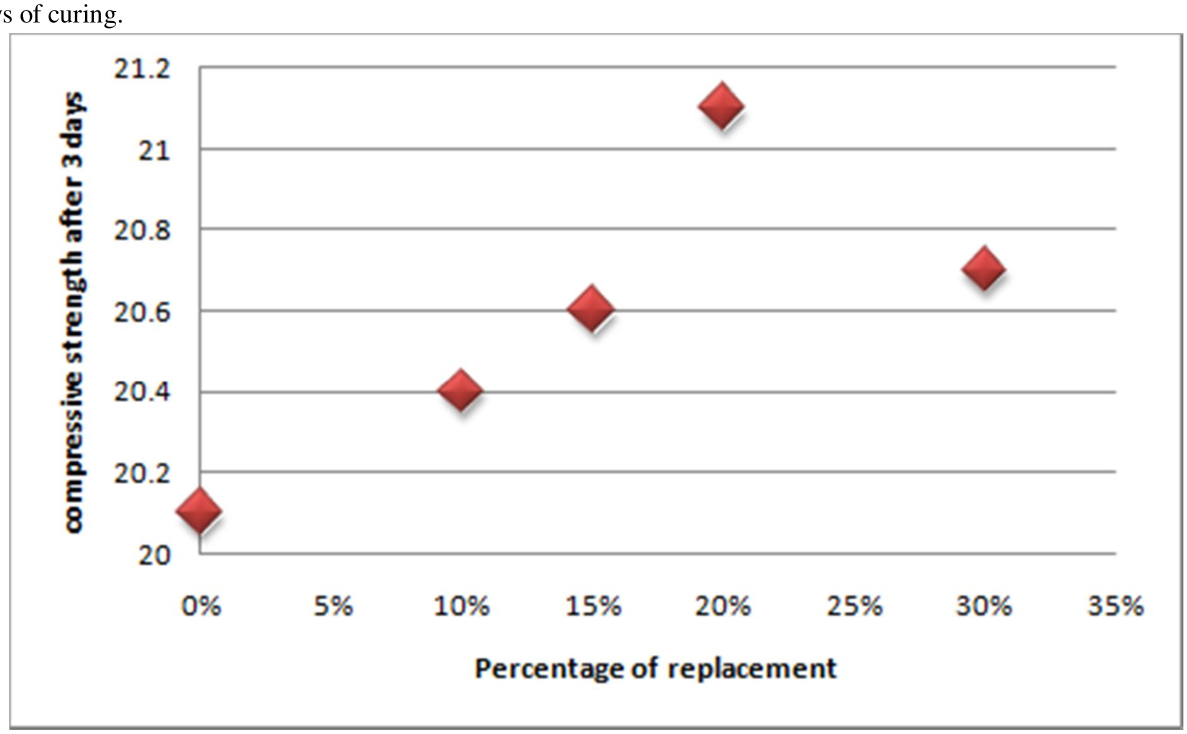

Fig. 3 – 21 days compressive strength for M1

This figure shows the maximum compressive strength is found at 20% replacement ofcement with silica fume after 21days of curing

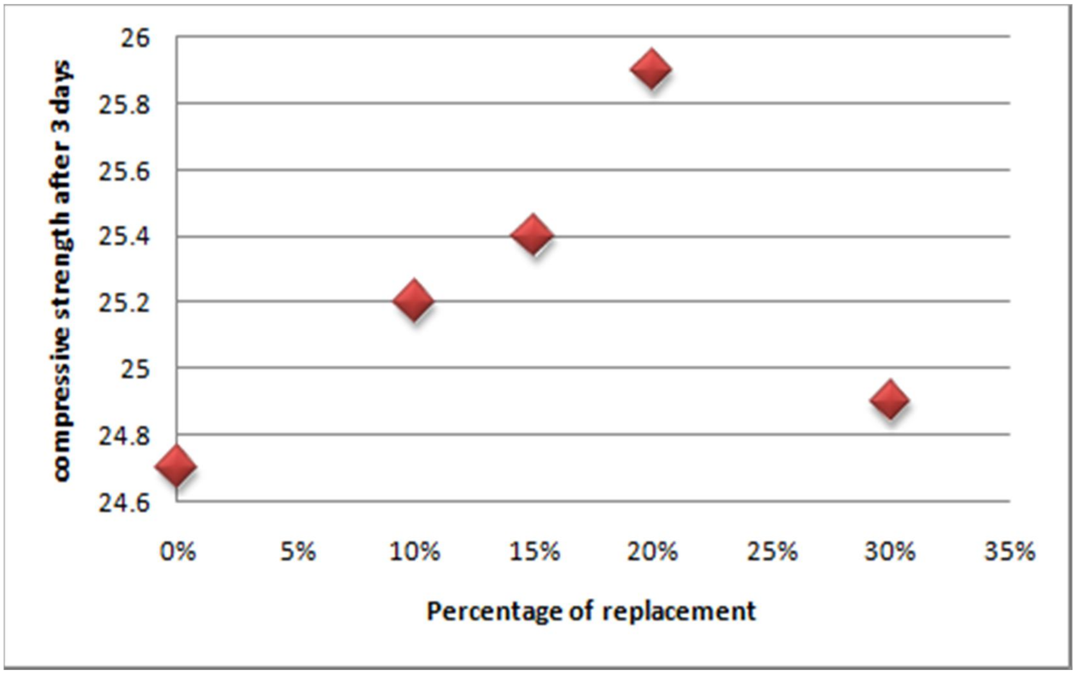

Fig. 4 – 28 days compressive strength for M1

From this figure it is observed that Maximum compressive strength is found at 20%replacement of cement with silica fume after 28 days of curing

