TO INVESTIGATE COMBINED INFLUENCE OF STEEL FIBER AND SILICA FUME ON HIGH STRENGTH CONCRETE RIGID PAVEMENT

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ABSTRACT-Fibres are generally mixed with concrete to enhance the resistance of cracking and strengthening of concrete. In this project, tests were carried out on steel fibre reinforced concrete to check the influence of fibres and silica fume on flexural strength of concrete. According to various research papers, it has been found that addition of steel fibres and silica fume enhances the strength of the concrete. In this project practical tests were carried out to find out optimum quantity of steel fibres required to achieve the maximum flexural strength for higher grades of concrete. Tests were also carried out on the concrete by placing the steel fibres in layers within the concrete at different depths. From the exhaustive and extensive experimental work it was found that with increase in steel fibre content (by weight of concrete) there was tremendous increase in Flexural strength. The minimum fibre content tested against different percentage of silica fume (5%, 10%, and 15%) and flexure strength is obtained. The experimental results were checked using linear regression technique. The results obtained by this test were used to design pavements to determine the advantages of mixing steel fibre and silica fume in high strength concrete.

Keywords: Steel fibre, Silica fume, Flexure strength, rigid pavement.

INTRODUCTION

Fibres are usually used in concrete to control cracking due to both plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibre produced greater impact, abrasion and shatter resistance in concrete. Generally fibre does not increase the flexural strength of concrete and so cannot replace moment resisting or structural steel reinforcement. Indeed, some fibre actually reduces the strength of concrete. The amount of fibre added to the concrete mix is expressed as a percentage of total volume of the composite (concrete and fibre), termed volume fraction (VF). VF typically ranges from 0.1 to 3%. Aspect ratio (l/d) is calculated by dividing fibre length (l) by its diameter (d). Fibre with a non circular cross section uses an equivalent diameter for the calculation of aspect ratio. If the modulus of elasticity of the fibre is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material increase in the aspect ratio of the fibre usually segments the flexural strength and the toughness of the matrix. However, fibres which are too long tend to get lumped up in the mix and create workability issues. Some recent research indicated that using fibre in concrete has limited effect on the impact resistance of the materials. This finding is very important since traditionally, people think that the ductility increases when concrete is reinforced with fibre. The results also indicated that the use of micro fibre offers better impact resistance compared with the longer fibre. [1]

Silica fume (SF) is a by product of the smelting process in the silicon and ferrosilicon industry. The reduction of high-purity quartz to silicon at temperatures up to 2,000^{o}C produces SiO2 vapours, which oxidizes and condense in the low temperature zone to tiny particles consisting of non-crystalline silica. By-products of the production of silicon metal and the ferrosilicon alloys having silicon contents of 75% or more contain 85–95% non-crystalline silica. The by-product of the production of ferrosilicon alloy having 50% silicon has much lower silica content and is less pozzolanic. Therefore, SiO2 content of the silica fume is related to the type of alloy being produced. Silica fume is also known as micro silica, condensed silica fume, volatilized silica or silica dust. The American concrete institute (ACI) defines silica fume as a ‘‘very fine no crystalline silica produced in electric arc furnaces as a by product of production of elemental silicon or alloys containing silicon’’. It is usually a grey colour powder, somewhat similar to Portland cement or some fly ashes. It can exhibit both pozzolanic and cementations properties. Silica fume has been recognized as a pozzolanic admixture that is effective in enhancing the mechanical properties to a great extent. By using silica fume along with super plasticizers, it is relatively easier to obtain compressive strengths of order of 100–150 MPa in laboratory. Addition of silica fume to concrete improves the durability of concrete through reduction in the permeability, refined pore structure, leading to a reduction in the diffusion of harmful ions, reduces calcium hydroxide content which results in a higher resistance to sulphate attack. Improvement in durability will also improve the ability of silica fume concrete in protecting the embedded steel from corrosion. [2]

