An Experimental Study on The Effect of Silica Fume And Stone Dust on Concrete

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Abstract- *The effect of silica fume in concrete improves both the mechanical and durability characteristics of the concrete. The paper aims to review the effect of silica fume on properties of concrete. The replacement of silica-fume as partial replacement of cement by weight at 0% (control mix), 5%, 10%, 15%, 20%, and 25%, with and without superplasticizer are studied. It emphasized the effect of silica fume on workability level and its maintenance of fresh concrete; strength development, strength optimization and elastic modulus of hardened concrete; and chemical and mechanical durability of mortar. The chemical and physical properties of silica fume shows that it is most reactive*

Concrete containing silica fume can have very high strength and can be very durable stone dust is a waste material obtained from cruher plants. It has potential to be use as partial replacement of natural river sand in concrete.

Stone dust could be stuff obtained from crushing plants and was collected from regionally accessible in space. It's potential to be used as partial replacement of natural sand in concrete. Use of stone dust in concrete not solely improves the standard of concrete however conjointly conserve the natural sand for future generations.

Keywords- Silica Fume, Stone Dust, Compressive Strength, Split Tensile Test, Concrete, Durability.

I. INTRODUCTION

Silica fume, also known as micro silica is an amorphous (non-crystalline) polymorph of silicon dioxide. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production. It is extremely fine with particles size less than 1 micron and with an average diameter of about 0.1 microns, about 100 times smaller than average cement particles. Its behaviour is related to the high content of amorphous silica (> 90%). The reduction of high- purity quartz to silicon at temperatures up to 2,000°C produces SiO_2 vapours, which oxidizes and condense in the low temperature zone to tiny particles consisting of non- crystalline silica.

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. stone dust could be obtained from crushing plants and was collected from regionally accessible in space .use of stone dust in concrete not solely improve the standard of concrete however conjointly conserve the natural sand for future generations.

These days engineers and scientists try to reinforce the strength of concrete by adding the many alternative economical and waste product as a partial substitute of cement and sand or as a admixture ash, silicon oxide fume (silica fume), steel slag, stone dust etc. are the few samples of these varieties of materials. These materials are typically by-product from additional industries for instance ash could be a waste matter from power plants and silicon oxide fume (silica fume) is a by-product ensuing from decrease of high purity quartz by coal or coke and wood chips in an electrical arc chamber throughout production of silica fume or ferrosilicon alloys and Stone dust is a waste material obtained from crushing plants. Currently it's wide to be used as partial replacement of natural stream sand in concrete. Use of stone dust in concrete not solely improves the standard of concrete however additionally conserve the natural stream sand for future generations. Substitution of traditional sand by stone dustt can serve each solid waste decrease and waste recovery. However currently day silicon oxide fume (silica fume) and stone dust are utilized in great deal as a result of it enhances the property of concrete. The employment of silicon oxide fume (silica fume) as a pozzolanic material has increased in recent years and currently day's stone dust is employed as a result of once mixed in definite proportions it improves the properties of each contemporary and hardened concrete like durability, permeability, compressive strength, flexural strength and split tensile strength etc. several authors have reported the utilization of silica fume and stone dust to examine the change of properties of concrete.

Vikas Srivastava, Alvin Harison, P. K. Mehta, Atul, Rakesh Kumar,Assistant Professor, Civil Engg. made research on effect of silica fume. Standard IS codes are used in this study. The research shows that the addition of silica fume reduces workability. However, in some cases it improves the workability. Silica fume inclusion increases the compressive strength of concrete significantly (6-57%). The increase depends upon the replacement level. The tensile and flexural strength of silica fume concrete is almost similar to the referral concrete. The addition of silica fume improves the bond strength of concrete. The modulus of elasticity of silica fume concrete is almost similar to the referral concrete.

Vikas Srivastava , Rakesh Kumar , V. C. Agarwal and P. K. researched about the silica effect in workability and compressive strength of OPC concrete.The referral concrete M25 was made using 43 grade OPC (Birla) and the other mixes were prepared by replacing part of OPC with silica fume. The replacement levels were 5%, 10%, 15%, 20%, 25% and 30% (by weight).The properties of cement were determined in accordance with IS – 8112: 1989. The optimum replacement level of cement by silica fume is found to be 5% by weight. There is a significant improvement in the compressive strength of concrete using silica fume at both 7 and 28 days as compared to the referral concrete. The workability in case of silica fume concrete is marginally improved. Beyond optimum silica fume level the strength decreases but the workability increases.

