INVESTIGATION OF COMPRESSIVE STRENGTH OF CONCRETE BY PARTIAL REPLACEMENT OF FINE AGGREGATE AND CEMENT WITH M-SAND AND SILICAFUME

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ABSTRACT – *Now a days natural sand is becoming scarce therefore it's necessary to supply a concrete with improved strength and performance with suitable materials. M-Sand (crushed stone aggregate) can achieve similar kind of strength with use of certain materials. This paper presents the optimization of partial replacement of M-Sand with natural sand and cement with silica fume. Natural Sand was replaced with M-Sand by 25%, 50% and 75%. Ordinary Portland Cement was partially replaced with Silica Fume by 10%, 15% and 20%. Concrete mixes were evaluated for compressive strength of concrete at the age of 7days and 28days.The result showed a increase in compressive strength of concrete when silica fume is 10% and when M-Sand percentage is 25%. It also shows that further addition of M-Sand resulted in decrease in compressive strength of concrete. On practical application we usually don't mix natural sand and river sand, So whenever M-Sand 100% is used in the concrete mix the required strength was attained when silica fume is 10%.*

Key Words: Silica fume, Compressive Strength, Water-cement ratio, M25 grade concrete, M-Sand.

1.INTRODUCTION

Concrete is that the homogeneous mixer of coarse aggregate, fine aggregate, cement, water and chemical admixture. Now a days mostly M-Sand (Crushed stone aggregate) is employed as a fine aggregate since natural sand is becoming scarce. Concrete with same compressive strength are often obtained using M-Sand as a replacement to natural sand. Silica fume (by-product in smelting process of ferrosilicon alloy or silicon metal) are often used as a replacement of cement to realize the high strength of concrete. These metals are utilized in many industrial applications which include aluminium and production , computer chip fabrication, and production of silicones, which are widely utilized in lubricants and sealants. While these are valuable materials, the by-product silica fume is of more importance to the concrete industry. Silica fume may be a highly reactive material utilized in relatively small proportions to reinforce the properties of concrete. Due to its very high amorphous silica content, silica fume could also be a really reactive pozzolanic material in concrete. Because the Portland cement in concrete begins to react chemically, it releases lime to form additional binder material called calcium silicate hydrate, which is almost just like the calcium silicate hydrate formed from the hydraulic cement . it's largely this extra binder that provides silica fume concrete it's improved hardened concrete properties. Improvements in other mechanical properties like modulus of elasticity or flexural strength also are seen. In many situations, the sturdiness of concrete is directly associated with its permeability. Therfore it's important to reduce the permeability of concrete which can be effectively done using silica fume. By reducing the permeability of the concrete, the time gets extended for any aggressive chemical to induce into the concrete where it can do its damage.

1.1 LITERATURE REVIEW

Ahamed.O.A., [1] aimed to produce a concrete that will decrease disadvantages of Portland cement concrete and resolve it. Mixture of Silica fume with concrete in this paper shows that the strength and hardness are increased. In this research the main goal is to compare the difference of compressive strength between standard concrete and concrete with silica fume with different additives ratio and to explore its effect on the main physical properties of concrete. In this research about

180 samples prepared and its compressive strength is examined, all concrete sample has the same mixing ratio and Silica fume added by the volume (5, 10, 15, 20 and 30%). The results show that the recommended addition will be 15% of Silica fumes for optimum compressive strength that reaches 74.8 MPa.

AMZ Zimar, GKPN Samarawickrama, S Jayakody., [2] thought about possibility of using Manufactured Sand (MS) in concrete structures with grade of 20. In this paper, experimental studies on compressive strength development of concrete with manufactured sand (CMS) were administered . The conventional river sand was replaced with 0%, 30%, 50%, 70% and 100% by the MS in concrete mixtures and test cylinders were cast for each percentage. The CMS cylinders were tested after 7 and 28 days of curing. Results indicated that river sand are often entirely replaced by MS however; water reducing admixtures got to be added as needed .

