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Study of High Strength Concrete Using Microsilica

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Abstract—

The framework of bridges, buildings, roads etc. need concrete. The concrete which is being used is not able to fulfil the contemporaneous needs. In India High Strength Concrete (HSC) is preferred for manufacturing practices and at the same time High Performance Concrete is used at high level. The properties of HSC are improved like mechanical and durability are improved by using silica fume in concrete. HSC has made the work of construction company more rewarding to design tall, long and light structures. HSC is helpful in designing buildings with good number of floors, wide area bridges and slim structure. The products like fly-ash, copper slag, silica fume etc. are produced by industries which leads to various environmental problems. The experiment on silica was done which stated that no strength is lost in silica-fume concretes. The experiment comprises four levels of silica-fume at the rate of 0%, 5.5%, 8.0%,9.5% and 11.0% which results high strength concrete.

Keywords— Micro-Silica, Concrete, Aggregate, Mix Proportion, High Strength

I. INTRODUCTION

The HSC is proved beneficial in making the construction companies to manufacture buildings with tall,long,slim and light structure. Industries have raised tall buildings with fine floors and longer bridges with slim structures.FISC has been proved useful in various applications all over the world.It has also proved beneficial in manufacturing offshore oil platforms,undersea tunnels and super-span bridges.The load of heavy vehiclesand traffic has to be managed in case of bridges.The weight of bridge decking is known as the dead load.If the decking is made thicker then its dead load goes up.Therefore,decking thickness should be increased to enhance the dead load. But this increases the dead load even more.Since a thin HPC can handle large traffic,the chain of decking thickness can be broken.The impermeability of concrete is more important than strength in case of long durability of structures. HSC and HPC helps in producing concrete with durability.

Silica fume (micro-silica) is considered as a pozzolanic admixture which promotes the mechanical properties as well as durability of concrete.To produce high strength and chemical resistant concrete silica fume is growing at very large scale. To get 28 days compressive strength, cement is replaced with silica. At present it is being used in the form of blended cement. The two major cement producers in Canada are presently marketing what is called type 10SFsilica-fume blended cement. The prescription of silica is always less than 10% whether it is used in its original form or blended one. Canadian standard allows 10 per cent maximum prescription of silica. Silica has been intended to used for other uses like to control potential alkali and produce concrete with high strength.It is the product of silicon-metal production.Silicon oxide consists near about 90-95% silica fume. Silica reacts with free lime that originates from hydration of cement; to get improved inter particle arrangement it fills in pores and revamp aggregate-paste bonding. Silica when reacts with free calcium hydroxide produce strong chemical compound calcium silicate hydrate and water.The presences of alkali particles get lessen due to this product which means the pH of pore fluid gets reduced. According to Diamond (l9X6) and Hausmann (196X), alkaline domain of concrete pores with pH greater than 13 is necessary to inspect the deterioration of the deep protection of steel inserted in the concrete. Due to this question is raisedregarding the consequences of using silica fume on the corrosion of reinforcing steel. Damage related to corrosion is the main cause of concern.

In concrete silica fume acts as damp-proof, provides resistance from electricity and great strength.Due to these properties corrosion related issues can be solved.First properties prevent penetration of water,oxygen and chloride in steel electrode. Ionic conduction is reduced due to resistance of electricity. There are many strength concrete formed by pozzolans, which also contains silica fumes. This concrete is more sensitive as compared to Portland cement. During hot and dry weather when concrete is more exposed to dryness, it expels the moisture which is required for the continuation of pozzolanic reaction that can continue to occur beyond the water curing period. To examine the effect of curing, the strength of the concrete and its characteristics of concrete skin which prevents the steel reinforcement should be taken into consideration.The objective of this work is to The object of the present work is to distinguish the silica fume concretes with the points of view of heat generation, shrinkage and sensitivity to curing, and to compare their performance with that of concretes made of Portland cement only, which having either the same cement components or the same water to cemented materials proportion.