H S Abdelgader and A S El-Baden research is about the silica fume addition in 2 stage of concrete strength.Two-stage concrete (TSC) is an innovative concrete that does not require vibration for placing and compaction. TSC is a simple concept; it is made using the same basic constituents as traditional concrete: cement, coarse aggregate, sand and water as well as mineral and chemical admixtures. As its name suggests, it is produced through a two-stage process. Firstly washed coarse aggregate is placed into the formwork in-situ. Later a specifically designed self- compacting grout is introduced into the form from the lowest point under gravity pressure to fill the voids, cementing the aggregate into a monolith.Each mix twenty four standard cylinder samples of size (150mm×300mm) of concrete containing crushed aggregate were produced. The tested samples were made from combinations of w/c equal to: 0.45, 0.55 and 0.85, and three c/s of values: 0.5, 1 and 1.5. Silica fume was added at a dosage of 6% of weight of cement, while super plasticizer was added at a dosage of 2% of cement weight. Results indicated that both tensile and compressive strength of TSC can be statistically derived as a function of w/c and c/s with good correlation coefficients. The basic principle of traditional concrete, which says that an increase in water/cement ratio will lead to a reduction in compressive strength, was shown to hold true for TSC specimens tested. Using a combination of both silica fume and super plasticisers caused a significant increase in strength relative to control mixes.

M. H. Zhang ,S. Swaddiwudhipong,K. Y.J. Tay &C. T. Tam researched about the effect of silica on cement hydration and temperature rise. With an initial temperature of 30°C, adiabatic temperature rise of the concrete with 8% silica fume as cement replacement was similar to that of the control Portland cement concrete up to about 18 h. After 24 h, however, the temperature of the silica fume concrete was lower than that of the control concrete. Since the concrete with 8% silica fume had a higher 28-day compressive strength (72.5 MPa) than the control concrete without silica fume (59.2 MPa), the concrete with silica fume is likely to have a lower temperature rise as compared with the control concrete of equivalent 28-day strength by reducing cementations materials content with the same water content. The extent of heat evolution in the silica fume pastes was generally greater at lower temperatures of 20–

Faseyemi Victor Ajileye (2012) Investigations on Silica Fume as Partial Cement Replacement in Concrete. Reviewed on the strength property of silica fume concrete. The particular gravity and chemical composition of silica fume and cement were replaced with silica fume from 0% to 25% and w/c ratio 0.50. The mix proportion was used 1:2:4. Cubes (150 x 150 x 150 mm) be fashioned and cured during a solidification tank for 3, 7, 14 and 28 days.

N. K. Amudhavalli, Jeena Mathew (2012) Studied the Effect of silica fume on the strength and durability characteristics of concrete. The main parameter investigated during this study is M35 grade concrete with partial replacement of cement by silicon dioxide fume by 0, 5, 10, 15 and 20%. An experimental study in Compressive strength, split durability, flexural strength at age of 7 and 28 days were carried out to concrete. Results Shows that silicon dioxide fume in concrete has improved the performance of concrete in strength yet as in sturdiness side.

prof. vishal S. Ghutke ,Prof. Pranita S. Bhandari conducted a research on influence of silica fume on concrete by replacing 5%,10%,15%,20% of cement with silica fume and compared the strength of the concrete with the regular concrete and driven the result from the experimentals.The research was based on code IS : 12269-1987(9). 53 grade of concrete was considered for the study. The difference between the study was examined with water cement ratio of 0.5 and 0.6 . the result was taken from testing the values .From the research it is studied that the optimum value . From the research it is studied that the optimum value of compressive strength can be achived in 10% replacement of silica fume.