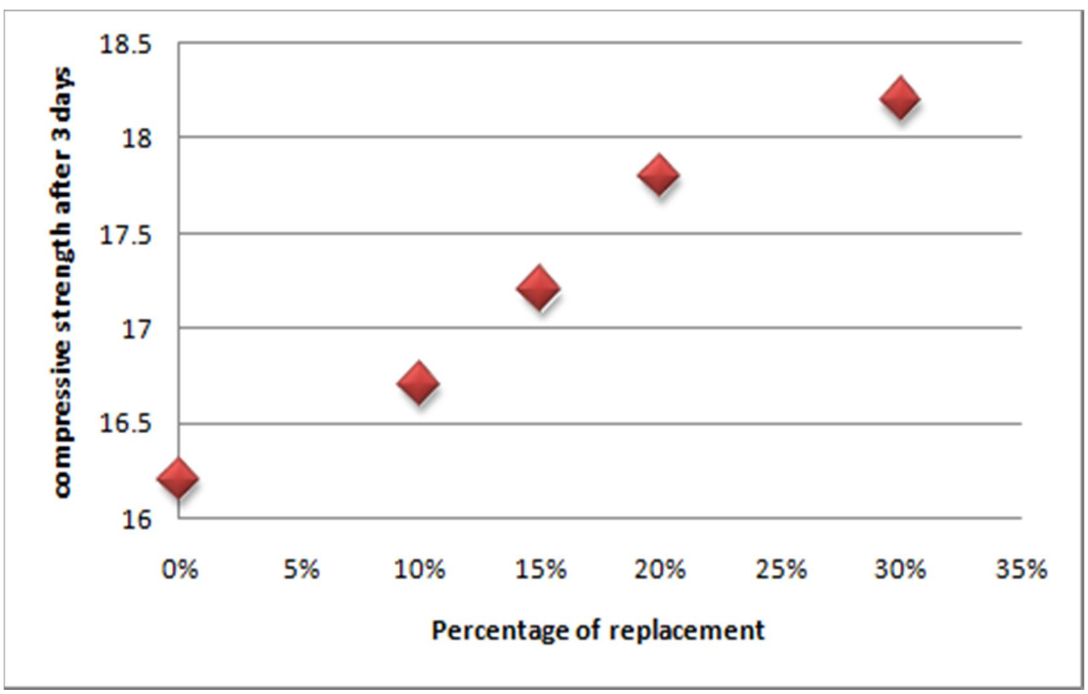

Fig. 5 – 7 days compressive strength for M2

Above graph shows that Maximum compressive strength is found at 30% replacement ofsand with steel powder after 7 days of curing

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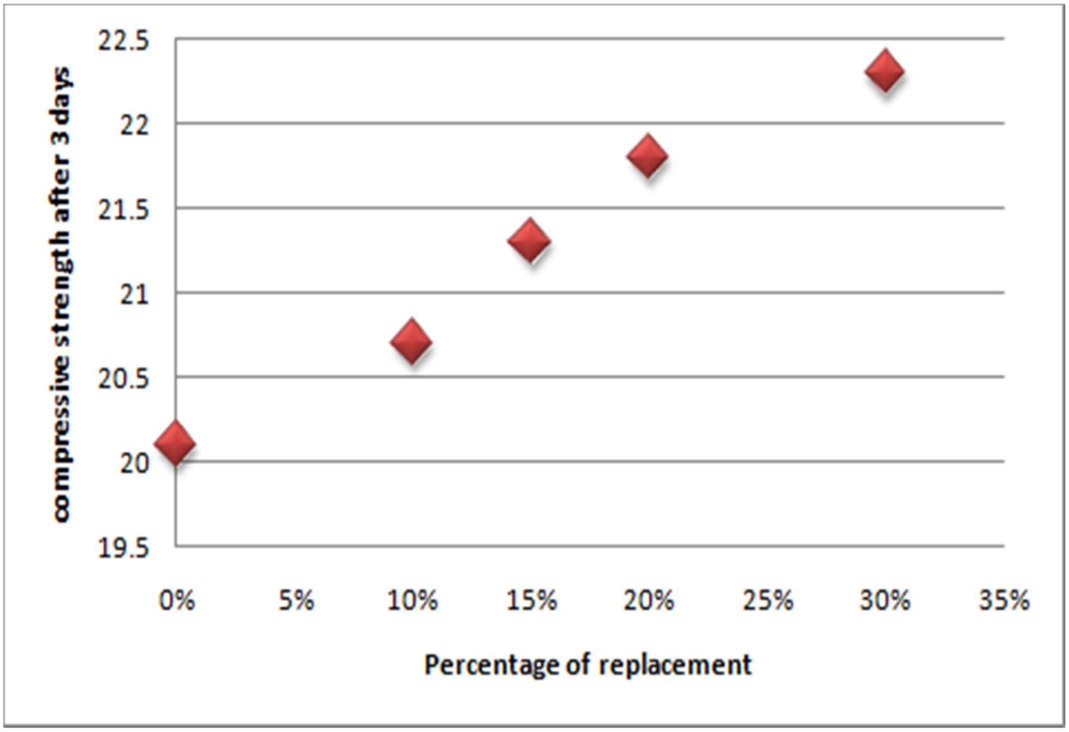

Fig. 6 – 21 days compressive strength for M2

Above graph represent the maximum compressive strength is found at 30% replacementof sand with steel powder after 21days of curing)