II. LITERATURE REVIEW

Amudhavalli& Mathew (2012) scrutinized concrete by mixing silica fume with concrete and examined the output with respect to strength and durability properties of concrete.The study experimented on M35 grade concrete and silica fume is replaced with cement in the percentage of0, 5, 10,15and by 20%. The study on characteristics of concrete like

strength, split tensile strength and compressive strength was carried out for 7 days and 28 days.From the output it is demonstrated the use of silica fume in concrete has upgraded concrete strength and its durability. [1]

Perumal&Sundararajan (2004) used high strength concrete grade such as M60, M70 and M110 for experimental study to examine the strength and durability of silica fume.Scrutinization was done on both strength and durability parameters for M60, M70 and M110, HPC trial mixes were observed up to maximum levels of replacement of cement with Silica fume. These mixes werecompared with the mixes which have 0 percentages of SF. In these investigation Compressive strengths of 60 N/mm^2, 70 N/mm^2 and 110 N/mm^2at 28days were gained by applying 10 percentreplacement of cement with SF. With this percentage of silica fume concretegives superiordurability properties. [2]

Ghutke&Bhandari (2014) did examination on the influenceof silica fume on concrete and observed that they get that thesilica fume is a good alternativeof cement. Themethod to get strength by concrete containing silica fume is fast in comparison to the ordinary concrete with fully cement. But the concrete with high silica has low workability.To obtain maximum strength silica fume should be replaced with 10% amount.Bt in some cases strength of concrete with 15%replacement of cement by silica fume was also found higher than normal concrete. This study concludes that percentage varies from 10 % to 15 % replacement level isgood for replacement. [3]

Hanumesh, Varun& Harish (2015) also did research on theMechanical Properties of Concrete includingSilica Fume as Partial Replacement with Cement.Themotive of this research is to examinethe mechanicalproperties of M20 grade control concrete and silicafume concrete with fourdifferent percentages (5, 10, 15and 20%) of silica fume as a replacement ofcement. The end readings demonstratethat by replacing silica fume upto 10% compressive strength of concrete increases.With 10% the compressivestrength and the split tensile strength of concrete declines.The optimaldose of silica fume in the form of percentage in concrete is 10% of the cement for M20 grade of concrete. [4]

Shanmugapriya& Uma (2013) did anexperiment on High Performance Concrete by replacing Silica Fume with Cement.The concrete with 60 Mpa target mean strength is used in theexperiment. The ratio of water to cement 0.32 withSuper Plasticizer named CONPLAST SP430.The specimens likebeams, cubes and cylinderswere cast for various doses of percentage and performed test atthe age of 7, 14and 28 days. Theexperimentationsatesthat the silica fumes will produce efficient compressive strength, flexure strength and split tensile strength by replacing silica with cement.The silica was used in 7.5% quantity when replaced with cement.

Jain &. Pawade (2015) examined the physical properties ofhigh strength silica fume concretes and theirreaction to cure methods were researched andcompared with reference Portland cementconcretes, having either the same concrete contentas the silica fume concrete or the same water tocementitious materials ratio.The experimentalprogram consists of six levels of silica-fumecomponents at 0% (control mix), 5%, 10%, 15%, 20%,and 25%, with and without super plasticizer. It alsocontains two mixes with15% silica fume added tocement in normal concrete. Durability ofsilicafumemortar was examined in chemical environmentsof sulphate compounds, ammonium nitrate,calcium chloride, and various kinds of acids. [6]

Roy &Sil (2012) experimentedthe effect of Replacement of Cement by Silica Fume onconventional Concrete.With this experiment the conclusion was made that maximum compressive strengthis obtained by replacing the cement with silica fume at 10 %as compared to those of the normal concrete (forcube and cylinder) whereas split tensile strengthand flexural strength of the SF concrete(3.61N/mm2 and 4.93N/mm2 respectively) areincreased by about 38.58% and 21.13%respectively over those (2.6 N/mm2 and 4.07N/mm2 respectively) of the normal concrete when10% of cement is replaced by SF.[7]

Amarkhail (2015) studiedeffects of SilicaFume on Properties of High-Strength Concrete. Heobserved that without harming concrete workability 10% cement can be replaced.Concrete with 10% silica fumereplacement get the highest compressivestrength following 15% silica fume replacementwith a minute difference.Concrete containing 15% silicafume content obtained the highest flexuralstrength. It is observed that 10% and 15% silica fume replacement is good for compressive strength of concrete. [8]

Sasikumar&Tamilvanan (2016) experimented on Properties of SilicaFumes as a Partial Replacement of Cement. Mainparameter examined in this study is M30 gradeconcrete with partial replacement of cement bysilica fume0%, 25%, 30%, 40% and 50%. Whensilica fume percentage increases from 0% to 25%, the normal consistency increases about 40%.The optimum 7 and 28-day compressive strengthhas been obtained in the 25 % silica fumereplacement level. Also the split tensile strength increases when 25% silica fume is used for replacing cement. [9]