1.1 PROJECT OBJECTIVE

In this procedure of investigation the subsequent are the most objectives of study:-

1. Comparative study of the behavior of the concrete with & while not silicon dioxide fume and Stone dust.
2. To work out the compressive, flexural and split strength and conjointly the durability of concrete with part replacement of silicon dioxide fume and stone dust.
3. To review the behavior of concrete mistreatment silicon dioxide fume and stone dust, in strength sweetening
4. To seek out the optimum proportion of silicon dioxide fume and stone dust for getting the most strength of concrete

II. EXPERIMENTAL INVESTIGATION

2.1 TEST MATERIALS

Cement (opc)

Portland Pozzolana Cement additionally ordinarily referred to as PPC cement of brand name, Marvel Cement is employed. The first raw materials used for this cement manufacture are sedimentary rock ($CaCO_2$) and clay (SiO_2, AI_2O3, and Fe_2O_3). The share of pozzolanic material utilized in the preparation ought to be between10 to 30%. If the percentage is exceeded, the strength of cement is reduced.

Concrete (20)

Grade of concrete 20 ,Charecteristics compressive strength ai 28 days in field (f_{ck}) 20 N/mm^2, maximum size of course aggegate20mm , Degree of workability (by slump test) 60mm (medium), Degree of quality control good.

1.

2.2 Test conducted & Quality Determine

Laboratory testing was done initial setting and final setting time , consistency test in cement and slump test,durability test, permeability test, compressive strength test, flexural strength test and split tensile strength etc. initial settting time is done by the apparatus vicat apparatus and slump test for consistency of concrete

Table 1 Physical Properties of Fine Aggregate (Sand)

Sr. No.	Property	Average
1	Specific Gravity	2.70
2	Fineness Modulus	2.76
3	Water Absorption	2%
4	Surface Texture	Smooth
5	Particle Shape	Angular

Similarly the physical properties of coarse aggerigate are given in the table 2.

Table 2 Physical Properties of Coarse Aggregate

Sr. No.	Property	Average
1	Specific gravity	2.95
2	Fineness Modulus	2.54
3	Water Absorption	0.5%
4	Particles Shape	Angular
5	Crushing Value	17.4
6	Impact Value	12.50

Similarly the physical and chemical properties of silica fume are given in the table 3 and 4

Table3 Physical Properties of Silica Fume

Properties	Observed Values
Color	Dark grey
Specific gravity	2.2
Fineness modulus	20000 m^2/kg
Bulk Modulus	240 kg/m^3

Table 4Chemical Properties of Silica Fume

Properties	Observed value
SiO_2	90-96%
Al_2O_3	0.6 -3.0%
Fe_2O_3	0.3-0.8%
MgO	0.4-1.5%
CaO	0.1-0.6%
Na_2O	0.3-0.7%
K_2O	0.04-1.0%
C	0.5-1.4%
S	0.1-2.5%

Loss of ignition (C+S)	0.7-2.5%

Similarly the physical properties ofstone dust are given in the table 2.

Table 5 Physical Properties of Stone Dust

Sr. No.	Property	Average
1	Specific Gravity	2.92
2	Fineness Modulus	2.67
3	Water Absorption	0.5%
4	Surface Texture	Rough
5	Particle Shape	Angular
6	Colour	Grey

III. RESULT AND DISCUSION

3.1. INITIAL AND FINAL SETTING TIME TEST

Table 1 Initial and Final setting time test

Sr. No	Setting Time (minutes)		Depth of penetration (mm)
	Initial	Final	
1.	37 minutes	10 hrs.	5 mm

Results:-

1. The initial setting time of the cement sample is found to be 37 minutes
2. The final setting time of the cement sample is found to be 10 hr

3.2. CONSISTENCY TEST

Table 2 Consistency test results of cement

Weight. of Cement (gm.)	Quantity of Water added (ml)	Penetration (mm)	Percentage of Water (P)
400	120	15	0.30
400	132	8	0.33
400	144	6	0.36