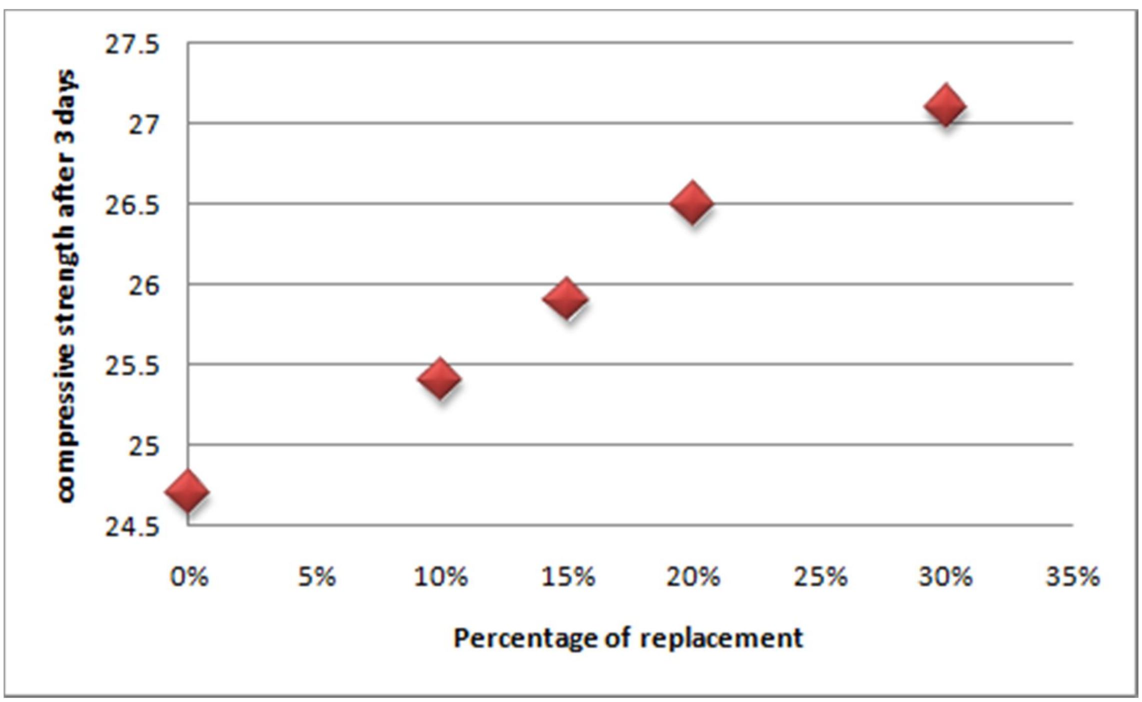

Fig. 7 – 28 days compressive strength for M2

From this figure it is observed that maximum compressive strength is found at30% replacement of sand with steel powder after 28 days of curing

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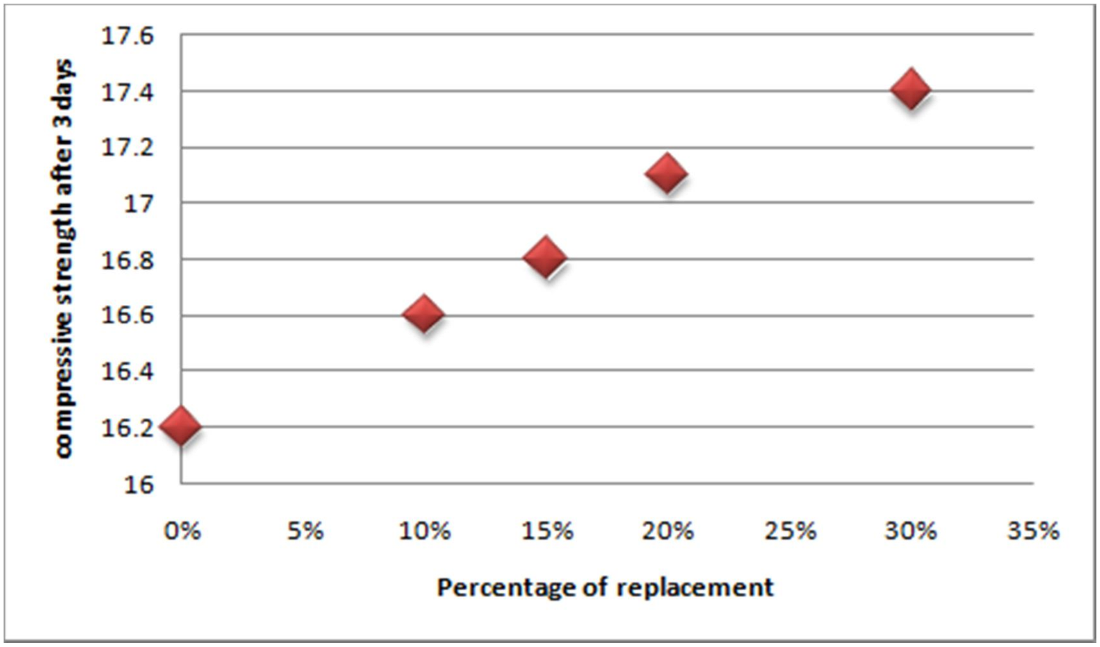

Fig. 8 – 7 days compressive strength for M3

From this figure it is observed that maximum compressive strength is found at 30% replacement of both cement and sand with silica fume and steel powder after7 days of curing