Ajileye (2012) For M30 grade of concrete, silica fume up to 10%of cement is good to enhance the compressivestrength of concrete. If at the 15% is used it decreases the compressive strength for 3, 7,14 and 28 days curing period in concrete. [10]

Sharma &Seema (2012) analysedthe effect ofpartial replacement of cement with silica fume oncompressive strength of concrete.M20 grade ofconcrete with W/C ratio as 0.5 and percentagereplacement was 0%, 10%, 20%. The optimalcompressive strength is get at 20% of cement by a Silica Fume at all age levels (i.e.24 hours, 7& 28 days). The 28 days compressivestrength at 20% replacement was obsereved to be 32.29MPa with a slump value of 21 mm. [11]

Pradhan and Dutta (2013) analyzedtheeffects of silica fume on conventional concrete. Theoptimum compressive strength was gained at20% cement replacement with silica fume at 24hours, 7days and 28 days. Higher compressivestrength concludes that the concrete mixed with silica fume was high strength concrete. [12]

Srivastava (2012) did study on the workability ofconcrete on replacement of silica fumeby cement at maximum level in traditional concrete. Mostly slump gets declinedwhen silica fume is added. But workability of cement was seen improved in some cases.The compressive of cement increases by 6-8% by adding silica fume.No change was seen in thetensileand flexural strength of the concrete. [13]

III. MATERIAL USED

A. Cement:

Ordinary Portland Cement of 53 grades (Ambuja) with following properties wasused

- Fineness : 2.68% residue on IS sieve no.9 (90 micron)
- Consistency : 30.5% as water requirement
- Soundness : 0.5 mm as Le-Chateliers expansion
- Initial setting time : 78 minute
- Final setting time : 220 minutes.
- Unitweight : 1 .280 gm/cm
- Specific gravity : 3.09

B. Fine Aggregate

Coarse sand falling in zone —I with following properties was used

- Unit weight : 1.68 gm/cm^3
- Specific weight : 2.78
- Fineness modulus : 2.93

C. Coarse Aggregate

Crushed stone has been used as coarse aggregate that contained 40%of 20 mm size and 60% of 10 mm size aggregate. The properties ofaggregate are as follows:

- Unit weight : 1.482 gm/cm^3
- Specific weight : 2.78
- Fineness modulus : 6.72

D. Micro-silica

Micro-silica, a product of M/SElkem India Pvt. Limited with following parameters wasused..

Table I Parameters of micro-silica

Parameters	Specification	Analysis
SiO_2	% Min 85.0	91.6
Moisture Content	% Max 3.0	0.9
Loss ignition	% Max 6.0	1.6
Carbon	% Max 2.5	0.8
Specific Surface	M^2/g Min 15	21.7
Bulk Density	Kg/m^3 500-700	640

E. Water

Potable water used was free from injurious amount of oils, acids, alkalis, salts,organic materials or other substance that may be deleterious toconcrete.

IV. MIX PROPORTION

Table II Mix proportions

Materials	M-A	M-B	M-C	M-D	M-E
w/c ratio	0.37	0.37	0.37	0.37	0.37
Cement (kg)	511	485	470	462	455
Micro-silica (kg)	0	26	41	49	56
Water (kg)	191	191	191	191	191
Fine aggregate (kg)	568.32	565.22	563.0	562.12	560.57
Coarse aggregate (kg)	1175.2	1168.8	1165.6	1162.37	1159.17
Superplasticizer (litre)	4.39	6.58	7.68	8.78	9.88
Slump (mm)	95	100	85	95	80

V. RESULTS

Following results of compressive strength, flexural strength and water absorption are drawn from the above experimental work.