Result- The consistency of cement is found to be 36%

3.3.SLUMP TEST

Table 3 Slump test result

Sr. No.	Slump Value (mm)	W/C ratio
1	60	0.50

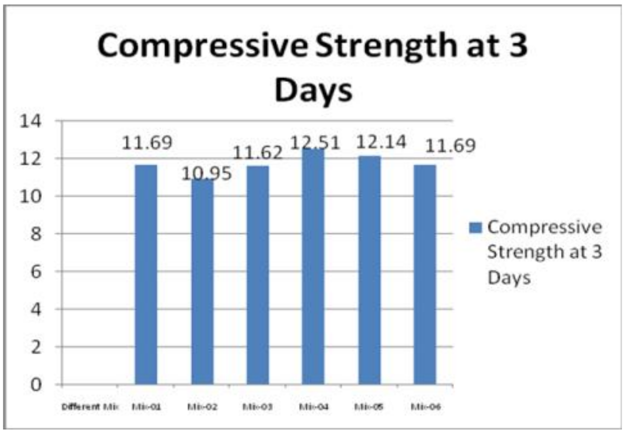
3.4.COMPRESSIVE STRENGTH TEST

Table 4 Compressive Strength Results for 3, 7 and 28 days

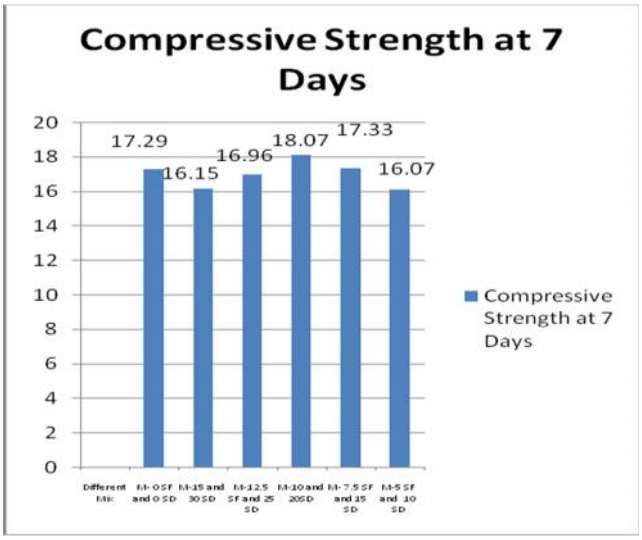
Different Mix	Compressive Strength at 3 Days (N/mm²)	Compressive Strength at 7 Days (N/mm²)	Compressive Strength at 28 Days (N/mm²)
Mix-01	11.69	17.29	25.7
Mix-02	10.95	16.15	24.33
Mix-03	11.62	16.96	26.36
Mix-04	12.51	18.07	27.55
Mix-05	12.14	17.33	25.84
Mix-06	11.69	16.07	25.66

Table5 Composition and Notations

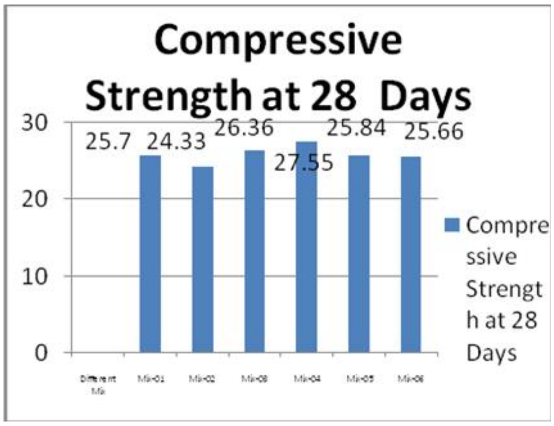
Sr. No.	Composition	Notations
Mix-1	No replacement	M-0 SF and 0 SD
Mix-2	Replacement 15% silica fume and 30% stone dust	M-15 SF and 30 SD
Mix-3	Replacement 12.5% silica fume and 25% stone dust	M-12.5 SF and 25 SD
Mix-4	Replacement 10% silica fume and 20% stone dust	M-10 SF and 20 SD
Mix-5	Replacement 7.5% silica fume and 15% stone dust	M-7.5 SF and 15 SD
Mix-6	Replacement 5% silica fume and 10% stone dust	M-5 SF and 10 SD