Shanmugapriya.T and Uma.R.N., [3] describes us about the optimization of partial replacement of manufactured sand by natural sand with silica fume in High Performance Concrete (HPC). Concrete mixes were evaluated for compressive strength and flexural strength. The Ordinary Portland Cement was partially replaced with silica fume by 1.5%, 2.5 %, and 5% and natural sand was replaced with manufactured sand by four proportions (i.e., 10%, 30%, 50%, 70%). The results indicated that there is an increase in the compressive and flexural strength of HPC nearly 20% and 15% respectively with the increase of manufactured sand percentage. Addition of up to 50% of manufactured sand as sand replacement yielded comparable strength. However, further additions of manufactured sand caused reduction within the strength. The optimum percentage of replacement of natural sand by M-sand is 50%. The results also revealed that increase in percentage of partial replacement of silica fume, increased the compressive and flexure strength of High Performance Concrete.

Mani Kandhan.K.U, Sathya Kumar.N., [4] carried out certain investigations to study about the compressive strength and split tensile strength of concrete using M-sand as fine aggregate instead of river sand. And compare the results obtained from both the river sand and also the M-sand. In order to achieve the strength, cement is replaced by silica fume by 15% in weight and also 1.2% weight of binder super plasticizer is added to obtain workability. This investigation mainly focused on the M-sand properties and the strength obtained from both the river sand and m-sand.

Akshatha.K.B., [5], made an attempt to determine the effect of SF and steel bars on M-45 grade concrete. The experimental investigation involved addition of silica fume is varied as 5%, 7.5%, 10% and 12.5% by weight of the cement. The steel fibres of aspect ratio 35 are also added to improve the tensile strength of the concrete. The addition of steel fibre is varied as 0.5%, 0.75% and 1% by volume fraction. The characteristics of the fresh concrete are carried out to find the workability of the concrete. The hardened properties of the concrete such as compressive strength, flexural strength, tensile strength and modulus of elasticity were carried out to determine the effect of silica fume and steel fibre. The addition of 7.5% SF and 0.75% hooked end steel fibre was found to be optimum.

Singh.L, Kumar.A., [6] had conducted an experimental study on the nature of silica fume and its influences on the properties of fresh concrete. It involves the study about how a partially replacement of cement by silica fume affect the strength parameters of concrete. Silica fume were used to replace 0% to 15% of cement, by weight at increment of 5% for both cube and cylinder. The results showed that partial replacement of cement with silica fume had significant effect on the compressive strength of cube and split tensile strength cylinder. The strength of concrete increases rapidly as we increases the silica fume content and therefore the optimum value of compressive strength is obtained at 10% replacement. After 10% its start decreasing under uniform load condition of 4 KN and similarly the split tensile strength increases up to 10% and then start decreasing under the uniform load condition of 2KN.

2.MATERIALS

2.1 CEMENT- It is a very fine powder with adhesive properties and acts as binder material in the concrete mix. Ordinary portland cement of 43 grade cement was used in this study. From the test conducted in the lab the specific gravity of the cement was found to be 3.15.

2.2 FINE AGGREGATE

2.2.1- NATURAL SAND - Locally available river sand having bulk density 1612kg/m³ was used and the specific gravity is 2.65. The fineness modulus of river sand is 2.55.

2.2.2- M-SAND - M-Sand was used as a partial replacement of natural sand. The bulk density of M-Sand was 1612kg/m³. The specific gravity and fineness modulus was found to be 2.56 and 2.8.

2.3 COARSE AGGREGATE - Crushed angular aggregate of size 20mm having bulk density of 1608kg/m was used. The specific gravity was found to be 2.7.

2.4 SILICA FUME - The silica fume was partially replaced with cement. Silica fume was collected from ASTRAA CHEMICALS PVT LTD, CHENNAI-06. It is available in its densified form and its bulk density was found to be 649.7kg/m. The specific gravity was found to be 2.2.

