IMPROVEMENT OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH SILICA FUME (S.F)

POTHULA RAJESH[1] and K.VAMSI KRISHNA[2]

[1] PG Student, Structural Engineering, Department of Civil Engineering, Malla Reddy Engineering College (Autonomous), Maisammaguda, Dhulapally (Post, Via. Kompally), Secunderabad -500100 Telangana ,India.

[2]Assistant Professor, Structural Engineering, Department of Civil Engineering, Malla Reddy Engineering College (Autonomous), Maisammaguda, Dhulapally (Post, Via. Kompally), Secunderabad -500100 Telangana ,India.

ABSTRACT :

The aim of this study is to evaluate the performance of S.F (S.F), as a admixture in Concrete. The S.F (S.F), industrial by product found to be an attractive cementations material which is by product of smelting process in the silicon and ferrosilicon industry. The Partial replacement of S.F (S.F), and its effects on Concrete properties has been studies by adopting M-25Concrete mix in this dissertation. The main parameter investigated in this study M-25Concrete mix with Partial replacement by S.F (S.F), with varying 0, % 10%, 20 % and 30 % by weight of cement. The Chart presents a detailed experimental study on compressive strength for 7, 28, 56 days respectively. The result of experimental investigation indicates that the use of Silica Fume (S.F), in Concrete has increased the strength and durability at all age when compared to normal Concrete. Hence the use of S.F (S.F), leads to reduction in cement quantity for construction purpose and its use should be promoted for better performance as well as for environmental sustainability.

Keywords: M25, silica fume, compressive strength, split tensile strength, flexural strength, etc,.

I.INTRODUCTION

During the last three decades, great strides have been taken in improving the performance of concrete as a construction material. Particularly Silica Fume (SF) and fly ash individually or in combination are indispensable in production of high strength concrete for practical application. The use of silica fume as a pozzolana has increased worldwide attention over the recent years because when properly used it as certain percent, it can enhance various properties of concrete both in the fresh as well as in hardened states like cohesiveness, strength, permeability and durability. Silica fume concrete may be appropriate in places where high abrasion resistance and low permeability are of utmost importance or where very high cohesive mixes are required to avoid segregation and bleeding

Concrete is the most widely used composite material today. The constituents of concrete are coarse aggregate, fine aggregate, cement and water. Rapid increase in construction activities leads to shortage of conventional construction materials. It is conventional that natural sand is being used as fine aggregate in concrete. The function of the fine aggregate is to assist in producing workability and uniformity in the mixture. The river deposits are the most common source of fine aggregate. Now-a-days the natural river sand has become scarce and very costly. Hence, it is necessary to think of alternative materials. The Quarry Dust may be used in the place of river sand fully or partly. It is proposed to study the possibility of replacing sand with locally available Quarry Dust without sacrificing the strength and workability of concrete by incorporating the Silica Fume as a mineral admixture. In the present day construction practice along with the strength equal importance is given to the durability of concrete. The Indian Standard Code of practice for plain and reinforced concrete recommends the minimum cement content to satisfy the strength and durability. Hence, the utilization of cement is increased. But, the cement production consumes large amount of energy and emits carbon dioxide, polluting the environment. One of the solutions to these problems is to use Pozzolana materials

SILICA FUME

Silica fume is a by- product in the production of silicon alloys such as ferrochromium, ferro-manganese, calcium silicon etc., which also creates environmental pollution and health hazard. Silica fume is known to improve both the mechanical characteristics and durability of concrete. Many modern concrete mixes are modified with the addition of admixtures, which improve the microstructure as well as decrease the calcium hydroxide concentration through a pozzolanic reaction. The subsequent modification of the microstructure of cement composites improves the mechanical properties, durability and increases the service-life properties.

OBJECTIVE OF THE STUDY

The scope and objectives are planned in two phases, the first being the preliminary study and the second the main study in the development of Silica Fume concrete as detailed here.

PRELIMINARY STUDY

- Determinatives of the engineering properties for all the constituent materials as well as for the additives and admixtures to suitably incorporate in the mix design and other assessment.
- Making a conventional concrete mix design for M25 grade concrete using IS methods and proposing an optimum mix based on the 7, 28, 56 and 90 days strength, for all experimentation.
- Investigation on the workability and strength characteristics of silica fume based concrete for cement replacement levels of 0 %, 10% and 20% and 30% with silica fume.