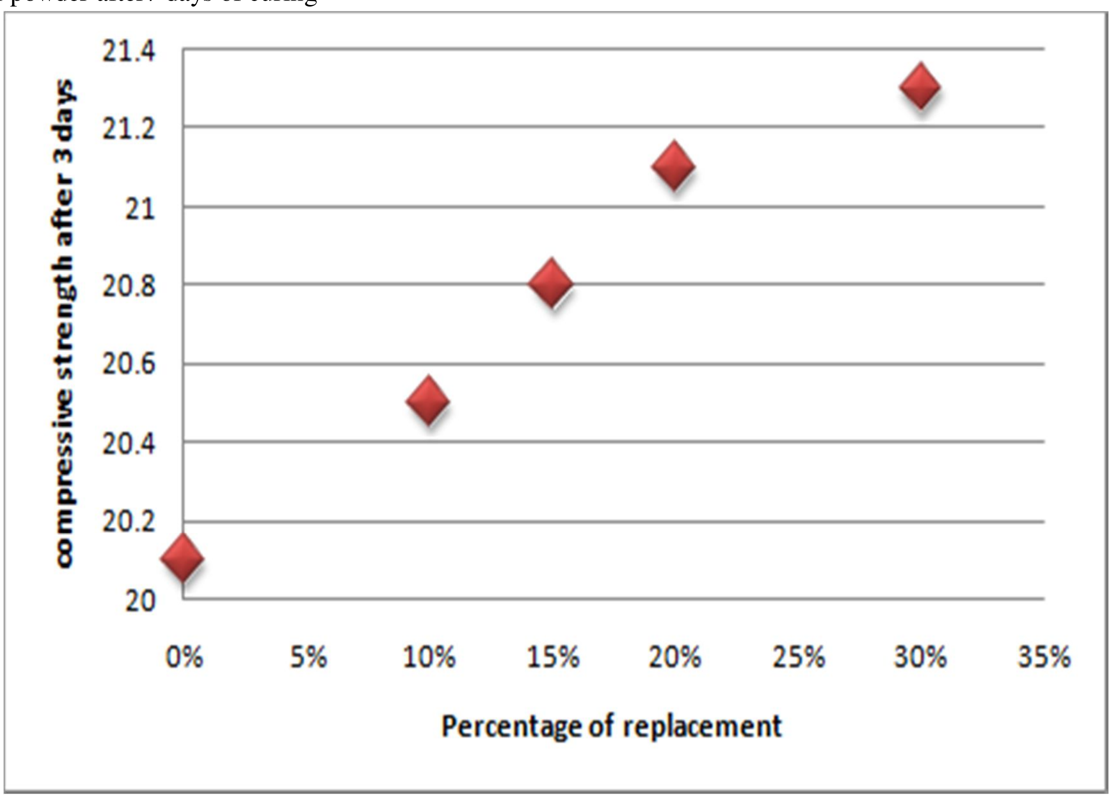

Fig. 9 – 21 days compressive strength for M3

The above figure shows the maximum compressive strength is found at 30%replacement of both cement and sand with silica fume and steel powder after21days of curing

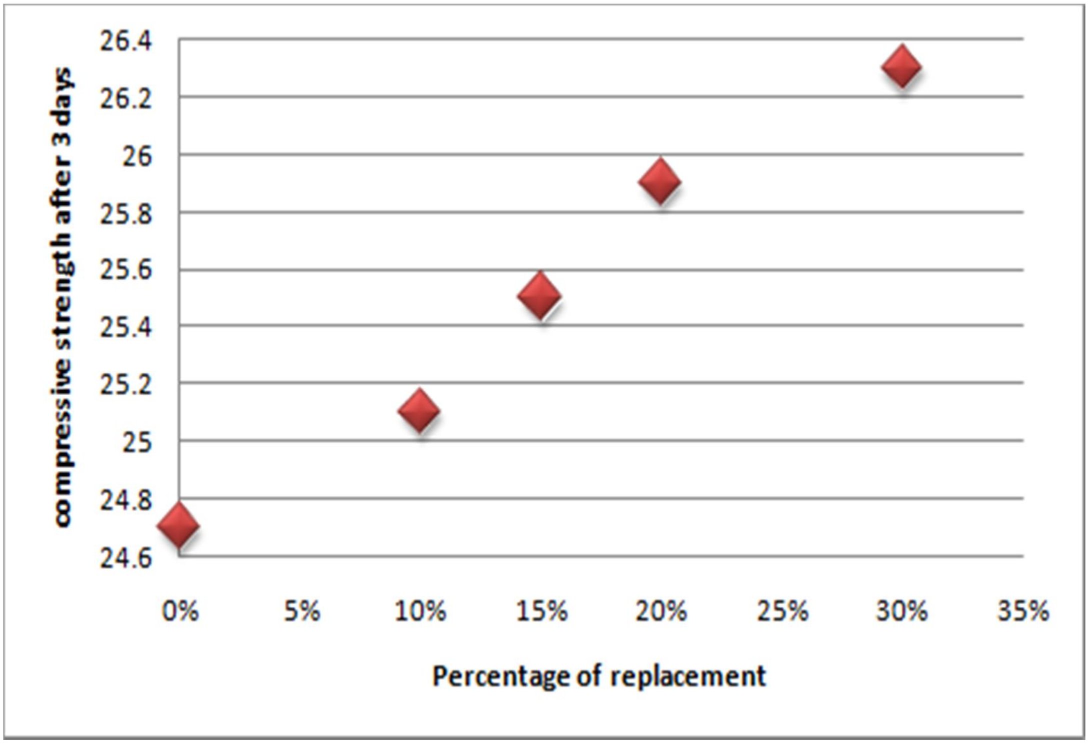

Fig. 10 – 28 days compressive strength for M3

From this figure it is observed that Maximum compressive strength is found at 30% replacement of both cement and sand with silica fume and steel powder after28 days of curing

B. Slump Cone Tests

Along with compressive strength workability of concrete is major parameter required for testing the quality of concrete mix, again by mixing marblepowder in cement concrete in different proportions such as in 10, 15, 20, 30%.

It has been observed from the results that slump value reduces with the increasein values of percentage replacement following changes are presented in following figures.However, it has been observed that workability of concrete increases with the combined use of silica fume and steel powder.