Figure.2-Silica fume

2.5 WATER - Fresh portable water, which is free from acid and organic substance was used for mixing the concrete**.**

3. MIX PROPORTION AND MIX DETAILS

M25 grade of concrete is designed as per the guidelines specified in IS10262-2009 & IS456-2000. Mix design is obtained as (1:1.76:2.78). Water cement ratio is taken as 0.5. Silica fume is added to the cement in four proportions 0%, 10%, 15%, 20%. For each silica fume proportions natural sand was replaced with m-sand in following percentage (0%, 25%, 50%, 75%, 100%). This is explained in the below table

TABLE-1: MIX PROPORTION OF CONCRETE BY IT'S WEIGHT

CUBE SET	SF (%)	CEMENT (Kg)	SF (Kg)	M-SAND (%)	M-SAND (kg)	NATURAL SAND (kg)	CA (kg)
1	0	1.33	0	100	2.34	0	3.7
2	0	1.33	0	75	1.755	0.585	3.7
3	0	1.33	0	50	1.17	1.17	3.7
4	0	1.33	0	25	0.585	1.755	3.7
5	0	1.33	0	0	0	2.34	3.7
6	10	1.197	0.133	100	2.34	0	3.7
7	10	1.197	0.133	75	1.755	0.585	3.7
8	10	1.197	0.133	50	1.17	1.17	3.7
9	10	1.197	0.133	25	0.585	1.755	3.7
10	10	1.197	0.133	0	0	2.34	3.7
11	15	1.13	0.2	100	2.34	0	3.7
12	15	1.13	0.2	75	1.755	0.585	3.7

13	15	1.13	0.2	50	1.17	1.17	3.7
14	15	1.13	0.2	25	0.585	1.755	3.7
15	15	1.13	0.2	0	0	2.34	3.7
16	20	1.064	0.266	100	2.34	0	3.7
17	20	1.064	0.266	75	1.755	0.585	3.7
18	20	1.064	0.266	50	1.17	1.17	3.7
19	20	1.064	0.266	25	0.585	1.755	3.7
20	20	1.064	0.266	0	0	2.34	3.7

For each cube set three cubes are casted and cured in water respectively for 7days and 28days.

Figure.3- Casting of cubes

4. RESULT AND DISCUSSION

The compressive strength test was carried out using compression testing equipment shown in figure.5. We will discuss the results we got in 6 cases and conclude them.

Figure.4- Cube kept under compression

Figure.5 – Compression testing machine

4.1 CASE-1: SILICA FUME 0%

Table-2: Test Result

S.NO	SILICA FUME %	M-SAND %	COMPRESSIVE STRENGTH N/mm²	
			7th DAY	28th DAY
1	0	100	17.5	26
2	0	75	21.3	29.33
3	0	50	18.6	27.64
4	0	25	17.8	26.3
5	0	0	17.3	25.4

4.1.1 GRAPH

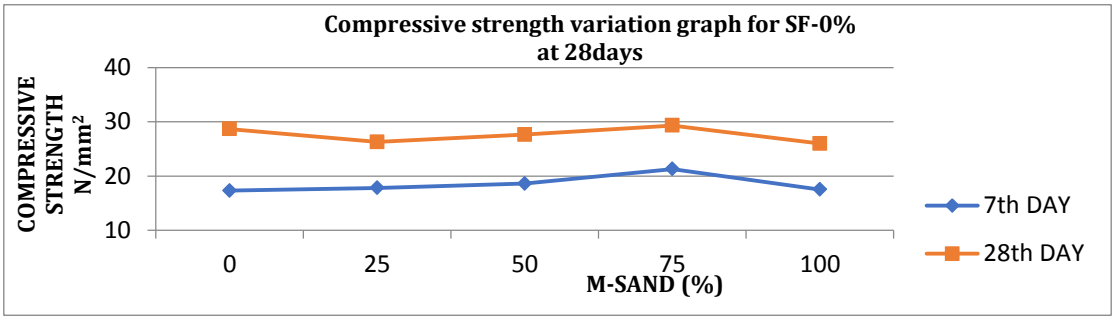

CHART-1: Compressive strength graph for SF 0%

4.1.2 DISCUSSION

For case 1 from the above graph it is clear that the compressive strength of concrete is higher when 25% of natural sand is replaced with M-Sand with silica fume 0%. Also target mean strength had not been achieved in any of the M-Sand proportions.