MAIN STUDY

- Mix design for M25 grade silica concrete using IS method and investigating the workability, strength and durability characteristics.
- Assessment of the comparison of characteristics of different replacement concrete after analysis of their experimental results.
- Assessment on the possibility of maximum replacement level of cement with silica fume in M25 grade concrete.

II.LITERATURE REVIEW

Amudhavalli& Mathew et al,.(2012) He studied the Effect of silica fume on the strength and durability characteristics of concrete. The main parameter investigated in this study is M35 grade concrete with partial replacement of cement by silica fume by 0, 5, 10,15and by 20%. a detailed experimental study in Compressive strength, split tensile strength, flexural strength at age of 7 and28 day was carried out. Results Shows that Silica fume in concrete has improved the performance of concrete in strength as well as in durability aspect.

Perumal& Sundararajan et all,.(2004) He observe the Effect of partial replacement of cement with silica fume on the strength and durability properties of high grade concrete. Strength and durability properties for M60, M70 and M11 0 grades of HPC trial mixes and to arrive at the maximum levels of replacement of cement with Silica fume, investigations were taken. The strength and durability characteristics of these mixes are compared with the mixes without SF. Compressive strengths of 60 N/mm2 , 70 N/mm2 and 110 N/mm2 at 28days were obtained by using 10 percent replacement of cement with SF. The results also show that the SF concretes possess superior durability properties.

REVIEW ON MIX DESIGN

Davidovits J and Sawyer J L depend on ground stun radiator slag to make geopolymer clasp. This kind of latches ensured in the USA under the title Early High-Strength Mineral Polymer was fall back on as a supplementary building up material in the age of precast strong things. Besides, a moment mortar package that required only the extension of mixing aquawater to convey an intense and to a great degree quick quality expanding material was made and utilized in recovery of strong air terminal runways, overskirts and runways, expressway and framework decks, and for a couple of new advancements when high early quality was required. Geopolymer has in like manner been fall back on to supplant regular polymer as a paste in strengthening assistant people. Geopolymers were seen to be warm confirmation and tough under UV light.

Matghew Sudhakar and Natarajan introduced the expansion of GGBS content, Compressive Strength is steadily increments. In this Coal Ash and GGBS Combination is brrequiste with 15M Alkaline Solution and aggregate substitution of around 30% is mulled over and Higher Compressive Strength up to 57Mpa is accomplished .However the expense of GGBS included Geopolymer is 7% Higher than OPC yet when we Consider Strength angle, it is just about 3 times than OPC at multi day.

Ganapati Naidu.etl introduced in this paper to think about quality properties of geopolymer solid utilizing low calcium fly cinder supplanting with slag in 5 unique rates. Higher groupings of GGBS result in higher compressive quality of geopolymer concrete 90% of compressive quality was accomplished in 14 days.

III. COLLECTION MATERIALS AND MIX DESIGN

To achieve the objectives discussed earlier, experimental program is planned to study the effect of replacement of cement in concrete by SILICA FUME (S.F) on strength properties of concrete.

1.CEMENT: Cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. The most important types of cement are used as a component in the production of mortar in masonry, and of concrete- which is a combination of cement and an aggregate to form a strong building material. The ordinary Portland cement of 53 Grade is used in accordance with IS: 12269-1987. Properties of this cement were tested and listed here. Fineness of cement = 5% ,Specific gravity if cement = 3.15 ,Standard Consistency of cement = 33% Initial setting time = 30 minute ,Final setting time = Not more than 10 hours.

COARSE AGGREGATE: Crushed stone aggregate of 20mm size is brought from nearby quarry. Aggregates of size more than 20mm size are separated by sieving. Tests are carried in order to find out the Specific gravity = 2.9 Fineness modulus = 7.5

FINE AGGREGATE: Locally available fresh sand, free from organic matter is used. The result of sieve analysis confirms it to Zone-II (according to IS: 383-1970).The tests conducted and results plotted below Specific gravity = 2.3, Fineness modulus = 3.06.

SILICA FUME : Silica fume is a by product of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive Pozzolona. Concrete containing silica fume can have very high strength and can be very durable. Silica fume is available from suppliers of concrete admixtures and, when specified, is simply added during concrete production. Placing, finishing, and curing silica-fume concrete require special attention on the part of the concrete contractor.