Table III Compressive Strength of Different mix (N/mm^2)

Mix Designation	7 Days	28 Days	60 Days	90 Days
M-A	31.65	40.87	44.61	46.24
M-B	32.40	43.34	48.83	52.44
M-C	33.90	45.96	50.14	54.76
M-D	30.95	48.43	52.03	52.11
M-E	30.52	43.78	46.78	51.67

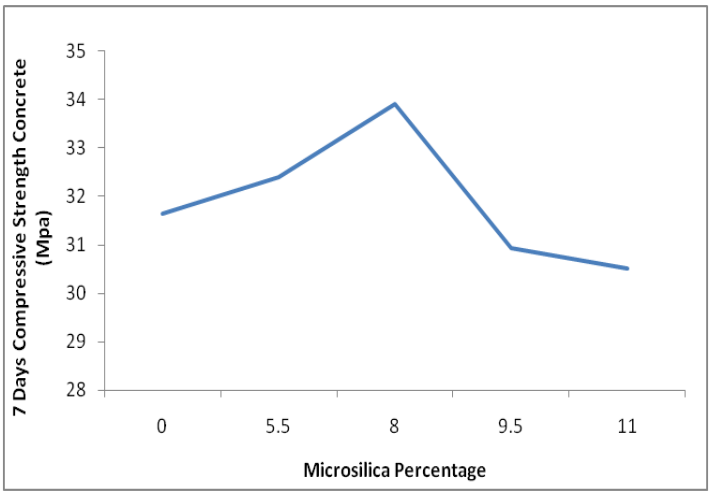

Fig. 1: 7days compressive strength

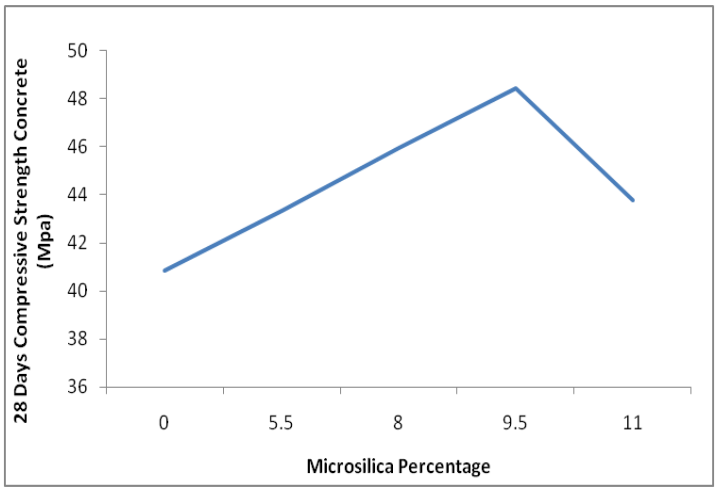

Fig. 2: 28 days compressive strength

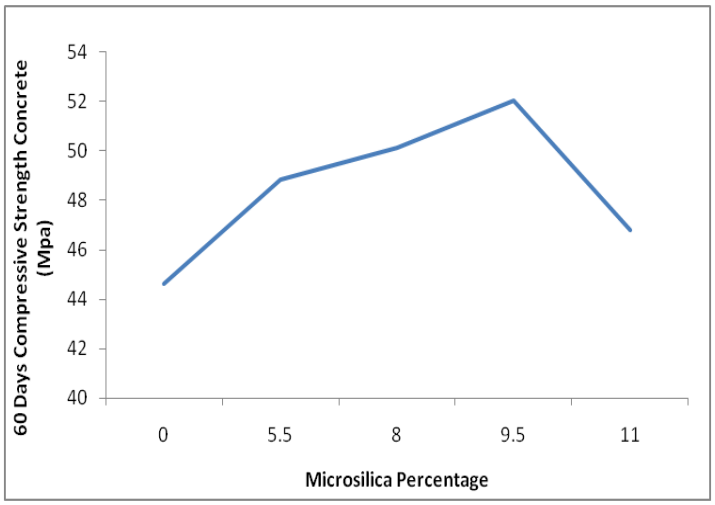

Fig. 3: 60 days compressive strength

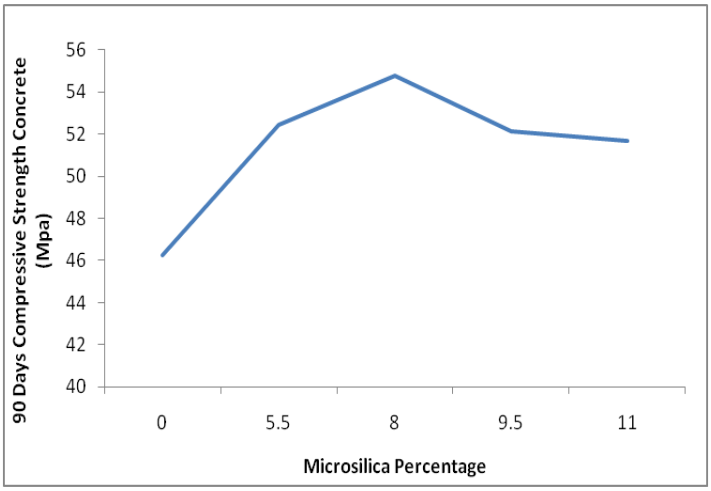