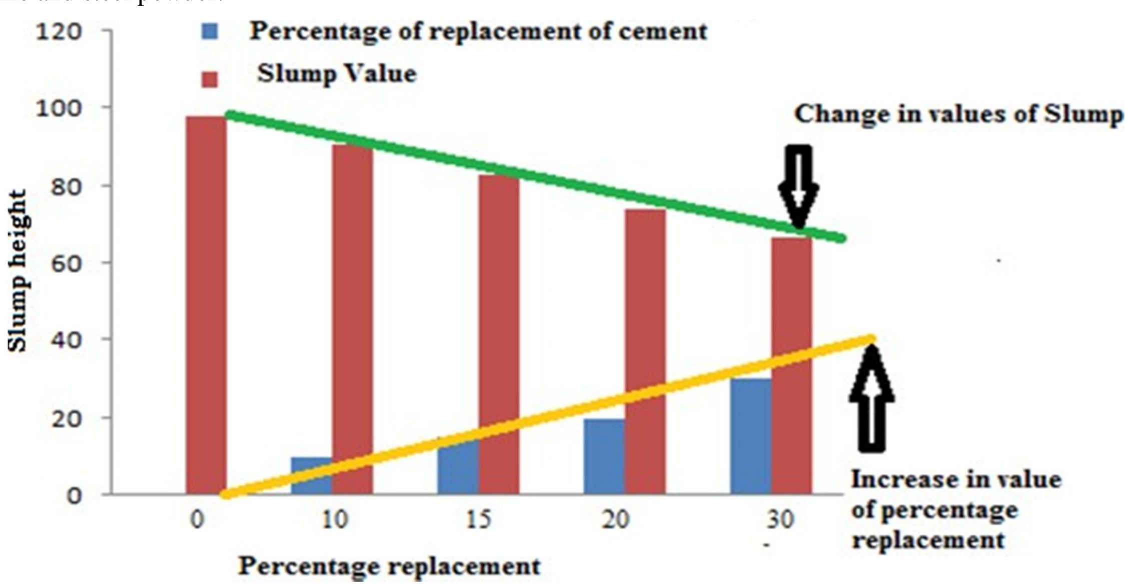

Fig. 11 Variation of slump with change in percentage replacement for M1

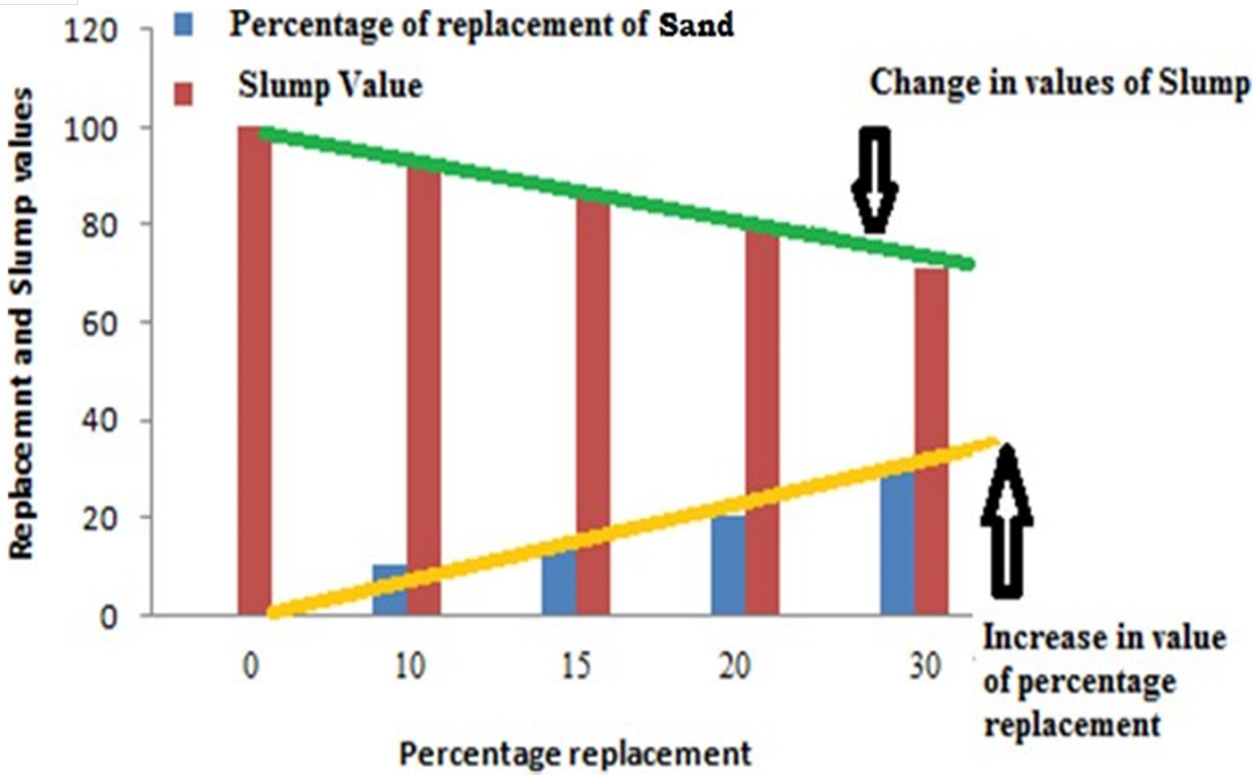

Fig. 12 Variation of slump with change in percentage replacement for M2

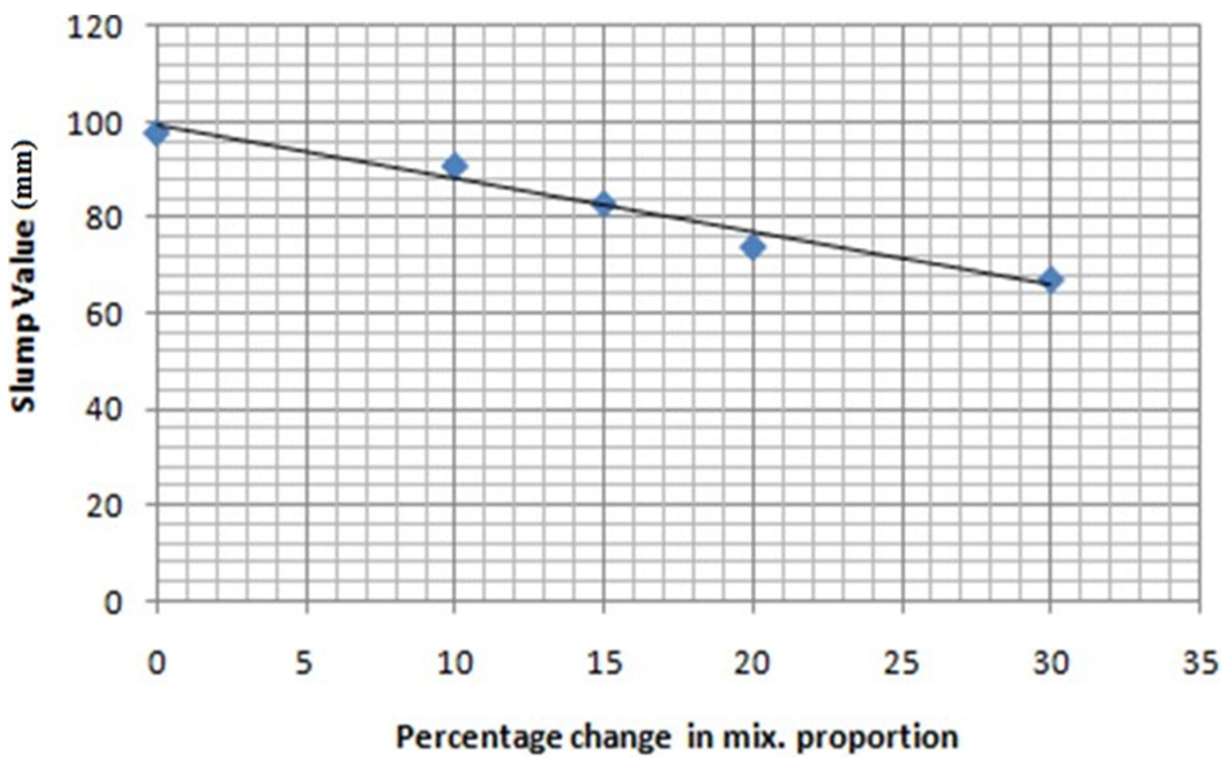

Fig. 13 – Change in slump value for M1

This figure shows the Variation of slump with change in percentage replacement, at 20%replacement of cement with silica fume.