4.2 CASE-2: SILICA FUME 10%

Table.3: Test Result

S.NO	SILICA FUME (%)	M-SAND (%)	COMPRESSIVE STRENGTH (N/mm²)		28TH DAY COMPRESSIVE STRENGTH OF SILICA FUME 0%	% INCREASE
			7TH DAY	28TH DAY		
1.	10	100	18.67	28	26	8
2.	10	75	22.4	30	29.33	2

3.	10	50	28	31.78	27.64	15
4.	10	25	29.3	33.33	26.3	26.7
5.	10	0	24	32	25.4	25.9

4.2.1 GRAPH

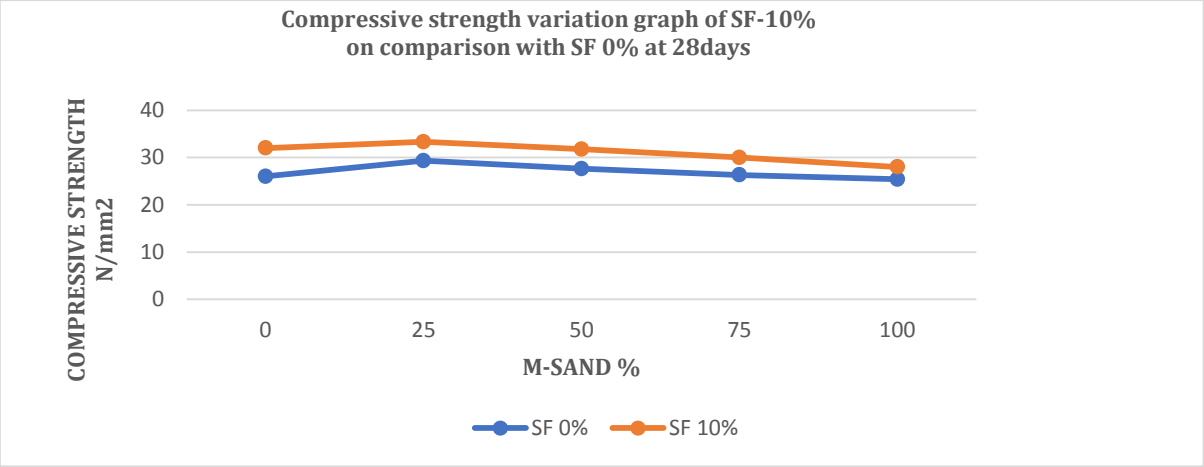

Chart-2: Compressive strength variation graph of SF 10% in comparison with SF 0% at 28day

4.2.2 DISCUSSION

For case 2 from the above graph it is clear that the compressive strength of concrete is higher when 25% of natural sand is replaced with M-Sand with silica fume 10%. Also target mean strength is achieved when the M-Sand proportions are 25% and 50%. It is to be noted that with increase in M-Sand percentage, strength seems to be decreasing. The table clearly shows the increase in compressive strength on 10% addition of silica fume to cement when compared with compressive strength of conventional concrete (i.e. silica fume 0%)

4.3 CASE-3: SILICA FUME 15%

Table.4: Test Result

S.NO	SILICA FUME (%)	M-SAND (%)	COMPRESSIVE STRENGTH (N/mm^2)		28TH DAY COMPRESSIVE STRENGTH OF SILICA FUME 0%	% INCREASE (OR) %DECREASE	28TH DAY COMPRESSIVE STRENGTH OF SILICA FUME 10%	% DECREASE
			7TH day	28th day				
1.	15	100	19.3	25.78	26	1 (decrease)	28	8
2.	15	75	23	26.4	29.33	9 (decrease)	30	12
3.	15	50	23.3	28	27.64	1.3 (increase)	31.78	11.8
4.	15	25	25.5	31.7	26.3	20 (increase)	33.33	4.8
5.	15	0	23.5	26	25.4	2.4 (increase)	31	18.7