Silica fume consists primarily of amorphous (non-crystalline) silicon dioxide (SiO2). The individual particles are extremely small, approximately 1/100th the size of an average cement particle. Because of its fine particles, large surface area, and the high SiO2 content, silica fume is a very reactive pozzolan when used in concrete. The quality of silica fume is specified by ASTM C 1240 and AASHTO M 307.

Silica-fume concrete does not just happen. A specified must make a conscious decision to include it in concrete to achieve desired concrete properties. Assistance in specifying silica-fume concrete for high strength or increased durability can be obtained from the SFA or from major admixture suppliers.

WATER: Generally potable water should be used. This is to ensure that the water is reasonable free from such impurities as suspended solids, organic matter and dissolved salts, which may adversely affect the properties of the concrete, especially the setting, hardening, strength, durability, pit value, etc.

MIX DESIGN OF M25 GRADE OF CONCRETE

Mix Proportion for Trail M25is 1: 1.19: 2.63. atw/c ratio of 0.43

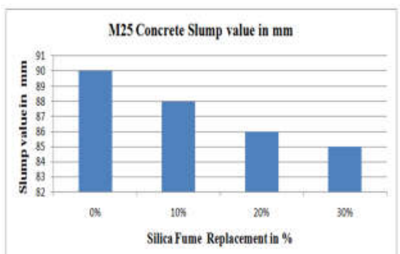
Material	Cement	Fine Aggregates	Coarse Aggregates	Water
Density	433kg/m3	518 kg/m3	1142 kg/m3	186 kg/m3
Proportions	1	1.19	2.63	0.43

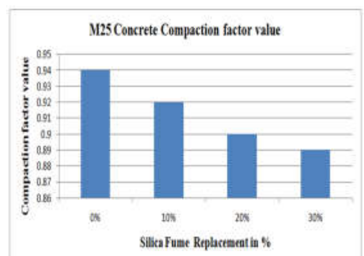
Grade of Cement Concrete	Cement OPC53 (Kg)	Silica Fume (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)	Water Content
M25	230	40.05	320	708	116
Addition of Extra10%	253	44.10	352	778	127.6

IV .RESULTS AND ANALYSIS

1. SLUMP CONE TEST AND COMPACTION FACTOR TEST RESULTS

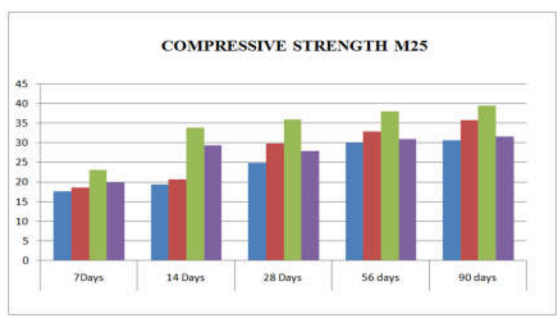
M25 Results			
S.no.	% Replacement (Silica Fume)	Slump value In (mm)	Compaction factor
1	0%	90	0.94
2	10%	88	0.92
3	20%	86	0.90
4	30%	85	0.89





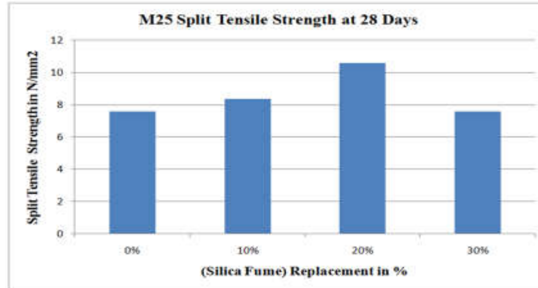
2. COMPRESSIVE STRENGTH TEST RESULTS

S.no	Type of Mix (Silica Fume)	M25 Compressive Strength in (N/mm2)				
		7Days	14 Days	28 Days	56 Days	90 Days
1	0%	17.56	19.26	24.8	29.82	30.52
2	10%	18.5	20.56	29.8	32.8	35.6
3	20%	23	33.7	35.9	37.89	39.4
4	30%	19.8	29.32	27.84	30.85	31.5



