Comparative study on Utilization of Condensed and Volcanized Silica Fume as partial replacement to Cement

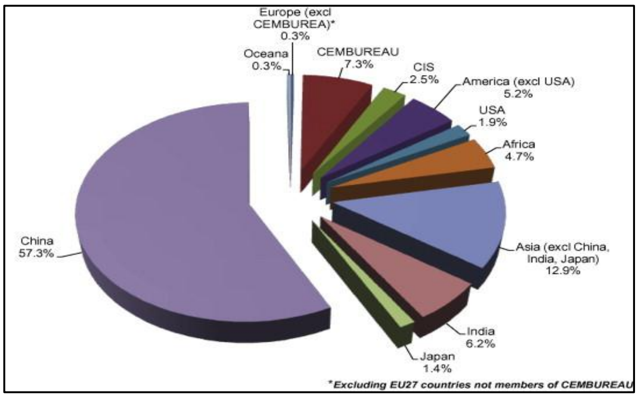
B. Sai Lakshmi[1] Y. Priyanka[2] V. Bhargavi[3]
[1]PG Student [2]Assistant Professor [3]Associate Professor
[1,2,3]Visakha Technical Campus, Visakhapatnam, Andhra Pradesh, India

Abstract— Due to rapid increase in the field of construction now a days due to various aspects like urbanization, Industrialization there was a great need for cementitious materials. So, a limitless research's have been carried out from time to time to replace these the cementitious materials with waste materials. In this aspect wastes like condensed silica and volcanized silica has provided a great path for study in place of cement. In this research the effect of high temperature on the workability and mechanical properties of silica incorporated concrete specimens were analyzed. For this purpose, concrete specimens containing 0, 5, 10,15 and 20% condensed silica fume and volatized silica fume substituted for cement with different w/b ratios and cured at different ages were prepared separately. The mechanical properties before and after exposure to high temperatures of 45°C were recorded. The results were further analyzed by comparison of mechanical properties and found that 15% variation in proportion was found to be optimum.

Keywords: Condensed Silica Fume, Mechanical Properties, Volcanized Silica Fume

I. INTRODUCTION

Most engineering constructions are not eco-friendly. Construction industry uses Portland cement which is known to be a heavy contributor to the CO2 emissions and environmental damage. In India, amount of construction has rapidly increased since last two decades. Using various types of supplementary cementing materials (SCMs), especially marble Powder as a cement replacement could result in a substantial reduction of the overall CO2 footprint of the final concrete product. Lesser the quantity of Portland cement used in concrete production, lesser will be the impact of the concrete industry on the environment. Recycling of industrial wastes has actually environmental, economic and technical benefits. These benefits can be seen from two different angles, one from the point of the waste producer and the other from the user part. For the producer, the benefits of recycling industrial wastes are economic and environmental for the user additional technical benefits may be attained from recycling. For the producer, the environmental benefit can be attained as far as the waste is recycled. It is independent of where it is recycled. But the economic benefit is determined on the demand for the waste by different users. One of the greatest environmental concerns in construction industry is the production of cement which emits large amount of CO2 gas to the atmosphere. It is estimated that 1 tone clinker production releases 1 tone CO2. Mixing of clinker to supplementary materials called blending is considered as a very effective way to reduce CO2 emission. It is estimated that the Rajasthan Marble Processing Enterprise produces 1800m3 (4500 tons) marble waste annually, which implies that using marble waste of The Rajasthan Marble processing enterprise as cement replacing material can indirectly reduce CO2emission to the atmosphere by 4500 tons annually. Recycling marble waste powder in substitution of cement also indirectly can reduce environmental problem related problems. Concrete is a mixture of binding material, coarse and fine aggregates and water. It is a versatile construction material due to its reasonable cost and easy availability of its constituents. Owing to increasing urbanization and other development activities in different sectors its consumption is increasing day-by-day. Increase in construction activities requires production of more and more quantity of concrete, which needs more and more natural river sand and coarse aggregate. During the process of production of coarse aggregate in crushing plants, a huge quantity of stone dust is produced which is considered worth less for any substantial use. This stone dust being a waste material can effectively be used in concrete making, as partial replacement of fine aggregate. The use of stone dust in concrete as partial replacement of fine aggregate will be an alternative material instead of conventional fine aggregate. This will result in conservation of natural resources (fine aggregate) up to some extent, besides helping in environment protection and disposal of stone dust in abundance Concrete, has relatively high compressive strength, but much lower tensile strength. Concrete has a very low coefficient of thermal expansion and shrinks as it matures. All concrete structures crack to some extent, due to shrinkage and tension. Glass fiber concrete (GFC) consists basically of a matrix composed of cement, sand, water, and admixtures, in which short length glass fibers are dispersed. The effect of the fibers in this composite leads to an increase in the tension and impact strength of the material.