4.3.1 GRAPH

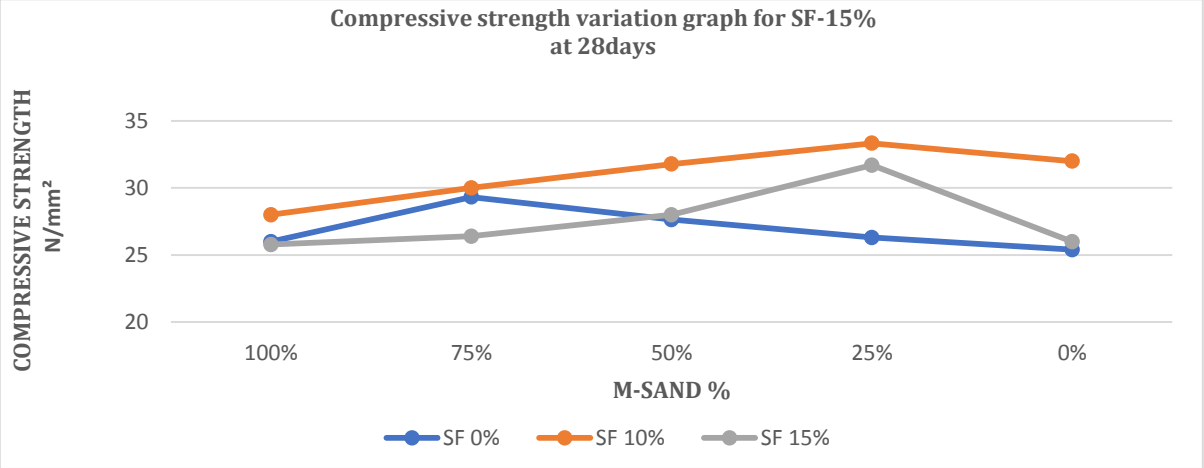

Chart-3: Compressive strength variation graph of SF 15% in comparison with SF 0% & SF 10% at 28days

4.3.2 DISCUSSION

For case 3 from the above graph it is clear that the compressive strength is higher when the 25% of natural sand is replaced with M-Sand with silica fume 15%. The target mean strength is achieved when 25% of natural sand is replaced with M-Sand. From the table it is clear that compressive strength of 15% addition of silica fume concrete decreases on comparison with 10% addition of silica fume concrete in all proportions of m-sand. But on comparison with conventional concrete the compressive strength increases on 0%, 25%, 50% of M-Sand proportions and decreases on the remaining M-Sand proportions.

4.4 CASE-4: SILICA FUME 20%

Table.5: Test Result

S.NO	SILICA FUME (%)	M-SAND (%)	COMPRESSIVE STRENGTH (N/mm²)		28TH DAY COMPRESSIVE STRENGTH OF SILICA FUME 0%	% INCREASE (OR) %DECREASE	28TH DAY COMPRESSIVE STRENGTH OF SILICA FUME 15%	% INCREASE (OR) %DECREASE	28TH DAY COMPRESSIVE STRENGTH OF SILICA FUME 10%	% DECREASE
			7th day	28th day						
1	20	100	19.1	25.8	26	0.7(decrease)	25.78	0	28	7.8
2	20	75	20	26.2	29.33	11(decrease)	26.4	0.76(decrease)	30	13
3	20	50	22.2	27.5	27.64	0.5(decrease)	28	1.78(decrease)	31.78	14
4	20	25	22.4	28.4	26.3	8(increase)	31.7	10.4(decrease)	33.33	15
5	20	0	21.24	26.5	25.4	4(increase)	26	2(increase)	31	17

