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Consequences on Compressive Strength of Concrete by Using Steel Fiber and Silica Fume

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***Abstract*: Concrete has undergone rapid and phenomenal development in the past few years in India. Higher grades of concrete are now becoming popular in the country with its proven utility in the construction of important structures. It is possible to minimize the cracks & increase the flexural strength of concrete and crack resistance and also improve the other properties of concrete by addition of SP, SF. Silica Fume consists of very fine vitreous particles, It has been found that Silica Fume improves compressive strength, bond strength, and abrasion resistance; reduces permeability; and therefore helps in protecting reinforcing steel from corrosion.**

***Keywords*: Steel Fibers, Silica Fume, Compressive Strength**

1. Introduction:-

Silica fume, also known as micro silica, is a by-product of the reduction of high-purity quartz with coal in electric furnaces in the production of silicon and ferrosilicon alloys. Silica Fume is also collected as a by-product in the production of other silicon alloys such as ferrochromium, ferromanganese, Ferro magnesium, and calcium silicon (ACI Comm. 226 1987b). Before the mid-1970s, nearly all Silica Fume was discharged into the atmosphere. After environmental concerns necessitated the collection and land filling of Silica Fume, it became economically justified to use Silica Fume in various applications. Silica Fume consists of very fine vitreous particles with a surface area ranging from 60,000 to 150,000 ft^2/lb or 13,000 to 30,000 m^2/kg when measured by nitrogen absorption techniques, with particles approximately 100 times smaller than the average cement particle. Because of its extreme fineness and high silica content, Silica Fume is a highly effective pozzolanic material (ACI Comm. 226 1987b; Luther 1990). Silica Fume is used in concrete to improve its properties. It has been found that Silica Fume improves compressive strength, bond strength, and abrasion resistance; reduces permeability; and therefore helps in protecting reinforcing steel from corrosion.

Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking internal cracks are inherently present in concrete and its poor tensile strength is due to propagation of cracks leading to brittle fracture of concrete. In the past attempts have been made to impart improvement in tensile properties of concrete members by way of using conventional reinforced bars and also by applying restraining techniques, Although both these method provide tensile strength to concrete members. They do not increase the inherent tensile strength. When loaded the micro cracks propagate and open up and owing to the effect of stress concentration additional cracks form in places of minor defects. The development of such micro crakes is the main cause of inelastic deformation in concrete. It has been recognized that the addition of small closely spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially improve its static & dynamic properties this type of concrete is known as Fiber Reinforced concrete. Fiber reinforced concrete can be defined as a composite material consisting of mixtures of cement mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers

2. Types of fibers:

- Steel fibers
- Polypropylene fibers
- Nylon fibers
- Asbestos fibers
- Glass fibers

2.1 Factors effecting properties of Steel Fiber Reinforced concrete:-

2.1.1 Relative Fiber Matrix stiffness:-

The modulus of elasticity of Matrix must be much lower than that of fiber for efficient stress transfer high modulus fibers such as steel; glass and carbon impart strength and stiffness to composite. Interfacial bond between the matrix and fibred also determine the effectiveness of stress transfer from the matrix to fiber. A good bond is essential for improving tensile strength of composite. The bond could be improved by larger area of contact, Improving the frictional properties and degree of gripping.

2.1.2 Volume of Fibers:-

The strength of the composite largely depends on the quantity of fiber used in it. It can be seen that the increase in the volume of fibers, increase approximately linearly, the tensile strength and toughness use of higher percentage of fiber is likely to cause segregation and hardness of concrete and mortar.

2.1.3 Aspect Ratio:-

Another important factor which influences the properties and behavior of composite is aspect ratio of fiber. It has been reported that up to aspect ratio 75 increases in aspect ratio increases the ultimate strength of concrete. Beyond 75, relative strength and toughness is reduced. Table below shows the effect of aspect ratio on strength & toughness. We are using aspect ratio 62.5.

2.1.4 Workability: -

Incorporation of steel fiber decreases the workability. This situation adversely affects the considerations of fresh mix even prolonged external vibration fails to compact the concrete. Another consequence of poor workability is non-uniform distribution of fiber. Generally, the workability and compaction standard of mix is improved through increased w/c ratio or by use of some kind of water reducing admixture.