Flexure strength is the ability of a beam or slab to resist failure in bending. It is measured by loading unreinforced 150 x 150 mm concrete beams with a span three times the depth (usually 450mm). The flexural strength is expressed as "Modulus of Rupture" (MR) in MPa. Flexural strength is about 12 to 20% of compressive strength. However, the best correlation for specific materials is obtained by laboratory tests. Designers of pavements use a theory based on flexural strength. Therefore, laboratory mix design based on flexure may be required, or cement content may be selected from past experience to yield the needed design MR. Some also use MR for field control and acceptance of pavements. Very few use flexural testing for structural concrete. Agencies not using flexural strength for field control generally find the use of compressive strength convenient and reliable to judge the quality of the concrete as delivered. Beam specimens must be properly made in the field. Consolidate by vibration in accordance with CSA A23.2-3C and tap sides to release bubbles. For higher slump, after Roding, tap the moulds to release bubbles and spade along the sides to consolidate. Never allow the beam surfaces to dry at any time. Immerse in saturated lime water for at least 20 hours before testing. Specifications and investigation of apparent low strengths should take into account the higher variability of flexural strength results. Standard deviation for projects with good control range from about 0.3-0.5MPa. Values over 0.7MPa indicate testing problems, and there is a high likelihood that testing problems, or moisture differences within a beam, will cause low strength. [3][4]

Rigid pavements are those which possess noteworthy flexural strength. The stresses are not transferred from grain to grain to the lower layers as in the ease of flexible pavement layers. The rigid pavements are made of Portland cement concrete plain, reinforced or pre-stressed concrete. The plain cement concrete slab is expected to take up about 40 kg/cm^2 flexural stress. The rigid pavement has the slab action and is capable of transmitting the wheel load stresses through a wider area below. The main point of difference in the structural behaviour of rigid pavement is the maximum flexural stress occurring in the slab due to wheel load and the temperature changes where as in the flexible pavement it is the distribution of compressive stresses. As rigid pavement slab has tensile strength **,** tensile stresses are developed due to bending of slab under the wheel load and temperature variation. The rigid pavement does not get deformed to the shape of lower surface as it can bridge the minor variation of lower layers. [5]

METHODOLOGY

Materials Used & Its Properties

Cement*:* Ordinary Portland cement (OPC) is by far the most important type of cement. The OPC was classified Into three grades namely, 33 grades, 43 grades and 53 grades depending upon the strength of the cement at 28 Days when tested as per IS 4031-1988. Ordinary Portland cement of 53 grade of ULTRATECH cement is used in this experimental work. Conforming weight of each cement bag was 50 kg

Fine aggregates: It should be passed through IS Sieve 4.75 mm. It should have fineness modulus 2.50-3.50 and silt contents should not be more than 4%. Coarse sand should be river sand or pit sad; or combination of the two. In our region, fine aggregates can be found from bed of Vaiterna River. It confirms to IS 383-1970 which comes under Zone-I
Coarse aggregates*:* It should be hard, strong, dense, durable and clean. It must be free from vein, adherent coatings and injurious amount of disintegrated pieces, alkalis, vegetable matters and other deleterious substances. It should be roughly cubical in shape. Flaky pieces should be avoided. It should confirm to IS 2838(I).

Water*:* Water should be free from acids, oils, alkalis, vegetables or other organic impurities. Soft waters also produce weaker concrete. Water has two functions in a concrete mix. Firstly, it reacts chemically with the cement to form the cement paste in which the inert aggregates are held in suspension until the cement paste has hardened. Secondly, it serves as a lubricant in the Mixture of fine aggregates and cement.

Admixture*:* An admixture is defined as a material, other than the cement, water and aggregate, i.e. uses as an ingredient of concrete and is added to the batch immediately before or during mixing.

Steel fibres: The typical diameter lies in the range of 0.75 mm twisted end steel fibres are being used in this project. Length of these fibres is 30 mm and the aspect ratio of 55. Density of steel fibre is 7850 kg/cum.