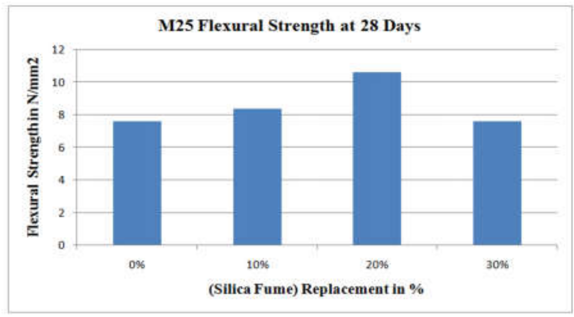
3. SPLIT TENSILE STRENGTH TEST RESULTS

S.no	Type of Mix (Silica Fume)	M25 Split Tensile Strength in (N/mm2)
		28 Days
1	0%	7.62
2	10%	8.4
3	20%	10.62
4	30%	7.62



4. FLEXURAL STRENGTH TEST RESULTS

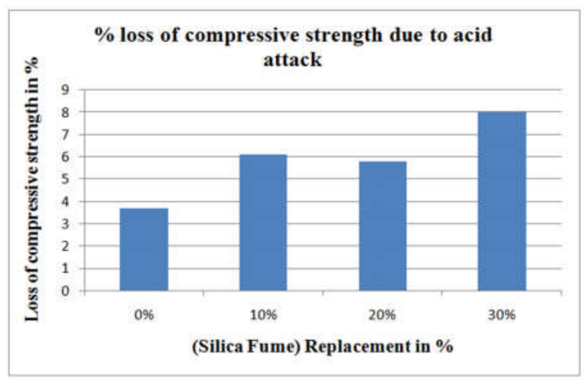
S.no	Type of Mix (Silica Fume)	M25 Flexural Strength in (N/mm2)
		28 Days
1	0%	8.52
2	10%	10.8
3	20%	12.56
4	30%	8.52



5. DURABILITY STRENGTH OF CONCRETE

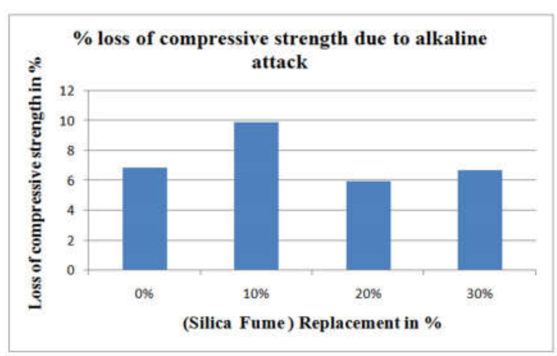
1. ACID ATTACK

Sl. no	% Replacement (Silica Fume)	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to acid attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to acid attack
1	0.00%	2261	2242	0.82	38.2	34.5	3.7
2	10.00%	2340	2318	0.94	39.6	33.5	6.1
3	20.00%	2351	2323	1.2	42.6	36.8	5.8
4	30.00%	2234	2202	1.44	38.5	30.5	8



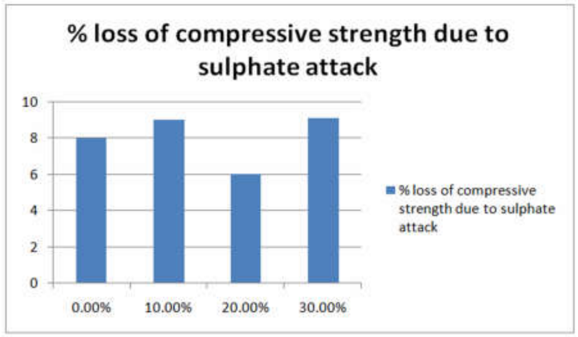
2. ALKALINE ATTACK

Sl.no	% Replacement (Silica Fume)	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to alkaline attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to alkaline attack
1	0.00%	2286	2259	1.2	29.5	22.6	6.9
2	10.00%	2340	2306	1.44	31.5	21.6	9.9
3	20.00%	2280	2244	1.6	32.5	26.5	6
4	30.00%	2310	2268	1.84	29.6	22.9	6.7



3. SULPHATE ATTACK

Sl.no	% Replacement (Silica Fume)	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to sulphate attack
1	0.00%	29.5	21.5	8
2	10.00%	31.5	22.5	9
3	20.00%	32.5	26.5	6
4	30.00%	29.6	20.5	9.1