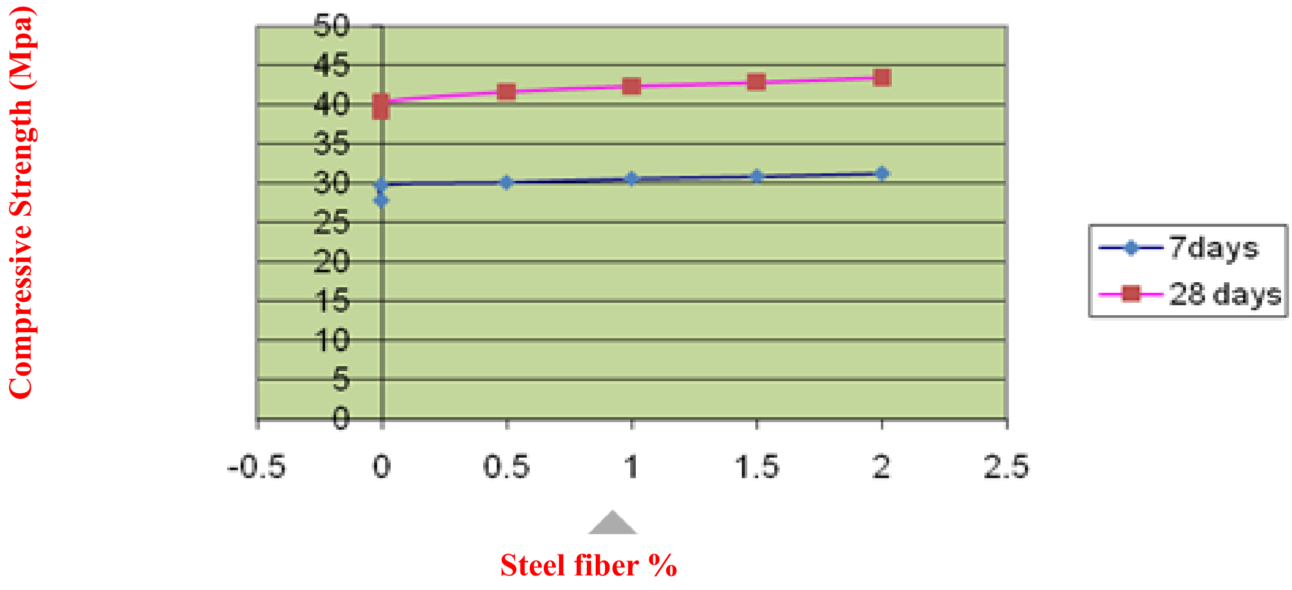
3. Compressive Strength (Mpa):-

Silica Fume (4%) (Table No.A)

Sr. No.	Mix design	Steel Fiber Length/Dia.	Cement Kg	Silica Kg	Water Lit.	F.A. Kg	C.A. (10mm) Kg	C.A. (20mm) Kg
1	Grade = M30 W/C Ratio= 0.42 Silica Fume = 4 %	L= 30mm D= 0.50	420	Nil	176.4	693	483.75	591.25
2			420	Nil	176.4	693	483.75	591.25
3			403.2	16.8	176.4	693	483.75	591.25
4			403.2	16.8	176.4	693	483.75	591.25
5			403.2	16.8	176.4	693	483.75	591.25
6			403.2	16.8	176.4	693	483.75	591.25

Silica Fume (4%) (Continue from Table No.A)

Sr. No.	Mix design	Steel Fiber Length/Diam.	SP (%)	Steel Fiber Vf (%)	Slump (mm)	Compressive Strength (Mpa)	
						7days	28 days
1	M30 W/C Ratio=0.42 Cement = 420Kg Silica Fume (4%)	L=30mm D=0.50	0	0	15	27.88	39.21
2			0.4	0	38	29.77	40.38
3			0.75	0.5	46	30.11	41.68
4			0.75	1	36	30.58	42.39
5			1	1.5	48	30.87	42.88
6			1	2	34	31.25	43.52



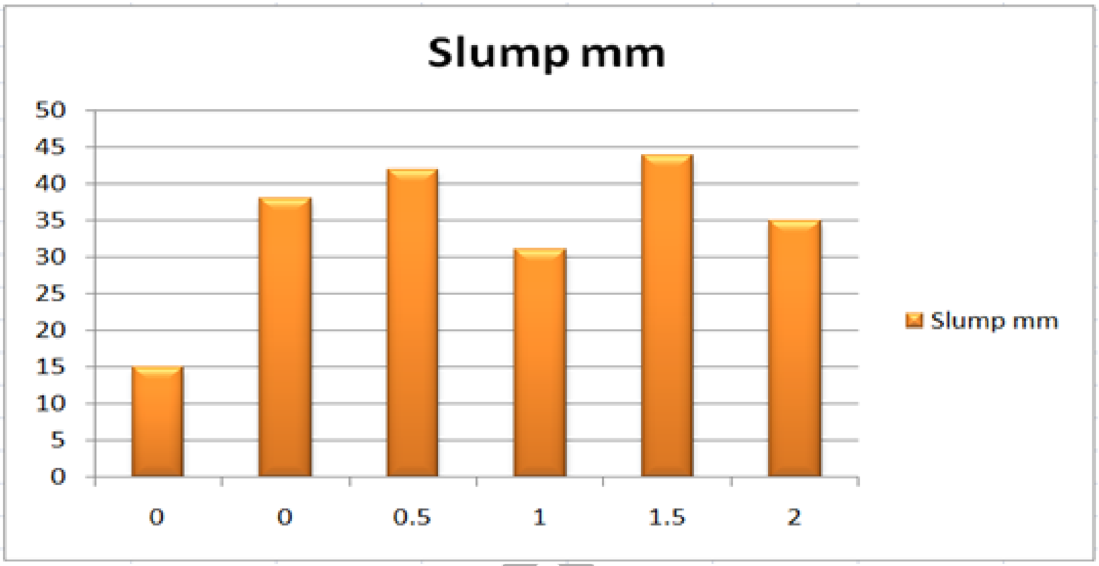
Silica Fume (8%) (Table No.B)