Fig. 4: 90 days compressive strength

Table IV Flexural strength (N/mm^2) of different

Mix Designation	28 Days	90 Days
M-A	4.46	5.37
M-B	6.83	7.23
M-C	6.94	7.06
M-D	5.72	6.63
M-E	5.13	5.98

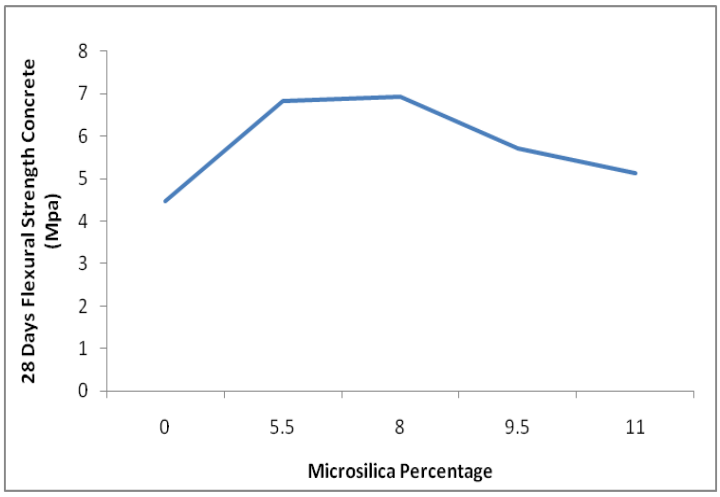

Fig. 5: Flexural Strength after 28 days

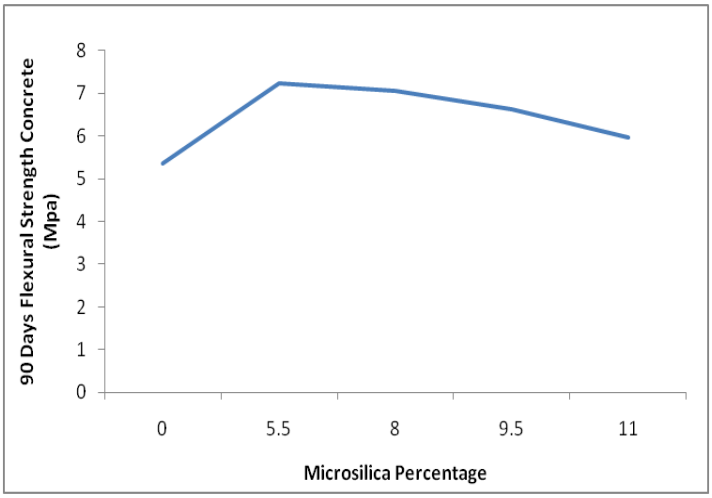

Fig. 6: Flexural Strength after 90 days

Table V Water absorption (%) of concrete

Mix Designation	28 Days	60 Days	90 Days
M-A	4.12	3.76	3.55
M-B	3.96	3.43	3.13
M-C	3.58	3.26	2.98
M-D	3.34	3.17	2.71
M-E	3.21	2.94	2.57