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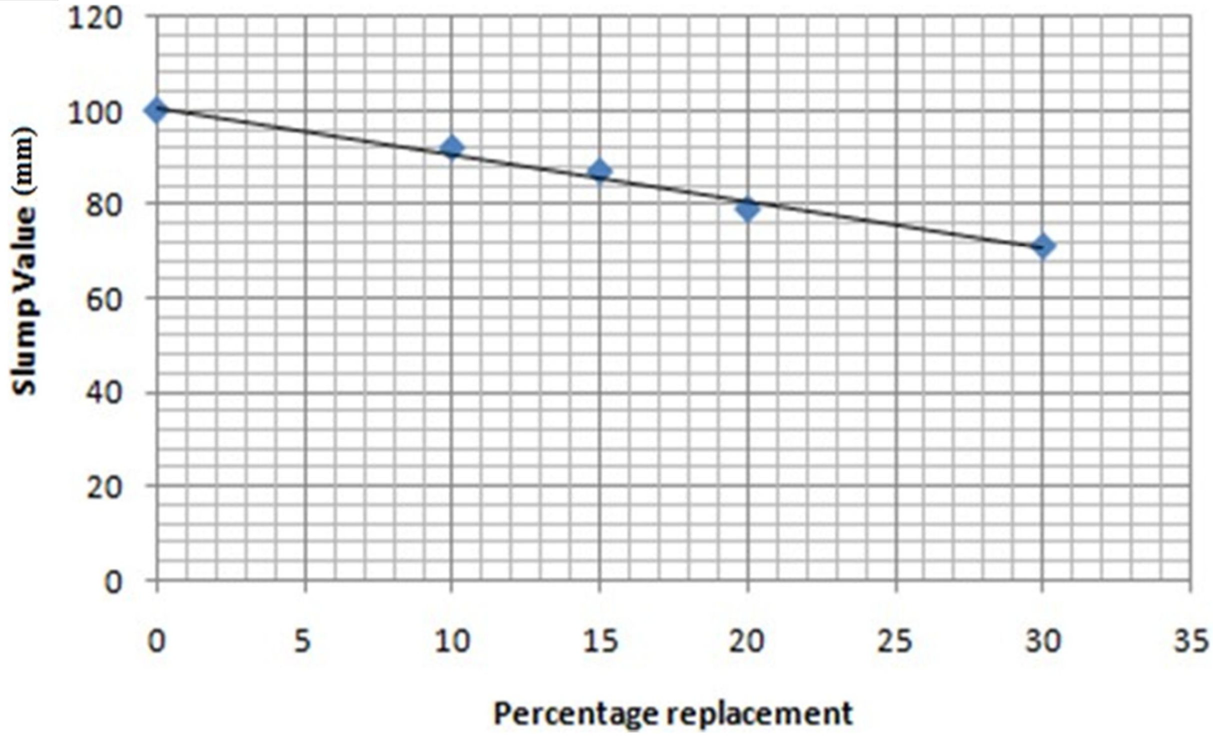

Fig. 14 – Change in slump value for M2

This figure shows the Variation of slump with change in percentage replacement, 30%replacement of sand with steel powder.