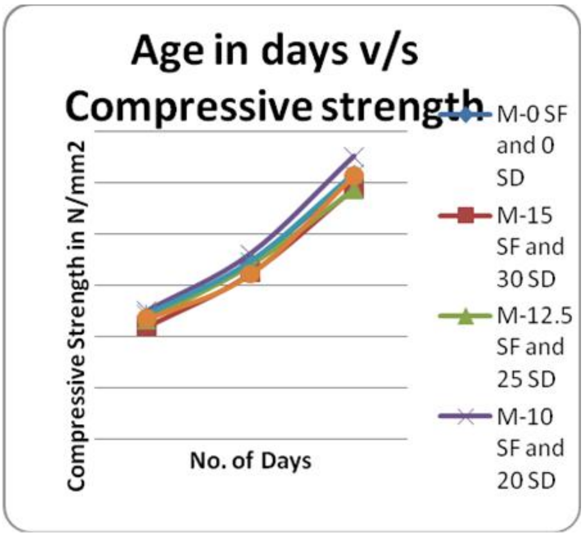
Graph 1 Compressive Strength at 3 days



Graph 2 Compressive Strength at 7 day



Graph 3 Compressive Strength at 28 days

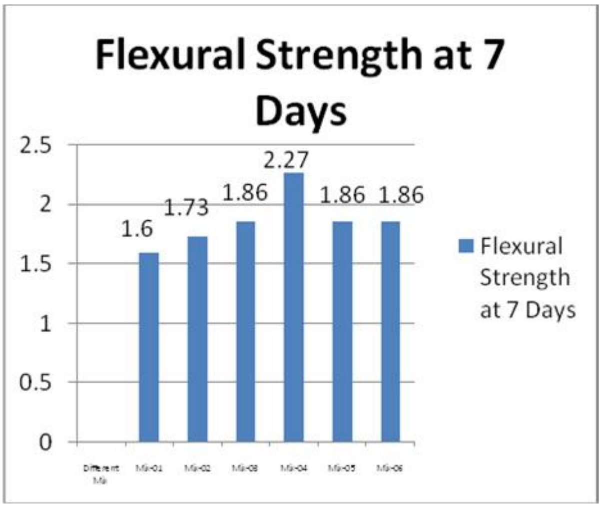


Graph 4 Variation of 3, 7 and 28 days Compressive Strength with variation of % of SF and SD

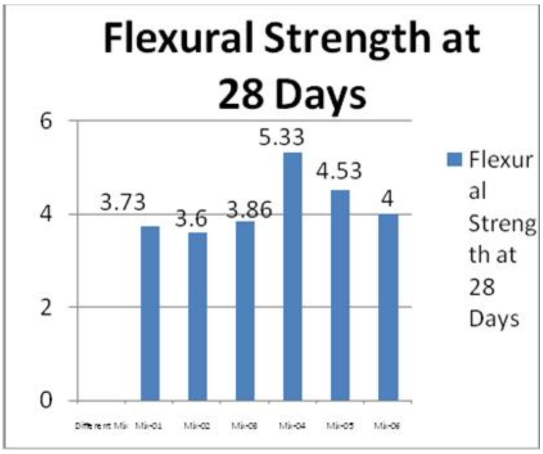
3.5. FLEXURAL STRENGTH TEST

Table 6 Flexural Strength Result for 7 and 28 days

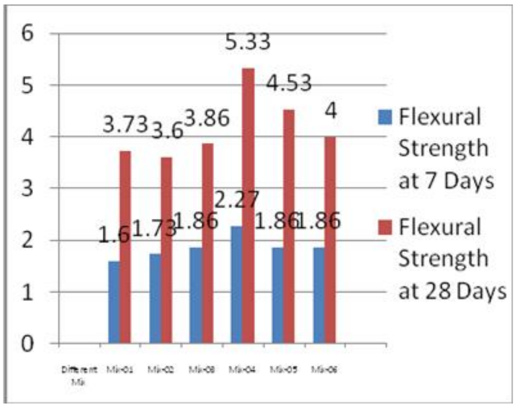
Different Mix	Flexural Strength at 7 Days (N/mm^2)	Flexural Strength at 28 Days (N/mm^2
Mix-01	1.60	3.73
Mix-02	1.73	3.60
Mix-03	1.86	3.86
Mix-04	2.27	5.33
Mix-05	1.86	4.53
Mix-06	1.86	4.00