4.4.1 GRAPH

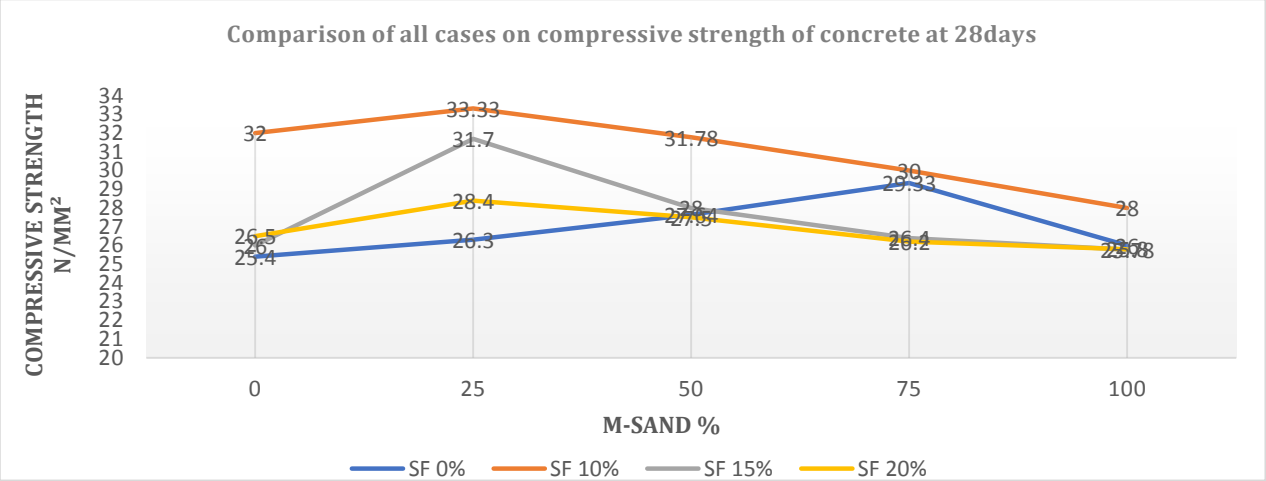

Chart-4: Comparison of all cases on compressive strength of concrete at 28days

4.4.2 DISCUSSION

For case 4 from the above graph it is clear the compressive strength of concrete is higher when the 25% of natural sand is replaced with M-Sand with silica fume 20%. The target mean strength has not been achieved on any of the M-Sand proportion for 20% addition of silica fume. From table.5 it is clear that the compressive strength of concrete on addition of 20% of silica fume decreases when compared with the compressive strength of concrete with 10% addition of silica fume. Similarly when compared with silica fume 0% the compressive strength increases on 0% and 25% of M-Sand proportions and decreases on remaining M-Sand proportions. When compared with 15% addition of silica fume the compressive strength of concrete decreases on 75%, 50%, 25% of m-sand proportions.

4.5 DISCUSSION ON M-SAND 25%

Table.6: Test Result

SILICA FUME (%)	28TH DAY COMPRESSIVE STRENGTH
0	26.3
10	33.33
15	31.7
20	28.4

4.5.1 GRAPH

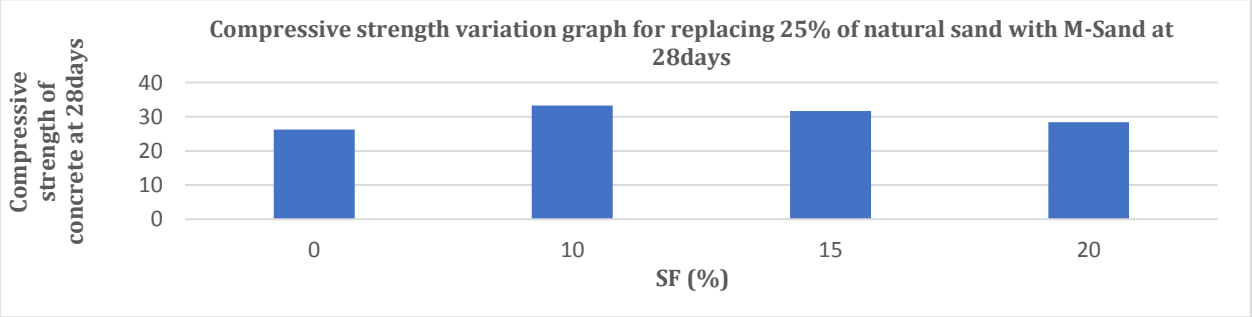

Chart-5: Compressive strength variation graph for replacing 25% of natural sand with M-Sand at 28days

4.5.2 DISCUSSION

For case 5 from the above graph, the compressive strength of concrete was found higher when 25% of natural sand is replaced with M-Sand on all three cases. The above graph represents the compressive strength of concrete at 28 days when 25% of natural sand is replaced with M-Sand for silica fume addition of 0%, 10%, 15%, 20%. It also indicates that compressive strength of concrete starts decreasing when the silica fume percentage exceeds 10%.