V.CONCLUSIONS

OBSERVATIONS AND CONCLUSIONS:

Below is the list of Observations & Conclusions of the current experimental project undertaken, based on the Materials chosen, Methodology adopted, Procedures followed and Test results obtained:

1. Based on the present experimental results, the physical and chemical composition of the Silica Fume is essentially responsible for the later hydration process. Their fineness and specific surface area coverage are highly suitable for the workability of concrete which was more than expected
2. The Slump value is decreasing with grade of concrete due to mineral admixtures which absorb the water content.
3. The compaction Factor is decreasing with increasing in the replacement of cement quantity.
4. Positive results were obtained by subjecting these recommended concrete mixes to additional compressive strength tests, flexural strength tests, tensile strength tests, and durability tests.
5. There is a significant increase in the compressive strength, Split Tensile strength and Flexural Strengths due to the addition of mineral admixtures up to 20% and thereafter it is decreasing.
6. Silica Fume, contributes to useful disposal of these waste materials, and reduces consumption of cement, thus lowering adverse effects on the environment.
7. The Concrete thus obtained by partial replacement of cement with natural admixtures are durable in long term use.
8. At 20 % to 30 % replacement there observed a change in the decreased rate of strengths and in Flexural Strengths and compressive strengths than the rate of change at 10 % to 20%.
9. The Compressive Strength and Durability values are increasing with the age of concrete specimen which is observed in graphs from 56 days to 90 days values.

FUTURE SCOPE OF STUDY:

- Increasing the quantity of the replacement of cement with more proportion of Silica Fume and testing for the better reducing of cement quantity.
- With this project, the optimum proportion of mineral admixtures is favourable for strength and Durability at 20% (Silica Fume). Therefore there can be a future scope to find out the exact proportion in between 20% and 30% at which the strength and durability values are decreasing in various grades of design mixes.
- More designated tests can be done for the accurate results in Compressive Strength, Flexural Strength and Durability properties.
- More admixtures can be selected along with Silica Fume and hence understanding the test results suitability for our requirements.

REFERANCES

Key References:

1. IS 456-2000 : Plain and Reinforced Concrete- Code of Practice
2. IS 10262-2009 : Concrete Mix Proportioning-Guidelines
3. IS 12269- 2013: Ordinary Portland Cement.53 Grade – Specification
4. IS 9103-1999 : Specifications for Concrete Admixtures
5. IS 516-1959: Methods of Tests for Strength of Concrete :Compressive Strength
6. Text book on Concrete Technology by M.S.Shetty.

Other References:

- Akram, T., Memon, S., Obaid, H.: Production of low cost self compacting concrete using bagasse ash, Construction and Building Materials, 23 (2009), pp. 703-712,
- Singh, N., Singh, V., Rai, S.: Hydration of bagasse ash-blended portland cement, Cement and Concrete Research, 30 (2000), pp. 1485-1488, doi: http://dx.doi.org/10.1016/S0008-8846(00)00324-0 Građevinar 1/2015 30 GRAĐEVINAR 67 (2015) 1, 23-30 Thirumalai Raja Krishnasamy, MurthiPalanisamy
- Cordeiro, G., Toledo, R., Tavares, L., Fairbairn, E.: Pozzolanic activity and filler effect of sugar cane bagasse ash in Portland cement and lime mortars, Cement and Concrete Composites,30 (2008), pp. 410-418, doi: http://dx.doi.org/10.1016/j. cemconcomp.2008.01.001
- Cordeiro, G., Toledo, R., Tavares, L., Fairbairn, E.: Ultrafine grinding of sugar cane bagasse ash for application as pozzolanic admixture in concrete, Cement and Concrete Research, 39 (2009), pp. 110- 115,

- Ganesan, K., Rajagopal, K., Thangavel, K.: Evaluation of bagasse ash as supplementary cementitious material, Cement and concrete composites, 29 (2007), pp. 515-524,
- Jiménez, V., León-Martínez, F., Montes-García, P., Gaona-Tiburcio, C., Chacon-Nava, J.: Influence of sugar-cane bagasse ash and fly ash on the rheological behavior of cement pastes and mortars, Construction and Building Materials, 40 (2013), pp. 691-701.