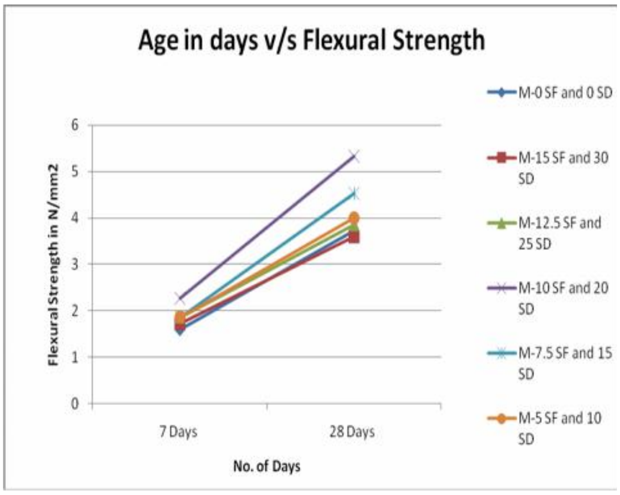
Graph 1 Flexural Strength at 7 days



Graph 2 Flexural Strength at 28 days



Graph 3 Flexural Strength in N/mm^2 at various age (Days)

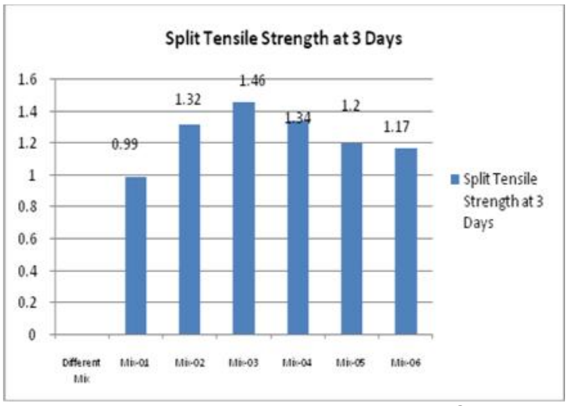


Graph 4 Variation of 3, 7 and 28 days Compressive Strength with variation of % of SF and SD

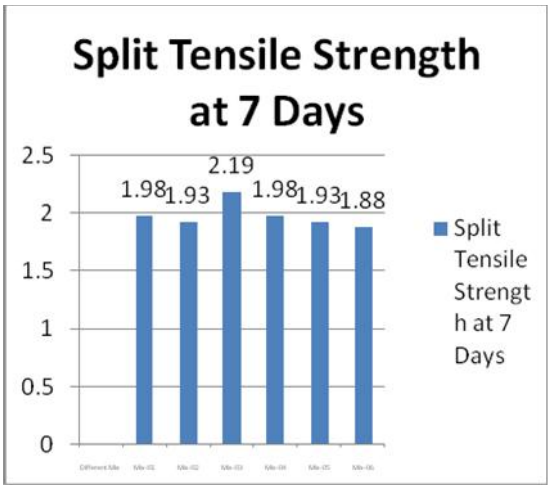
3.6. SPLIT TENSILE STRENGTH TEST

Table 7 Split Tensile Strength Result for 3, 7 and 28 days

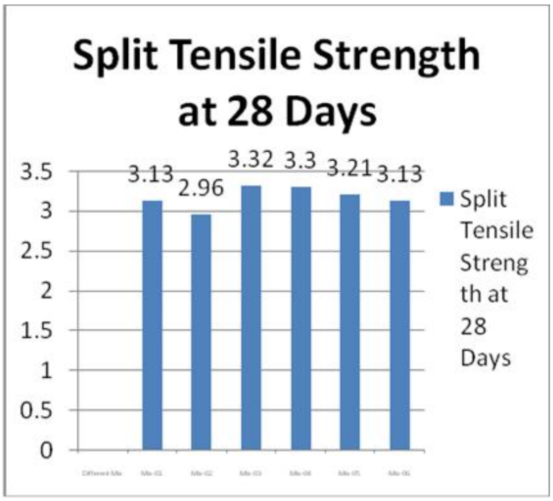
Different Mix	Split Tensile Strength at 3 Days (N/mm²)	Split Tensile Strength at 7 Days (N/mm²)	Split Tensile Strength at 28 Days (N/mm²)
Mix-01	0.99	1.98	3.13
Mix-02	1.32	1.93	2.96
Mix-03	1.46	2.19	3.32
Mix-04	1.34	1.98	3.30
Mix-05	1.20	1.93	3.21
Mix-06	1.17	1.88	3.13