Silica fume: Elkem Silica fume of specific gravity 2.2 is used in this project to obtain the higher strength of concrete.

Methodology:
Portland cement reinforced concrete reinforced with more or less randomly distributed fibres. In FRC, Thousands of small fibre are dispersed and distributed randomly and at particular depth in the concrete during mixing, and thus Improve concrete properties in directions Dry ingredients (aggregates and cement) would be mixed Be mixed in the mixer for 30 seconds. After that, steel fibres would be added. Then water (with Super plasticizer) would be added gradually in and the mixing would be continued.

Casting of 3 beams without steel fibres to compare our results with the steel fibre reinforced concrete. Casting of approximately 30-40 concrete beams (15cm x 15cm x 70cm) using twisted end steel fibres in the concrete for determining flexural strength of concrete.

This experiment requires lot of trial work needed to find out the maximum strength at optimum quantity of steel fibres. The optimum quantity of steel fibre is tested against the different percentages of silica fume.

Determination of Flexural Strength of Steel Fibred Reinforced Beam*:*

One normal concrete beam of size (700mmX150mmX150mm) is casted in the mould and kept to cure for 24 hours. It is then unmolded and kept in water tank for 28 days. After 28 days, the beams would be tested for their flexural strength in the following method. The bed of the testing machine should be provided with two steel rollers, 38mm in diameter on which the specimen is to be supported. These rollers should be so mounted that the distance from centre to centre is 60 mm for 150 mm specimen.

The bearing surfaces of the supporting and the loading rollers shall be wiped, clean and any loose sand or other Material should be removed from the surfaces of the specimen where they are to make contact with the rollers.

Two points loading can be conveniently provided by the arrangement as shown in figure. The load is transmitted to through a load cell and spherical seating on to a spreader beam. This beam bears on rollers seated on steel plated bedded on the test member with mortar, high strength plaster or some similar material. The test Member is supported on the roller bearings acting on similar spreader plates.

The specimen was placed over the two steel rollers bearing of 50 mm left from the ends of the beam. The Remaining 600 mm was divided into three parts of 200 mm each as shown in the figure. Two points loading Arrangement was done as shown in the figure. Loading was done by the hydraulic jack of capacity 600 KN. At The centre one dial gauges were used for recording the deflection of the beams.

The load shall be applied without shock and increasing continuously at the rate such that the extreme fibre stress Increases approximately 7 kg/sq.cm/min that is at the rate of loading of 400 kg/min for the 15 cm specimen and at The rate of 180 kg/min for the 10 cm specimen. The load shall be increased until the specimen fails and the Maximum load applied to the specimen during the test shall be recorded. The appearance of the flexural faces of the concrete and any unusual features in the type of failure shall be noted. [6]

Concrete Mix Design: ACI method is adopted for concrete

Mix design and material for 1m^3 is calculated as follows

S.N.	Material	Quantity kg/m^3
1.	Cement	450
2.	Coarse Aggregate 20 mm	576
3.	Coarse Aggregate 10 mm	500
3.	Fine Aggregate	667
4.	Super plasticizer	5.8
5.	Silica fume	30
6.	Steel fibre	30
7.	Water	188 litre