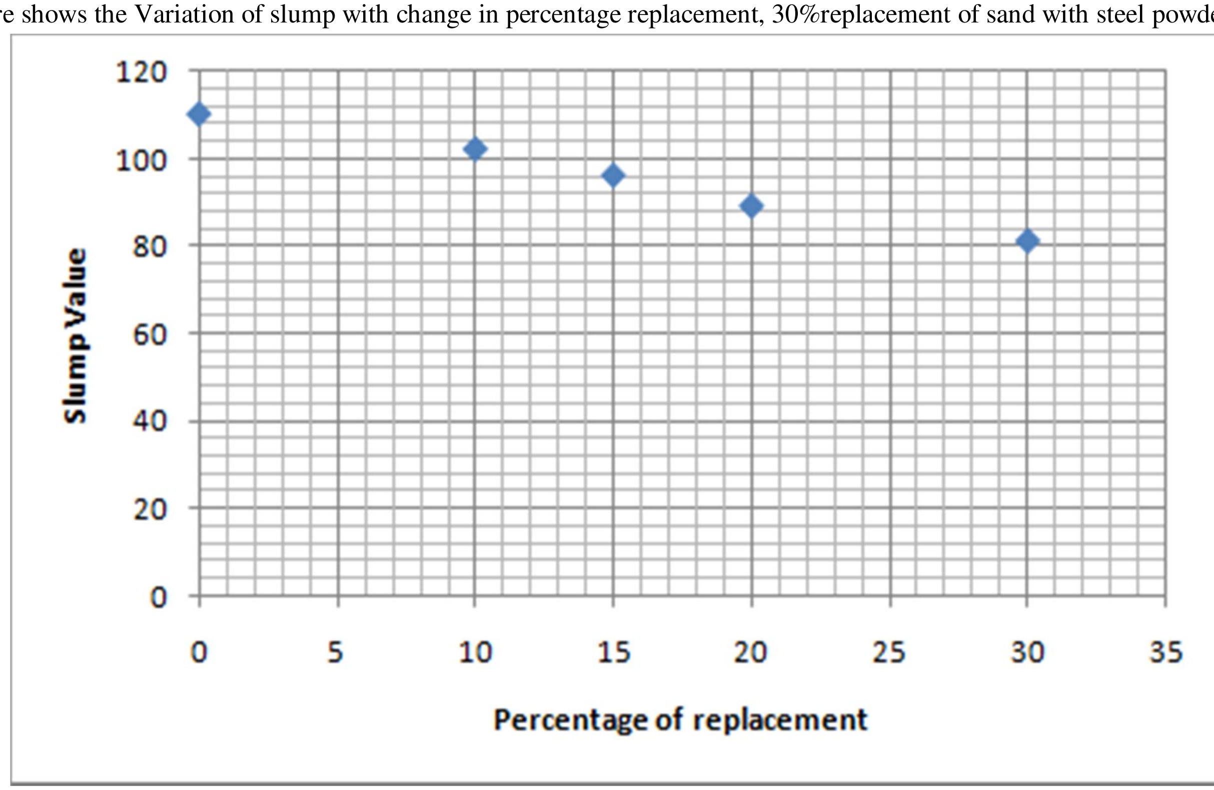

Fig. 15 – Change in slump value for M3

This figure shows the Variation of slump with change in percentage replacement, at 30%replacement of both cement and sand with silica fume and steel powder.

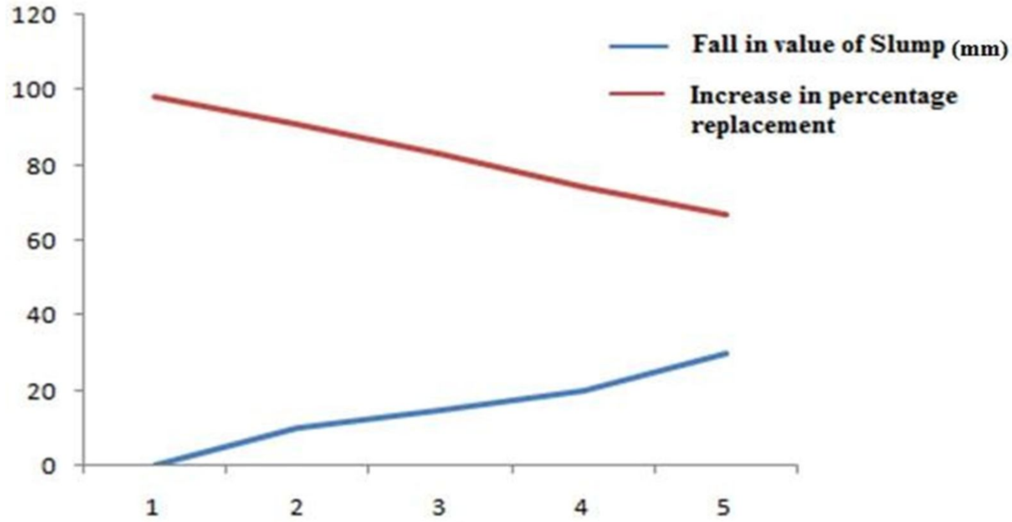

Fig. 16 - Fall in value of slump with increase in % replacement for M1

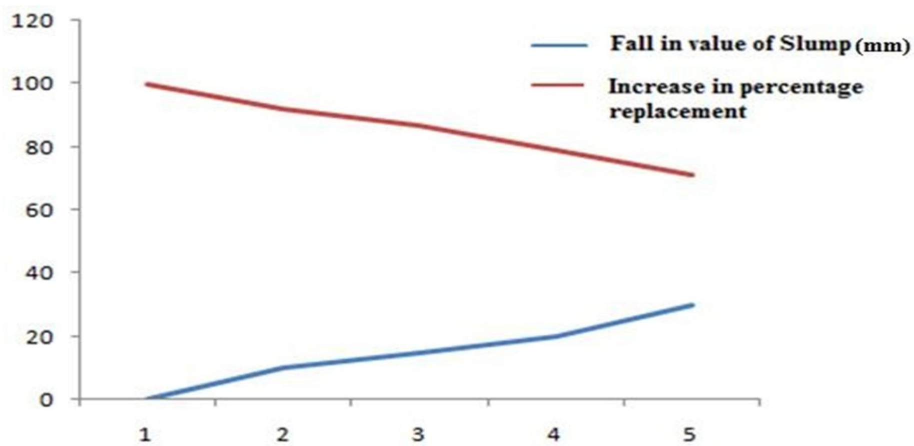

Fig. 17 - Fall in value of slump with increase in % replacement for M 2

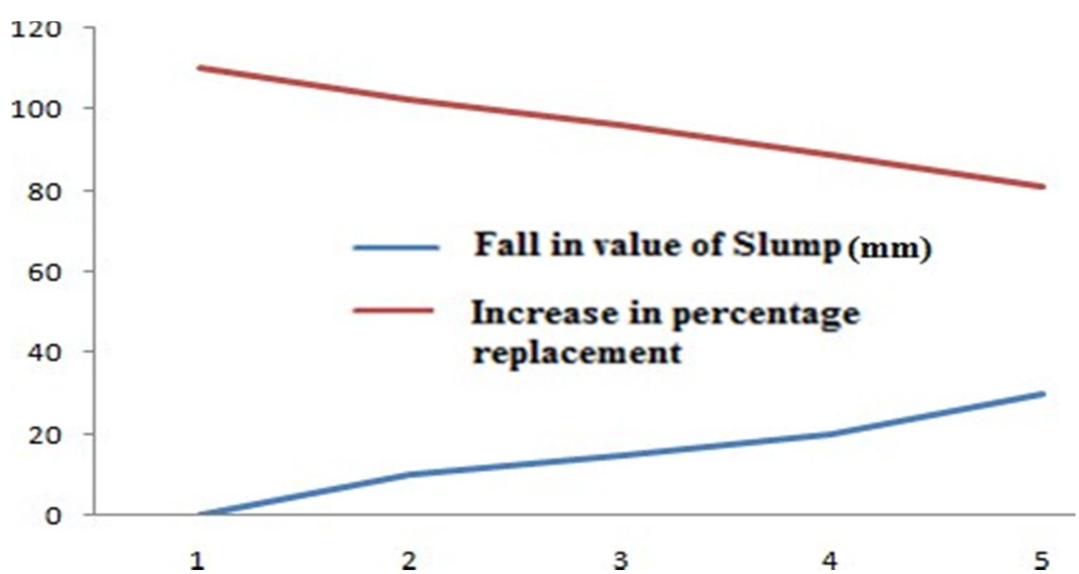

Fig. 18 - Fall in value of slump with increase in % replacement for M35

C. Observation

Experiments had been conducted to determine the suitability of silica fume and steel powder as alternative construction materials. Several Concrete mixes have been prepared by replacing cement with these materials, to determine compressive strength and slump values. It has been observed from experimental results that compressive strength increases up-to a certain point by replacing chief ingredients with supplementary materials and workability decreases with the increase in percentage of replacement. Setting time increases with increase in percentage of replacement.