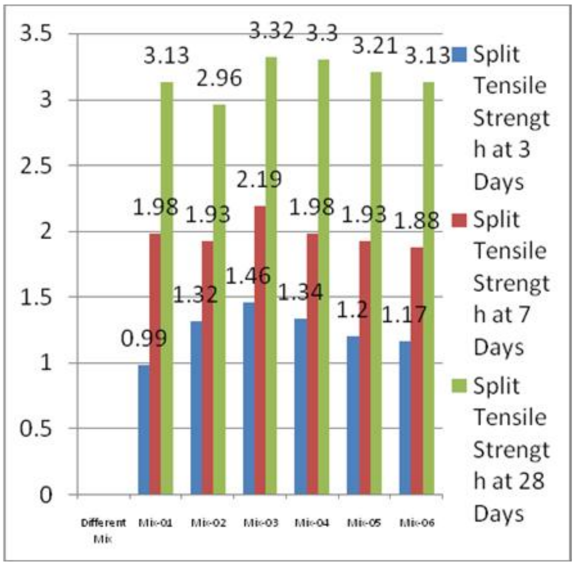
Graph 1 Split Tensile Strength in N/mm^2 at 3 Day



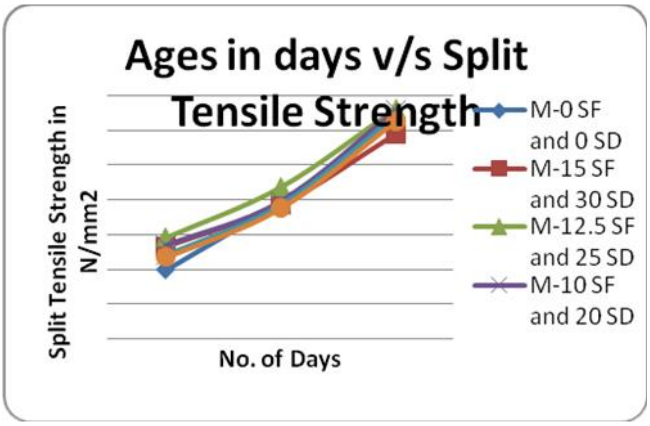
Graph 2 Split Tensile Strength in N/mm^2 at 7 days



Graph 3 Split Tensile Strength in N/mm^2 at 28 days



Graph 4 split tensile strength in N\mm 2 at age of (age)

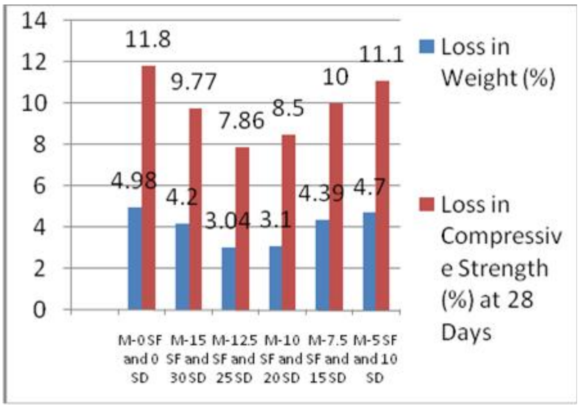


Graph 5 Split Tensile Strength in N/mm^2 at various age (Days)

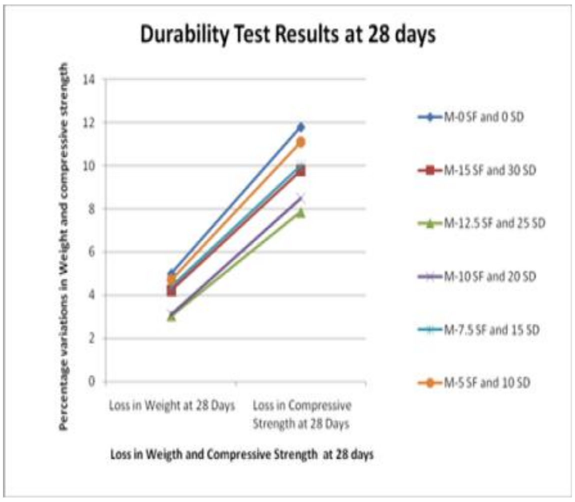
3.7. DURABILITY TEST

Table 8 Durability Test Results

Different Mix	Loss in Weight (%) at 28 Days	Loss in Compressive Strength (%) at 28 Days
M-0 SF and 0 SD	4.98	11.8
M-15 SF and 30 SD	4.2	9.77
M-12.5 SF and 25 SD	3.04	7.86
M-10 SF and 20 SD	3.1	8.5
M-7.5 SF and 15 SD	4.39	10
M-5 SF and 10 SD	4.7	11.1