II. LITERATURE REVIEW

Kumar & Dhaka (2016) conducted studies on partial replacement of cement with silica fume and its effects on concrete properties. The main parameter investigated in this study M-35 concrete mix with partial replacement by silica fume with varying 0, 5, 9, 12 and 15% by weight of cement. This paper presents a detailed experimental study on compressive strength, flexural strength and split tensile strength for 7 days and 28 days respectively. The results of experimental investigation indicate that the use of silica fume in concrete has increased the strength and durability at all ages when compared to normal concrete.

Alok (2016) conducted studies on partial replacement of Cement in M-30 Concrete from Silica Fume and Fly Ash. Replacement levels of OPC by Silica Fume were 0%, 2.5%, 5%and 7.5%where replacement levels of Ordinary Portland cement by Fly Ash were 0%, 5%, 10% and 15% by weight. 1% super-plasticizer was used in all the test specimens for better workability at lower water cement ratio and to identify the sharp effects of Silica Fume and Fly Ash on the properties of concrete. Water-cement ratio was kept 0.43 in all cases.43.1 N/mm2 was the maximum compressive strength which was obtained at replacement level of 7.5% by weight of SF and 20% by weight of FA with cement.6.47 N/mm2 was the maximum flexural strength which was obtained at replacement level of 7.5% by weight of SF and 20% by weight of FA with cement.2.573 N/mm2 was the maximum split tensile strength which was obtained at replacement level of 7.5% by weight of SF and 20% by weight of FA with cement

Sasikumar et al. (2016) Performed an Experimental Investigation on Properties of Silica Fumes as a Partial Replacement of Cement. Main parameter investigated in this study is M30 grade concrete with partial replacement of cement by silica fume0%, 25%, 30%, 40% and 50%. The normal consistency increases about 40% when silica fume percentage increases from 0% to 25%. The optimum 7 and 28-day compressive strength has been obtained in the 25 % silica fume replacement level. Also, the split tensile strength is high when using 25% silica fume replacement for cement.

Hanumesh et al. (2015) observes the Mechanical Properties of Concrete Incorporating Silica Fume as Partial Replacement of Cement. The main aim of this work is to study the mechanical properties of M20 grade control concrete and silica fume concrete with different percentages (5, 10, 15 and 20%) of silica fume as a partial replacement of cement. The result showed that the compressive strength of concrete is increased by the use of silica fume up to 10% replacement of cement. From 10% there is a decrease in compressive strength and the split tensile strength of concrete is increased by the use of silica fume up to 10% replacement of cement. From 10% there is a decrease in split tensile strength. The optimum percentage of replacement of cement by silica fume is 10% for M20 grade of concrete.

Amarkhail (2015) observed Effects of Silica Fume on Properties of High-Strength Concrete. He found that up to 10% cement may be replaced by silica fume without harming the concrete workability. Concrete containing 10% silica fume replacement achieved the highest compressive strength followed by 15% silica fume replacement with a small difference. Concrete with 15% silica fume content achieved the highest flexural strength.10% and 15% silica fume content as replacement of cement were found to be the optimum amount for significantly enhancement of compressive strength and flexural strength respectively.