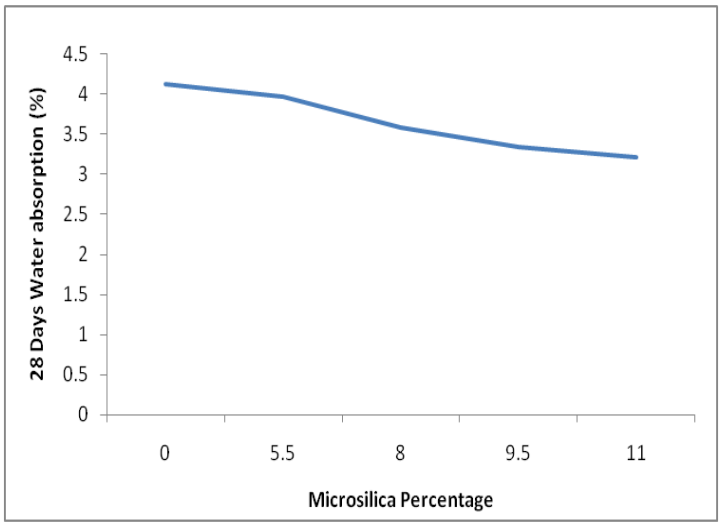

Fig. 7: Water absorption after 28 days

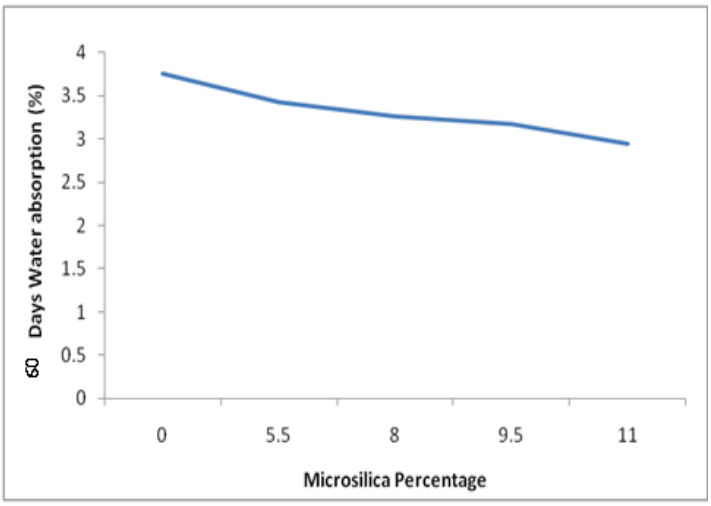

Fig. 8: Water absorption after 60 days

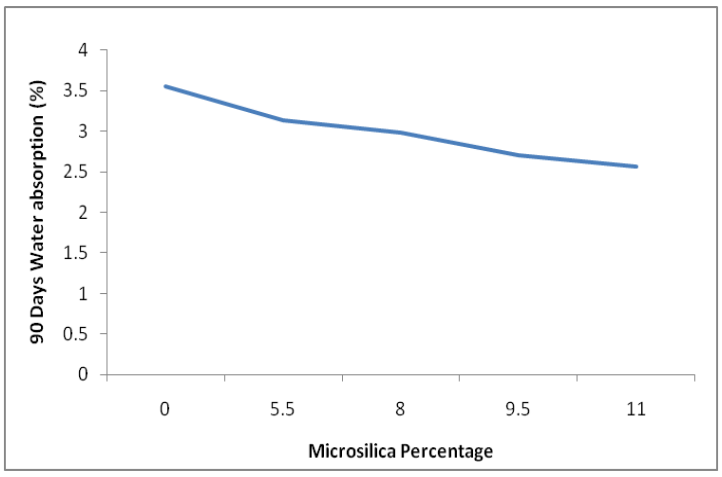

Fig. 9: Water absorption after 90days

VI. CONCLUSIONS

A. The amount of water required for normal consistency of cementations material increases with the increase of' micro-silica percentage.
B. Initial and final setting time of cementations material decrease with increase of micro-silica percentage.
C. With the partial replacement of cement by micro-silica, it is found that the strength of cementitious material decreases with increase in content of micro-silica upto 28 days. However this difference reduces with age.
D. The expansion of cementitious material slightly increases with addition of 9.5% and 11.0% micro-silica. However it needs further investigation.
E. The workability of concrete decreases with increase of the content of micro-silica.
F. The compressive strength of concrete increases with increase of micro-silica, but after certain percentage the gain in strength starts decreasing. The 28days, 60 days and 90 days strength of concrete aremaximum at 9.5% micro-silica content, whereas 7days strength is maximum at 8.0% micro-silica content.
G. The flexural strength of concrete with 8.0% micro-silica at 28days and 90 days gives the maximum strength.
H. Water absorption decreases with increase of micro-silica in concrete.
I. The colour of groundmass changes with addition of micro-silica and it become dark in colour and conflrni the increase in binding property of cementitious material.
J. Reaction rim develops in case of cement with micro-silica.
K. Binding material is more uniform in case of concrete with micro-silica than the concrete without micro-silica.
L. The addition of micro-silica gives high strength, more durable anduniformly distributed binders in concrete.

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