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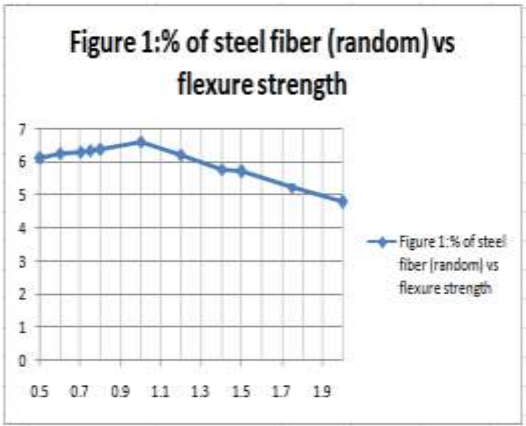
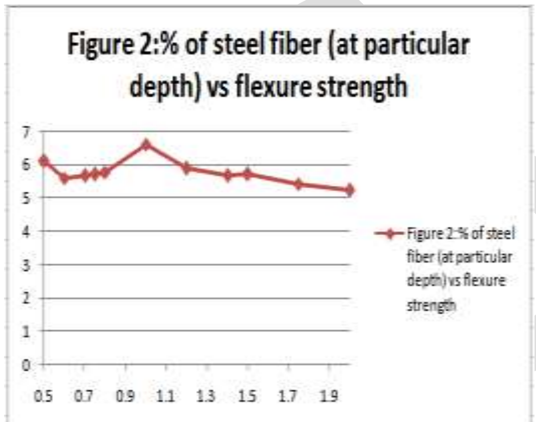
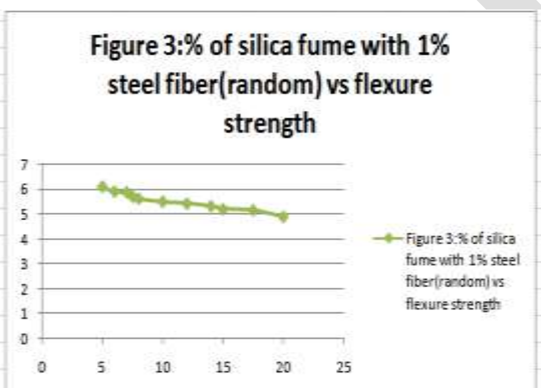
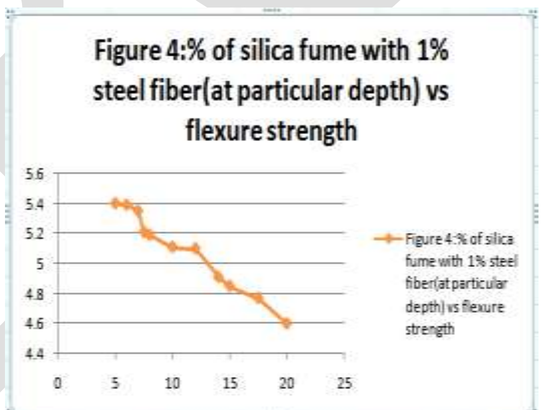
CONCLUSION









1. The addition of a steel fibre into the concrete increases the flexural strength.
2. The flexure strength of concrete obtained in an addition of steel fibre randomly is more as compared to when steel fibre added at one third from the top edge. This is because when we add steel fibre randomly in concrete then there is strong bond between concrete and steel fibre so we got more flexure strength but when we add at particular depth there is not enough bond between concrete and steel fibre so we got less flexural strength.(refer fig: 1 and fig:2)
3. At constant percentage of fibre =1%, it is observed that the flexural strength is increased 85% as compared to plain concrete strength.
4. The constant percentage of steel fibre (1% randomly mix) is tested against different percentage of silica fume (5%, 10%, and 15%), the flexure strength is increases when we add up to 5% of silica fume beyond that flexure strength decreases.(refer fig: 3)
5. The constant percentage of steel fibre (1% at particular depth) is tested against different percentage of silica fume (5%, 10%, and 15%), the flexure strength is increases when we add up to 5% of silica fume beyond that flexure strength decreases.(refer fig: 4).
6. The result obtained are checked analytically and using software NCSS. We are getting the same value as shown below

Sr. No.	**Flexure strength from experimental method**	**Flexure strength using Analytical method**	**Flexure strength using NCSS software**
1.	**6.1**	**6.11**	**6.33**
2.	**6.6**	**6.11**	**6.13**
3.	**5.7**	**6.11**	**5.93**

7. The pavement thickness is found out using IRC-58 , the 75% reduction in thickness of pavement using steel fibre as shown below

Sr.No.	Flexure Strength (kg/cm^2)	Pavement thickness (cm)
1	66 (using steel fibre)	22
2	56(without steel fibre)	28
3	54(without steel fibre)	33

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