Jain et al. (2015) studied the Characteristics of Silica Fume Concrete. The physical properties of high strength silica fume concretes and their sensitivity to curing procedures were evaluated and compared with reference Portland cement concretes, having either the same concrete content as the silica fume concrete or the same water to cementitious materials ratio. The experimental program comprised six levels of silica-fume contents (as partial replacement of cement by weight) at 0% (control mix), 5%, 10%, 15%, 20%, and 25%, with and without superplasticizer. It also included two mixes with15% silica fume added to cement in normal concrete. Durability of silica-fume mortar was tested in chemical environments of sulphate compounds, ammonium nitrate, calcium chloride, and various kinds of acids.

Ghutke et al. (2014) examine the Influence of silica fume on concrete. Results showed that the silica fume is a good replacement of cement. The rate of strength gain in silica fume concrete is high. Workability of concrete decreases as increase with % of silica fume. The optimum value of compressive strength can be achieved in 10% replacement of silica fume. As strength of 15% replacement of cement by silica fume is more than normal concrete. The optimum silica fume replacement percentage varies from 10 % to 15 % replacement level.

III. Experimental Procedure

Mix	Cement (kg)	CSF (Kg)	C.A (Kg)	F.A (Kg)	W/c ratio	Water (litres)
C.C	394	-	1456	886	0.5	197
CSF 5	375	19	1456	886	0.5	197
CSF 10	356	38	1456	886	0.5	197
CSF 15	337	57	1456	886	0.5	197
CSF 20	318	76	1456	886	0.5	197

Table 1: Mix Calculation for Condensed Silica Fume

Mix	Cement (kg)	VSF (Kg)	C.A (Kg)	F.A (Kg)	W/c ratio	Water (litres)
C.C	394	-	1456	886	0.5	197
VSF 5	375	19	1456	886	0.5	197
VSF 10	356	38	1456	886	0.5	197
VSF 15	337	57	1456	886	0.5	197
VSF 20	318	76	1456	886	0.5	197

Table 2: Mix Calculation for Volcanized Silica Fume

Mix	Cement (kg)	VSF+ CSF (Kg)	C.A (Kg)	F.A (Kg)	W/c ratio	Water (litres)
C.C	394	-	1456	886	0.5	197
VSF + CSF 5	375	19	1456	886	0.5	197
VSF + CSF 10	356	38	1456	886	0.5	197

VSF + CSF 15	337	57	1456	886	0.5	197
VSF + CSF 20	318	76	1456	886	0.5	197

Table 3: Mix Calculation for Condensed + Volcanized Silica Fume

IV. RESULTS

A. *Fresh Properties:*

The following are the results obtained in various laboratory tests carried out in this study:

% Of CSF	7 days (Mpa)	14 days (Mpa)	28 days (Mpa)
CC	22.3	23.4	26.5
5%	22.6	24.2	27.2
10%	21.6	23.6	25.8
15%	23.2	24.4	28.4
20%	19.9	23.2	25.9

Table 4: Compressive strength results w.r.t Condensed Silica Fume

% of VSF	7 days (Mpa)	14 days (Mpa)	28 days (Mpa)
C.C	19.2	22.4	27.2
5%	20	23.2	25.9
10%	18.8	20.4	26.4
15%	18.6	23.6	28.6
20%	20.4	21.6	27.4

Table 5: Compressive strength results w.r.t Vulcanized Silica Fume

% of CSF + VSF	7 days (Mpa)	14 days (Mpa)	28 days (Mpa)
C.C	22.2	23.6	25.4
5%	21.4	22.2	26.2
10%	21.6	23.4	24.8
15%	19.4	23.2	27.4
20%	19.6	22.2	26.9

Table 6: Compressive strength results w.r.t CSF & VSF

% of CSF	7 days (Mpa)	14 days (Mpa)	28 days (Mpa)
C.C	2.56	2.78	3.34
5%	2.78	3.12	3.45
10%	2.43	3.06	3.23
15%	2.62	3.28	3.78
20%	2.82	3.12	3.22

Table 7: Split Tensile Strength results w.r.t CSF

% Of VSF	7 days (Mpa)	14 days (Mpa)	28 days (Mpa)
CC	2.64	2.90	3.22
5%	2.48	2.82	3.10
10%	2.32	2.74	3.08
15%	2.62	2.86	3.20
20%	2.72	2.74	3.18