Sr. No.	Mix design	Steel Fiber Length/Dia.	Cement Kg	Silica Kg	Water Lit.	F.A. Kg	C.A. (10mm) Kg	C.A. (20mm) Kg
1	M30 W/C Ratio=0.42 Cement = 420Kg Silica Fume (8%)	L= 30mm D= 0.50	**420**	**Nil**	**176.4**	**692.71**	**483.75**	**591.25**
2			**420**	Nil	176.4	692.71	483.75	591.25
3			**386.4**	33.6	176.4	692.71	483.75	591.25
4			**386.4**	33.6	176.4	692.71	483.75	591.25
5			**386.4**	33.6	176.4	692.71	483.75	591.25
6			**386.4**	33.6	176.4	692.71	483.75	591.25

Silica Fume (8%) (Continue from Table No.B)

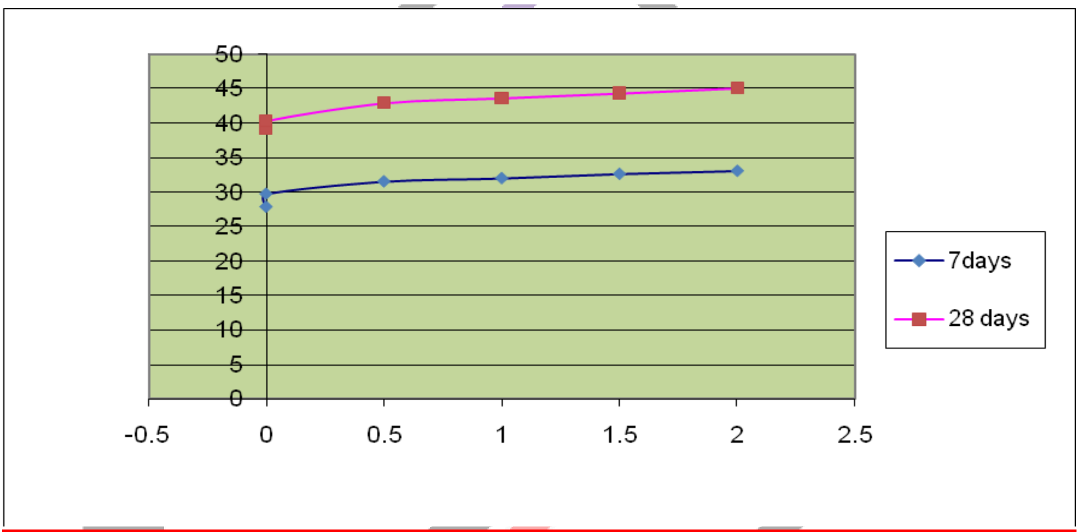
Sr. No.	Mix design	Steel Fiber Length/Diam.	SP (%)	Steel Fiber Vf (%)	Slump (mm)	Compressive Strength (Mpa)	
						7days	28 days
1	M30 W/C Ratio=0.42 Cement = 420Kg Silica Fume (8%)	L=30mm D=0.50	**0**	**0**	**15**	**27.88**	**39.21**
2			**0**	0	38	29.77	40.38
3			**1**	0.5	42	31.58	42.97
4			**1**	1	31	32.05	43.68
5			**1.2**	1.5	44	32.68	44.38
6			**1.2**	**2**	**35**	**33.12**	**45.12**

Slump (mm)



Steel fiber %

Compressive Strength (Mpa)