In the present study usefulness of silica fume and steel powder as construction materials has been investigated through laboratory experiments. Various Concrete blocks have been casted using these materials to investigate compressive strength and slump values. The results show that marble powder may be used in concrete upto 15 to 20% of weight of cement and concrete waste can be used upto 15% for optimum values of strength and workability.

V. CONCLUSIONS AND FUTURE

Following are the conclusions of the present work –

1) By replacing cement with silica fume in M1 mix compressive strength increases up-to 20% and then decreases with increase in percentage replacement of cement.
2) Compressive strength has been found to be highest at 20% replacement of cement by Silica fume in M1 mixes.
3) Slump value is found to be decreasing by increasing the percentage of silica fume.
4) Compressive strength increases and Slump value decreases by increasing the percentageof replacement of sand by steel powder in M2 mixes.
5) Hence, from above results it has been recommended to replace cement about 20% with silica fume for higher compressive strength and optimum workability.
6) Results indicate that compressive strength increases with the combined use of steel powder and silica fume in concrete.
7) Slump value is higher in case of M3 concrete mix when compared with M1 and M2 mixes. However, with the increase in percentage of replacement value of slump cone decreases in all the three concrete mixes M1, M2 and M3.

A. Future Scope Of Present Work

To investigate the appropriateness and effectiveness of alternative materials in civil engineering work and materials, as a replacement to chief constituents, further more result has been required.

1) This work can be extended for high grade of concrete.
2) Mix design of concrete by using other waste materials.

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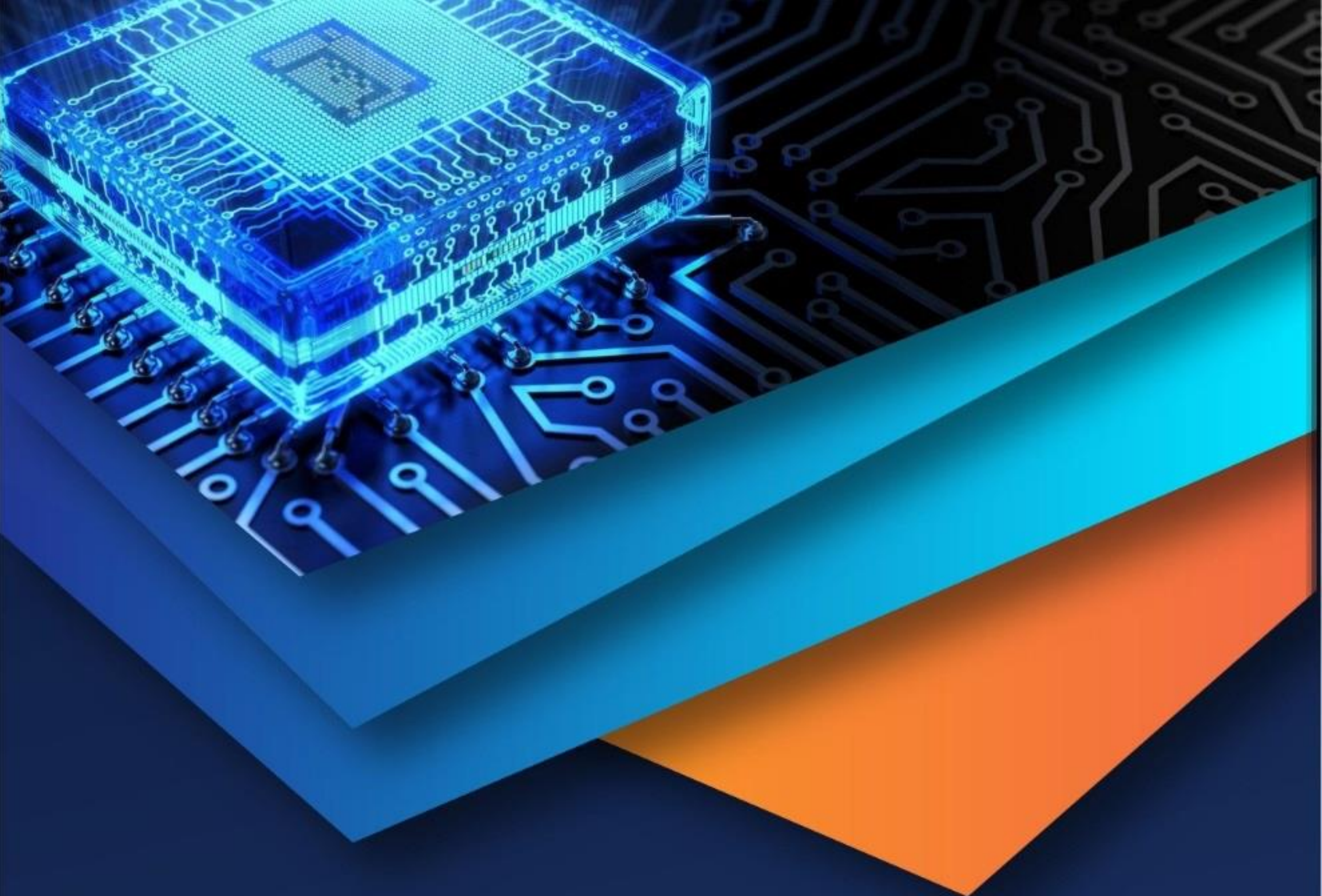

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