Table 8: Split Tensile Strength results w.r.t VSF

% Of CSF + VSF	7 days (Mpa)	14 days (Mpa)	28 days (Mpa)
CC	2.64	2.90	3.26
5%	2.48	2.82	3.10
10%	2.32	2.74	3.18
15%	2.62	2.86	3.32
20%	2.72	2.74	3.12

Table 9: Split Tensile Strength results w.r.t CSF + VSF

% Of CSF	7 days (Mpa)	14 days (Mpa)	28 days (Mpa)
CC	2.56	2.78	3.34
5%	2.12	2.67	3.12
10%	2.45	2.63	2.96
15%	2.28	2.96	3.59
20%	2.32	2.78	3.15

Table 10: Flexural Strength results w.r.t CSF

% Of VSF	7 days (Mpa)	14 days (Mpa)	28 days (Mpa)
CC	2.5	2.43	2.89
5%	2.21	2.86	3.02
10%	2.87	2.95	3.48
15%	2.54	3.13	3.98
20%	2.22	3.22	3.26

Table 11: Flexural Strength results w.r.t VSF

% Of CSF + VSF	7 days (Mpa)	14 days (Mpa)	28 days (Mpa)
CC	2.26	2.88	3.14
5%	2.3	2.75	3.32
10%	2.4	2.68	3.42
15%	2.64	2.82	3.85
20%	2.28	2.67	3.75

Table 12: Flexural Strength results w.r.t CSF + VSF

% Replacement	28 days (Mpa)		
	CSF	VSF	CSF + VSF
C C	26.5	27.2	25.4
5%	27.2	25.9	26.2
10%	25.8	26.4	24.8
15%	28.4	28.6	27.4
20%	25.9	27.4	26.9

Table 13: Compressive Strength Results at 14 & 28 days

V. CONCLUSION & FUTURE SCOPE

A. *Conclusion*

- From the above experimental study optimum percentage of condensed Silica Fume and vulcanized silica fume can be utilized at a percentage variation of 10% to 15%.
- Up to the percentage replacement of 10% to 15% there is an improvement of 5% in the strength of concrete has been observed in terms of Compressive Strength, Flexural Strength and Tensile Strength on partial replacement of Cement with condensed Silica fume and silica fume.
- Flexural Properties have shown a better performance at the age of 28 days when replace with vulcanized silica fume than condensed silica fume.
- 15% proportion of replacement with VSF is found to have more optimistic among all the combinations.

- From the results of workability, it was evident that the mix is suitable for structural components.
- Overall the mix can be utilized in residential constructions.

REFERENCES

[1] Kumar, R., Dhaka, J. (2016). Review paper on partial replacement of cement with silica fume and its effects on concrete properties. International Journal for Technological Research in Engineering. 4, (1).
[2] Sasikumar, A. (2016). Experimental Investigation on Properties of Silica Fumes as a Partial Replacement of Cement. International Journal of Innovative Research in Science, 5 (3), 4392-4395.
[3] Hanumesh B. M., Varun, B. K. & Harish B. A. (2015). The Mechanical Properties of Concrete Incorporating Silica Fume as Partial Replacement of Cement. International Journal of Emerging Technology and Advanced Engineering. 5 (9), 270.
[4] Amarkhail, N. (2015). EFFECTS OF SILICA FUME ON PROPERTIES OF HIGH-STRENGTH CONCRETE. International Journal of Technical Research and Applications, 13-19.
[5] Ghutke, V. S. & Bhandari, P.S. (2014). Influence of silica fume on concrete. IOSR Journal of Mechanical and Civil Engineering, 44-47.
[6] Shanmugapriya, T. & Uma R. N. (2013) Experimental Investigation on Silica Fume as partial Replacement of Cement in High Performance Concrete, The International Journal of Engineering and Science (IJES) .2 (5), 40-45.
[7] IS 10262 (2009): Guidelines for concrete mix design proportioning
[8] IS 456(2000): Indian Standard Plain and Reinforced Concrete