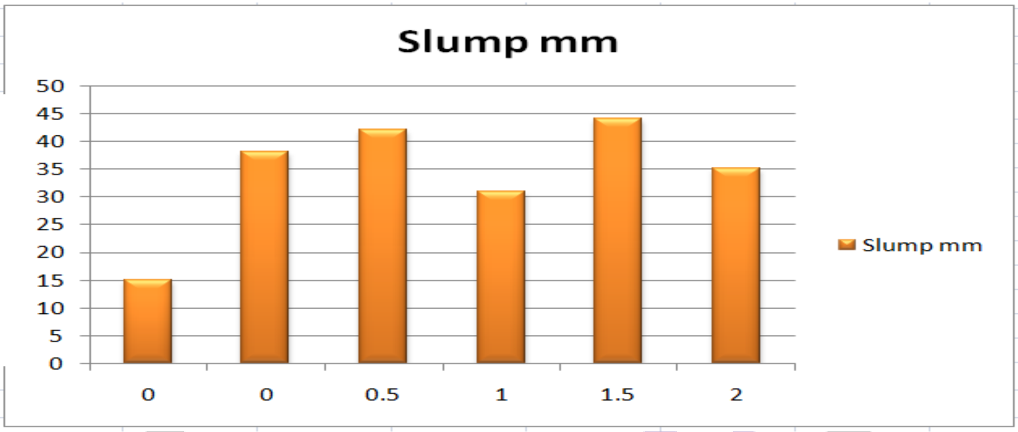


Steel fiber %

Silica Fume (12%) (Table No.C)								
Sr. No.	**Mix design**	**Steel Fiber Length/Dia.**	**Cement Kg**	**Silica Kg**	**Water Lit.**	**F.A. Kg**	**C.A. (10mm) Kg**	**C.A. (20mm) Kg**
1	M30 W/C Ratio=0.42 Cement = 420Kg Silica Fume (12%)	L=30mm D=0.50	**420**	**Nil**	**176.4**	**692.71**	**483.75**	**591.25**
2			**420**	Nil	176.4	692.71	483.75	591.25
3			**369.6**	50.4	176.4	692.71	483.75	591.25
4			**369.6**	50.4	176.4	692.71	483.75	591.25
5			**369.6**	50.4	176.4	692.71	483.75	591.25
6			**369.6**	50.4	176.4	692.71	483.75	591.25

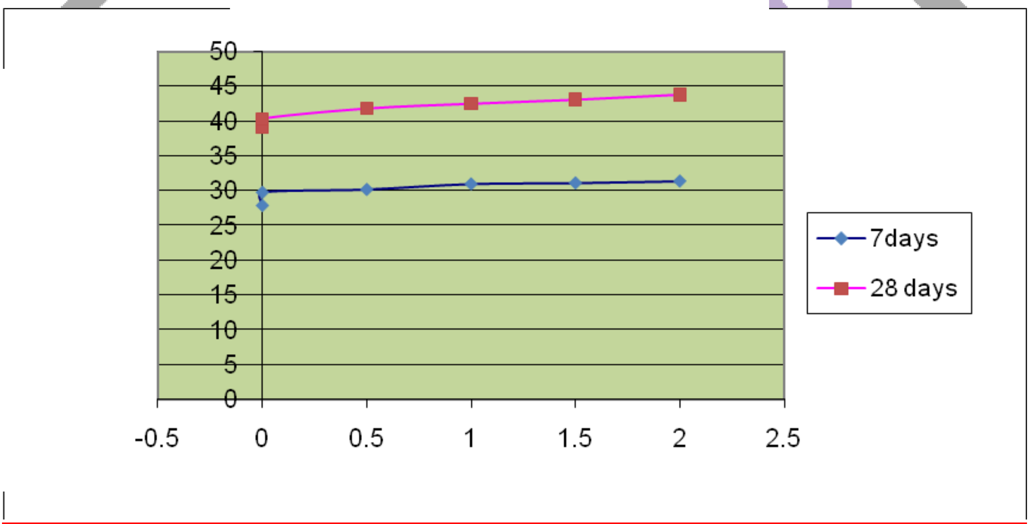
Silica Fume (12%) (Continue from Table No.C)							
Sr. No.	Mix design	Steel Fiber Length/Diam.	SP (%)	Steel Fiber Vf (%)	Slump (mm)	Compressive Strength (Mpa)	
						7days	28 days
1	M30 W/C Ratio=0.42 Cement = 420Kg Silica Fume (12%)	L=30mm D=0.50	0	0	15	27.88	39.21
2			0	0	38	29.77	40.38
3			1	0.5	42	30.18	41.85
4			1	1	31	30.98	42.54
5			1.2	1.5	44	31.12	43.12
6			1.2	2	35	31.38	43.84

Slump (mm)



Steel fiber %

Compressive Strength (Mpa)



Steel fiber %

4. Conclusion:-

- With the increase in Steel fibers and Silica fume, the compressive strength of the concrete increases to a considerable limit.
- Silica fumes are a great binding material thus silica fume increases the ultimate strength of concrete.
- With the increase in steel fibers, the workability of the concrete decreases.
- The objectives of Fibers reinforcement and construction are to build safe, serviceable, economical, durable and aesthetic structures.
- The primary aim of Fiber reinforcement to minimize the probability of failure to an acceptable low value.

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