Graph1 Durability Test results of Concrete Cube at 28 days



Graph 2 Variation of 28 days % loss in weight and compressive strength with variation of % of SF and SD

IV. CONCLUSION

Be proposed that the review of various researchers were analysed and following conclusions were arrived.By adding 1.0% silica fume, there is large amount of increase in strength after 7, 14 and 28 days respectively. The Compressive strength tends to increase with increase percentages of silica fume in the mix and decreases after 10% replacement. The optimum strength of cube is gain at 10% replacement for all 7, 14 and 28 days respectively. Split tensile strength adding 0.5% silica fume in the mix, there is an increase in the strength of cube after 7 days as compared to concrete without replacement. And after 14 days and 28 days there is enormous increase in strength as compared to the control mix. Be Proposed by adding 1.0% silica fume, there is large amount of increase in strength after 7, 14 and 28 days respectively. The Compressive strength, Flexural strength, Split tensile strength and Durability test of concrete mixes made with and without silica fume and stone dust has been determined at 3, 7 & 28 days of curing. The strength gained has been determined of silica fume and stone dust added concrete with 0%, 5%, 7.5% 10%, 12.5% & 15% and 0%, 10%, 15% 20%, 25% & 30% for M20 grade as partial replacement of cement and sand in conventional controlled concrete. From the results, it is concluded that the silica fume and stone dust are superior replacement of cement and sand up to 10% and 20%. Silica fume has high silicon dioxide (90-96%) content.

The cement in concrete releases hydroxide throughout the hydration process. The silicon oxide fume reacts with the hydroxide to make further binder material. the provision of binder and rocky structure of stone dirt keep bond formation between the concrete particles, ensuing improved strength properties and sturdiness of concrete. Additionally silicon oxide fume fill the voids between the cement particles and results in increase within the durability. The decrease in strength properties of concrete with increase in the silica fume and stone dust content beyond 10% and 20% are due to the over generation of binder which increases the brittleness of concrete in the presence of high content of silica fume. When activity all the tests and analyzing their result, the subsequent conclusions are derived:

1. The results achieved from the existing study shows that silica fume and stone dust are great potential for the utilization in concrete as partial replacement of cement and sand.
2. The percentage increase in compressive strength at 3, 7 and 28 days with 10% & 20% replacement of silica fume and stone dust give 6.9%, 4.5% and 7% (i.e., 12.51 N/mm^2, 18.07N/mm^2 and 27.55 N/mm^2) more strength as compared with conventional concrete mix (i.e., 11.7 N/mm^2 17.29 N/mm^2 and 25.7 N/mm^2).
3. The percentage increase in Flexural strength at 7 and 28 days with 10% & 20% replacement of silica fume and stone dust give 41.9% and 43% (i.e., 2.27 N/mm^2 and 5.33 N/mm^2) more Flexural strength as compared with conventional concrete mix (i.e., 1.6 N/mm^2 and 3.73 N/mm^2).
4. The percentage increase in Split tensile strength at 3, 7 and 28 days of 12.5% & 25% replacement of silica fume and stone dust give 47.5%, 10.6% and 6.1% (i.e., 1.46 N/mm^2, 2.19 N/mm^2 and 3.32 N/mm^2) more Split tensile strength as compared with conventional concrete mix without replacement of Silica Fume and Stone Dust (0.99 N/mm^2, 1.98 N/mm^2 and 3.13 N/mm^2) but the Split tensile strength with 12.5% silica fume and 25% stone dust remolded specimen (i.e., 3.32 N/mm^2) and the strength for 10% silica fume and 20% stone dust remolded specimen (i.e., 3.30 N/mm^2) is almost same at 28 days.
5. Thus, it is observed that the Split tensile strength is increases up to 10% silica fume 20% stone dust replacement level.
6. The percentage of loss in Weight and compressive strength at 28 days found to be 3.04%, 4.98% and 7.86% and 11.8% with and without replacement of cement and sand by Silica Fume (12.5%) and Stone Dust (25%). Thus replacement of silica fume and stone dust are found to have increased the durability against acid attack.
7. From the results, it is concluded that the Silica Fume and Stone Dust are superior replacement of Cement and Sand up to 10% and 20%.

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