4.6 DISCUSSION ON M-SAND 100%

Table.7: Test Result

SILICA FUME (%)	28TH DAY COMPRESSIVE STRENGTH
0	26
10	28
15	25.78
20	25.8

4.6.1 GRAPH

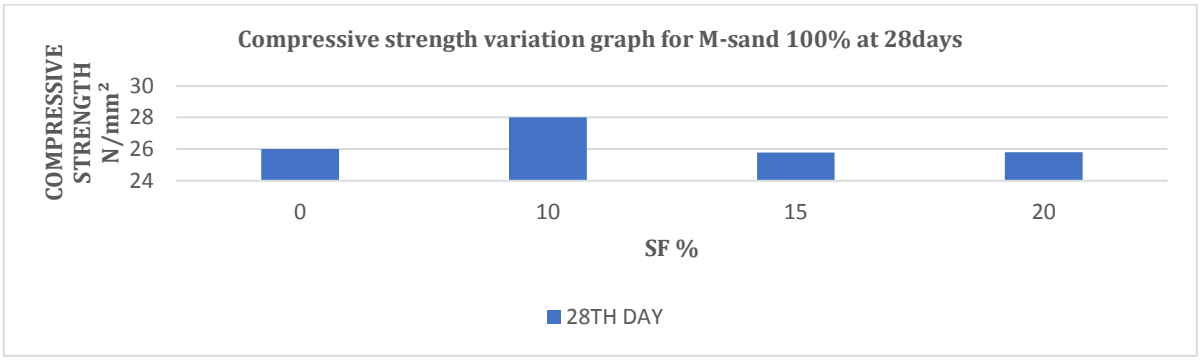

Chart-6: Compressive strength variation graph for replacing 100% of natural sand with M-Sand

4.6.2 DISCUSSION

The reason for this discussion is practically we don't mix M-Sand with natural sand we either go with 100% M-Sand or 100% natural sand, so to have an idea in that sense we had done this. For case 6 from the above graph it is certain that

compressive strength upto 28N/mm^2 is obtainable using 10% addition of silica fume. Though it has not achieved the target mean strength it is certainly giving us better result than the conventional concrete. The strength starts decreasing on further addition of silica fume.

5. CONCLUSION

The following conclusions are drawn from this investigation

- It is observed that the compressive strength of concrete can be increased by partial replacement of silica fume for cement and M-Sand for fine aggregate.
- From the above experimental results, it is evident that compressive strength can be increased by partial replacement of M-Sand with fine aggregate. The optimal percentage of replacement of natural sand by M-Sand is 25%.
- On comparing with other silica fume proportions, the compressive strength of concrete increases by 28% by replacing 25% of natural sand with M-Sand and 10% of cement by silica fume at the age of 28 days.
- For M-Sand 100% the compressive strength of concrete increases by 9% on replacing 10% of cement by silica fume at the age of 28days when compared with other silica fume proportions.
- From the previous points it is evident that the optimum percentage of silica fume in this study is 10%.
- High performance concrete using silica fume is effective because high early strength is achieved and it reduces the construction period.

6.REFERENCE

[1] Ahmad, O. A. (2017). Production of high-performance silica fume concrete. American Journal of Applied Sciences, 14(11), 1031-1038.

[2] Al-Sodani, K. A. A., Maslehuddin, M., Al-Amoudi, O. S. B., Saleh, T. A., & Shameem, M. (2018). Performance of corrosion inhibitors in cracked and uncracked silica fume cement concrete beams. European Journal of Environmental and Civil Engineering, 1-16.

[3] Anilkumar, P. M., Raghavendra, M., & Sudhakumar, J. (2014). Effects of Silica fume and fly ash on durability characteristics of high performance concrete. Int. J. Emerg. Technol. Adv. Eng, 4(10), 298-303.

[4] Indian standard code for guidelines for concrete mix design (first revision) IS: 10262- 2009, bureau of Indian standards, July 2009, New Delhi.

[5] Indian standard code for practice for plain and reinforced concrete (fourth revision) IS: 456- 2000, bureau of Indian standards, July 2000, New Delhi.

[6] Shanmugapriya,T., & Uma, R. N. (2012). Optimization of partial replacement of M-sand by natural sand in high performance concrete with silica fume. International Journal of Engineering Sciences & Emerging Technologies, 2(2),73-80.

[7] Singh, L., Kumar, A., & Singh, A. (2016). Study of partial replacement of cement by silica fume. International Journal of Advanced Research, 4(7), 104-120.

[8] Terence C.Holland.(2005). Silica Fume User's Manual. US Department of transportation, FHWA-IF-05-016.